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Declarative memories in interaction: Episodic system engagement in semantic-based encoding and retrieval.

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Ph.D. in Psychology

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Department of Social and Organizational Psychology

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"What we have is this incredibly sophisticated mechanism of transforming… It's almost like coding. You have these little bits and pieces that are occurring in time and then you have the possibility of reconstruction or reactivation, which is … they are very, very, very intriguing and by the way, it is extremely economic."

António Damasio,
The Convergence and Divergence of Memory,
"Big Think" interview,
July 2, 2010.

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My interest in research drove me to a journey of discovery across the Atlantic. Based on prior experience, I was curious to further understand what is “behind” the cognitive style in Autism Spectrum Disorders. On this journey, I met Dr. Joana Carmo, who was my main supervisor during my Masters in Cognitive Science at the University of Lisbon. Dr. Carmo was influential in encouraging me to continue investing in research and pursuing my training in a Doctoral Program, acting as my co-supervisor. I am grateful for her encouragement, support, theoretical contributions, and expert advice. She also connected me with relevant colleagues from her scientific network, such as the Center for Cognitive Science team, at Tëchnische Universität Kaiserslautern – TUK (Germany) and the CADin team (Cascais, Portugal). I thank to both institution teams for their warm welcome and for providing the best conditions for developing my research training.

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Resumo

Memórias episódicas (mais contextuais) e semânticas (mais abstratas) aparecem frequentemente dissociadas na literatura. Recentemente, a interdependência entre estes sistemas de memória ganhou interesse renovado, mas os seus aspetos funcionais e estruturais ainda requerem esclarecimento. Este trabalho aborda a interdependência entre memórias episódicas e semânticas, examinando o envolvimento do sistema episódico na codificação e recuperação de conhecimento conceptual enriquecido com representações episódicas (tipicidade de itens; nomes próprios). Duas tarefas de memória manipularam o conhecimento conceptual (esquemas versus tipicidade; nomes comuns versus nomes próprios) durante a codificação ou recuperação, em amostras de jovens adultos saudáveis e amostras com limitações ou deterioração episódica (idosos; indivíduos autistas). Examinámos também a dinâmica da interdependência dos sistemas episódico e semântico com medidas neurofisiológicas. Em sete artigos a) revimos, produzimos e normalizámos materiais estímulo, e mostrámos b) que sistemas episódicos e semânticos interagem ao processar conhecimento conceptual apoiado em representações episódicas, c) a relevância do sistema episódico e suas conexões nessa interdependência, evidenciando que adultos mais velhos e indivíduos autistas são menos eficientes no uso da atipicidade dos itens para melhorar a recuperação episódica, e que adultos mais velhos foram capazes de usar informações esquemáticas para compensar perdas episódica, d) a natureza episódica de nomes próprios e, e) a dissociação funcional e neural entre processos de base semântica e episódica e sua interdependência. Este trabalho informa abordagens neuro-cognitivas de modelos de interação de memórias declarativas e categorização, apresenta contributos para contextos de avaliação e intervenção, e estimula modelos abrangentes de diagnóstico precoce e reabilitação de memória.

Palavras-chave: Memória Episódica; Memória Semântica; Hipótese da Interdependência; Modelo de Transformação de Memória; Envelhecimento; Perturbação do Espectro do Autismo.

Categorias e Códigos de Classificação do PsycINFO:

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Abstract

Episodic (context-dependent) and semantic (abstract-like) memories often appear dissociated in the literature. Recently, the interdependence between these two memory systems has gained renewed interest, but its functional and structural aspects still require clarification. This work addresses the interdependence between episodic and semantic memories by examining the episodic system involvement in encoding and retrieving conceptual knowledge enriched with episodic representations (item-typicality and proper names). Two memory tasks manipulating conceptual knowledge (schemas versus item-typicality and common versus proper names) during encoding or retrieval were used in samples of healthy young adults and samples with episodic constraints or deterioration (aging and autistic individuals). We also examined the dynamics of the episodic and semantic systems interdependence with neurophysiological measures. In seven articles, we: a) reviewed, produced and normed stimulus materials, b) showed that episodic and semantic systems interact when processing conceptual knowledge supported by episodic representations, c) uncovered the relevance of the episodic system and its connections in this interdependence, showing that older adults and autistic individuals are less efficient in using atypical information to improve episodic retrieval, and that older adult were able to use schematic information to compensate their episodic loss, d) exposed the episodic-dependent nature of proper names, and e) established the functional and neural dissociation between semantic and episodic-based process and their interdependence. This work informs neurocognitive approaches of declarative memories interaction and categorization models. From an applied perspective, these findings provide inputs to assessment and intervention contexts while encouraging comprehensive models of early diagnosis and memory rehabilitation.

Keywords: Episodic Memory; Semantic Memory; Interdependence Hypothesis; Memory Transformation Account; Aging; Autism Spectrum Disorder.

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PART I | GENERAL INTRODUCTION

CHAPTER 1.

Overview

Memory is a critical cognitive function that allows us to mentally represent, store and retrieve our experiences and information. Through memories, we may review the past, act in the present and anticipate the future. Our memories serve many socio-interactional processes and other complex cognitive functions, such as language, thinking, problem-solving, or decision-making. Despite the extant research, hundreds of years of memory studies were not enough to exhaust this topic, and memory structures and processes are still under scientific scrutiny.

In the domain of declarative memories - consciously formed and accessed memories, many studies have documented the dissociation between episodic (contextual-based) and semantic (abstract-based) memories in their processes and neural structures (e.g., Knowlton & Squire, 1995; Squire & Zola, 1998; Tulving, 1972; 1985; Tulving & Markowitsch, 1998; Vargha-Khadem et al. 1997; Yonelinas, 2002, but see McKoon & Ratcliff, 1986). However, how episodic and semantic systems interact has increasingly been discussed, much driven by developments in neurocognitive techniques (e.g., De Brigard et al., 2022; Greenberg & Verfaellie, 2010; Renoult et al., 2019). Still, the brain structures and mechanisms involved in encoding and retrieving episodic and semantic memories in light of their interaction need to be further clarified. The current work addresses this issue by examining the interplay between episodic and semantic memory systems in an attempt to clarify their role during encoding and retrieval memory processes.

Most memory theories suggest the involvement of the episodic system in the formation of new memories, but disagree on their nature and on whether the episodic system and its underlying brain structures (i.e., the hippocampal formation) is involved in the retrieval of both declarative memories (see Nadel, 2020; Nadel et al., 2012; Sekeres et al., 2017; Winocur et al., 2010; Winocur & Moscovitch, 2011; but see also Squire, 1992 for a classic perspective). However, recent approaches showed that the episodic system is necessary for maintaining and retrieving a contextual version of the experience even after a transformed abstract representation is formed in the semantic systems (Sekeres et al., 2018; Winocur et al., 2010). So, both episodic and semantic versions of an experience may coexist and interact for best representing the world. These assumptions raise questions about the functionality and mechanisms involved in episodic and semantic interaction that we address in the current work: Do episodic and semantic systems actually interact for memory retrieval? Is the interaction between episodic and semantic memory systems required in encoding and retrieving episodic memories? Can this interplay between memories also support some sort of semantic retrieval? Is this interaction elicited differently according to the type of knowledge (i.e., if more or less contextual-based) being processed? Moreover, how does this interplay between memories operate when memory function is constrained? Specifically, could this interactive system lead to semantic memory failures in alleged cases of natural episodic decline as in aging or permanent episodic constraints as in autism spectrum disorder (ASD)?

Could this interaction between systems help overcome emerging memory deficits resulting from the natural cognitive decline expected with aging?

The current research took the questions mentioned above as initial challenges attempting to overcome theoretical gaps in memory literature regarding the interdependence between memory systems.

We will address the interaction between episodic and semantic memory systems by examining the selective influence of different types of semantic content available during encoding (more general or more contextual) in recognition and their recollection and familiarity operations, as well as by examining the influence of different levels of contextual requirements in naming retrieval of semantic labels in their functional and neural aspects. We also examined the interaction between memories in conditions in which episodic memory is constrained to clarify the specific role of the episodic system in declarative memories' interaction. We hypothesized that the episodic system, in interaction with the semantic system, plays a role in memory formation and retrieval of semantic knowledge (at least in semantic knowledge with enduring contextual traits), to build and re-establish contextual and abstract versions of memory traces. Based on this interaction perspective of episodic and semantic memories, episodic system' constraints, as those presumed in healthy aging and neurodevelopmental disorders (ASD) populations, are likely to disrupt memory interaction and affect some types of semantic-based encoding and retrieval.

In Part I, we briefly review declarative memory literature, focusing on the interactive view of episodic and semantic memories supported by a developmental neurocognitive approach (Chapter 2). This section provides the theoretical framework for the main research questions and their examination and informs the design of the set of integrated experimental studies subsequently presented.

In Part II, we present seven papers reporting our empirical work. Five of these papers are already published, and two are under editorial consideration.

Chapter 3 presents a systematic review and a normative study to support the selection of suitable materials for the subsequent empirical studies. The systematic review of norms for common objects (3.1.) summarizes the state-of-art of normed stimuli of common objects and characterizes the existent experimental materials and procedures to assist in the future selection or development of new stimuli. Subsequently, we present a normative study of real objects that informs about the categorical organization structure of common objects and provides estimates for each item in several relevant dimensions in a cultural-based manner while discussing potentially interfering variables (3.2.).

Chapter 4 presents three empirical articles investigating the interaction between declarative memory systems by examining the role of selectively activating the semantic system on episodic memories in a remember-know paradigm. Specifically, these studies were designed to inspect the selective role of different conceptual knowledge during encoding (i.e., categorical schemas vs. item-typicality) and its impact on recognition and related recollection and familiarity processes in samples with a preserved episodic system (healthy young adults; 4.1.), samples with potential natural age-related episodic memory decline (older adults; 4.2.), and samples with alleged episodic impairments (autistic individuals; 4.3.).

Chapter 5 presents a second set of articles addressing the interaction between declarative memory systems by inspecting the role of different episodic system engagement in semantic memories. Specifically, these studies contrast common objects (abstract-based) and proper names categories (contextually rich), such as topographical places and people, and their putative episodic requirements in a picture-naming task to scrutinize the role of the different levels of contextual richness in the retrieval of semantic categories. The first paper in this chapter compares the processing of proper names items from categories of people and places in a sample with young and older adults (5.1.). This paper presents an overview of the aging effect in naming those semantic categories to explore if the alleged semantic memory advantage in older adults could reduce the episodic difficulties expected for this age group. In addition, we offered normative data on people and places items in several relevant variables. Subsequently, the functional and neuronal aspects involved in naming retrieval of those categories were examined in healthy adults (5.2.). In this paper, the neural underpinnings of naming retrieval were inspected with Electroencephalography (EEG) to evaluate the neural oscillatory patterns across three categories engaging the episodic system differently.

Finally, in Part III, we summarize our main findings, discuss some of limitations of our studies, and anticipate possible research avenues in the examination of episodic and semantic memory systems interaction. This thesis concludes with a section emphasizing its main theoretical and applied contributions. We discuss how our work may inform neurocognitive models of declarative memories and assessment, intervention and rehabilitation strategies in clinical and psychoeducational contexts.

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CHAPTER 2.

Theoretical Framework

2.1. Episodic and semantic memory systems: From dissociation to interaction

Since the seminal work of Tulving (1972; 1985), the characteristics, specific processes, and, particularly, the differences between episodic and semantic memory have been extensively investigated in memory and neurocognitive research. Consequently, the previously documented interactions among these memory systems (see McKoon & Ratcliff, 1986, but see also Tulving, 1972; 2002) lost stage to the dissociative perspective that has persisted as the main view of episodic and semantic systems until recently.

While defining declarative memories, Tulving (1985) acknowledged two entirely hypothetical types of conscious representational systems: episodic and semantic. Episodic memory is more dependent on a particular context or event and endowed with autonoetic conscious awareness – as being "aware of the subjective time" (Tulving, 1985). Due to its experiential nature, the episodic memory system favors the storage and re-experience of detailed and personal events in a time- and self-based manner. Tulving (2002) suggested that this memory system constitutes an evolutionary gain for the human species, allowing us to anticipate the future and revisit the past in a subjective manner (Tulving, 2002), thus improving survival chances. Semantic memory is defined as a more abstract and context-free representation based on facts, concepts, referents, and meanings, being of noetic conscious awareness (Tulving, 1972; 2002). This memory system allows us to optimize brain resources by using previous learning to respond rapidly to environmental needs. Episodic and semantic memories rest on two separate neurocognitive systems, with the episodic system being developed later and early disrupted in life (Tulving, 1985; 2002).

Tulving's seminal work constituted a remarkable contribution to the memory field, and the dissociative perspective has generated an enormous bulk of research until nowadays (e.g., Gardiner et al., 1998; Renoult & Rugg, 2020 for reviews). However, the possibility of one system influencing the other (although not at the center of the debate) was early recognized in his work (Schacter & Tulving, 1994; Tulving, 1972; 2002). Recent developments in memory brain research also suggest that memory systems are not entirely dissociated (see Nadel et al., 2012; Winocur et al., 2010).

Currently, the interactive view of the two memory systems gathers significant attention, adding to the dissociation approach a more comprehensive understanding of how memory systems concur to support many different cognitive tasks (e.g., Rabin et al., 2010; Rubin & Umanath, 2015; Renoult et al., 2015; 2019). Notably, a recent collection of fourteen articles published in a special issue presenting the latest conceptual advances regarding episodic and semantic memory, offers evidence against the idea of two entirely independent memory systems (see De Brigard et al., 2022). However, due to its complexity, the debate on semantic and episodic memory systems interaction is far from being exhausted.

The following subsections first present a brief review of the dual perspectives of episodic and semantic memories supporting their neural and cognitive dissociation and then introduce the interaction view of declarative memory systems along with evidence strengthening this latter argument.

2.1.1. Memory retrieval: Recollection and familiarity processes and their neural correlates

Declarative memories are often evaluated using recognition memory tasks. Recognition memory is the conscious process of identifying items previously encountered during our prior experiences (i.e., old vs. new presented ones). In contrast, recall tasks involve the capability of freely evoking previously learned information. Notably, in recognition tasks, memory is more easily accessed than during recall since the presence of a cue directs the mental search of the prior experience with the specific item.

There are different approaches regarding the nature, functions, and neural substrates supporting declarative memory recognition. However, our intention in this work is not to exhaust the debate regarding recognition models. Instead, we will focus on a well-established model supporting the dissociative perspective of memories.

Broadly speaking, single-process models argue that recognition is based on a single process driven by the strength of the item-specific memory traits (e.g., Dunn, 2004; Wixted, 2007). Dual-process models, however, have been stating that there are specific conscious awareness operations or components supporting recognition differently based on the level of self-based conscious awareness, known as recollection and familiarity (Gardiner, 1988; Tulving, 1985). The recollection component reflects the vivid contextual details about the prior subjective experience with the item and is taken as a threshold matching (Yonelinas, 2002). In contrast, familiarity does not depend on the re-instantiation of the context in which the event occurred. In this case, retrieval is achieved by a factual-based process of knowing something/someone without recovering any specific contextual details regarding the previous experience (Yonelinas, 2002).

The dual-process perspective implies a functional and structural independence between the recognition components associated with the well-known dissociation of episodic and semantic memories. In this perspective, recollection and familiarity operations mirror a classic distinction between autonoetic and noetic awareness related to episodic and semantic memories, respectively (Gardiner et al., 19998; Tulving, 2000; Tulving, 2002; Vargha-Kadhem et al., 2003). According to this view, recollection refers to the “what”, “where,” and “when” aspects of the specific original event, is supported by hippocampal structures and reflects episodic-like memories. Familiarity is a less self-based and more abstract processing that (partially) depends on neural substrates somewhat overlapping with semantic memories (Yonelinas, 2002). Therefore, recollection and familiarity act independently, but both might contribute to memory recognition (e.g., Yonelinas, 2002). These dual-process models have been increasingly used in neurocognitive approaches to recognition (Yonelinas et al., 2010).

The classic Remember-Know paradigm is the most common design to contrast the two memory components in a single paradigm (Tulving, 1985). In this paradigm, after a learning phase, participants are asked to recognize previously learned items. When participants recognize the items, they are asked to provide a phenomenological judgment of their memory experience by indicating if they Remember their detailed and vivid prior experience with the item or if they Know the item, based on a familiar feeling of previously encountering the item. Recollection processes are assumed to influence Remember responses since these require the retrieval of the detailed context in which memories were formed and are highly dependent on the episodic system. Familiarity sense, instead, is examined using Know responses that are based on the abstract gist information, reflecting their semantic-like nature (Gardiner, 1988; Gardiner et al., 1998; Tulving, 2000; Yonelinas et al., 2010, but see also Migo et al., 2012 for a different perspective).

Recollection and familiarity processes are argued to be behaviorally, cognitively, and neurally dissociated, at least to some extent (e.g., Aggleton & Brown, 2006; Yonelinas et al., 2010). These dissociated processes are shown by the different ways in which Remember and Know responses are affected by different cognitive variables and requirements (Gardiner, 1988; Java & Gregg, 1997; Curran, 2004; Gardiner & Parkin, 1990), methodological aspects of the task (Dalla Barba, 1997; McCabe & Geraci, 2009) and aging (e.g., Koen, & Yonelinas, 2014).

From a neurocognitive perspective, recollection operations selectively trigger higher hippocampal response, while familiarity-like processes are more related to the activation of cortically allocated extra-hippocampus regions, like the anterior temporal lobe/dorsolateral prefrontal regions and perirhinal cortex (Bowles et al., 2010; Brown & Aggleton, 2001; Aggleton & Brown, 2006; Cansino et al., 2002; Eichenbaum et al., 2007; Yonelinas et al., 2005; 2010, but see also Smith et al., 2011 for a divergent finding). In fact, the hippocampus seems to be involved in an associative system of recollection that supports self-consciousness regarding the previous experience with an item, the binding of episodic traces, and the item-context reactivation (Brown & Aggleton, 2001; Yonelinas, 2002). Supporting this argument, prior studies with older adults showed that a good reinstatement of episodic memories (i.e., contextual congruency or shifting in context) depends exclusively on the preservation of the MTL structures, including the hippocampus (Vakil et al., 2010).

The selective role of the hippocampus in memory retrieval has also been corroborated in several studies using the Remember-Know paradigm. For instance, some evidence associated the reduced recollection experience with a disrupted episodic system, including hippocampus functioning and connectivity constraints (e.g., Montaldi & Mayes, 2011; Ranganath et al., 2004; Schoemaker et al., 2014; Yonelinas et al., 2010). Imaging studies using this paradigm also reported a dissociated pattern of remember and know responses in Autism Spectrum Disorder, Alzheimer's Disease (AD), and healthy aging groups. Overall, these results indicate that typically-developed individuals showed more "Remember" than "Know" responses, while both clinical samples – the autistic individuals and the AD patients – presented preserved "Know" and compromised "Remember" responses compared with healthy matched controls (e.g., Gaigg et al., 2015; Rausch et al., 2007). Moreover, aging people showed an interesting pattern of intact or even improved familiarity processing, despite their impaired recollection (see, for example, Koen & Yonelinas, 2014; Mäntylä, 1993; Parkin & Walter, 1992; Peters & Daum, 2008). We interpret these findings as indicating dysfunction or constraints of the episodic system and its neural substrates by natural decline expected with aging or by neurocognitive disorders or pathological conditions. Notably, these results also indicate the possibility of intrusive or cooperative hippocampus-cortical interactions in clinical and non-clinical amnesic conditions. For instance, in the study of Gaigg et al. (2015), autistic individuals presented disrupted recollection associated with difficulties in processing the semantic relations during encoding. This pattern was accompanied by reduced hippocampal activity but also by enhanced prefrontal engagement during the reinstatement of memories, suggesting a compensatory mechanism of effortful encoding to reduce the limitations of a compromised binding process. Likewise, the high reliance on familiarity processes observed in older adults (see Peters & Daum, 2008) suggests a compensation mechanism to support recognition.

The dynamics of memory systems and their substrates systems was also shown in functional magnetic resonance imaging (fMRI) studies with healthy adults, employing adaptations of the R/K paradigm (Harand et al., 2012; Takashima et al., 2009). Specifically, these studies have shown that transformations in the nature of the memory, from more recollective to more familiarity-based memories, is supported by a strengthening of neocortical representations (semanticization) while disentangling from the hippocampus. These results are consistent with previous finding associating the semantic system with less hippocampal activity and higher cortical engagement (see Dudai et al., 2015; Sekeres et al., 2018), as occurs with familiarity memories.

Together, these findings suggest that, although dissociated, episodic and semantic systems concur and interact to support learning and retrieval. Nevertheless, the interplay between episodic and semantic memories, in their functional and structural aspects, is not fully understood.

2.1.2. Declarative memory models, structures and interaction

Models and theories of declarative memories have been improving in their structural and functional levels thanks to developments in neuropsychology, psychophysiology, and neuroscience, including recent advances in neuroimaging techniques. However, while the possibility of mapping the brain structures underlying memory systems has been widely documented using different neural techniques, this mapping still poses a robust challenge at different levels of analysis (e.g., regional, networks, cellular, molecular). Therefore, it is essential to enrich this structural literature with a functional perspective. Below, we review the main findings from neurocognitive models in light of an interdependence perspective to further clarify the functional properties of episodic and semantic memory systems and their interaction.

The medial temporal lobe (MTL), including the hippocampus, has been consistently referred to as the main structure supporting episodic memories (e.g., see Yonelinas, 2002; O´Keefe & Nadel, 1978; Squire, 1992; Winocur et al., 2010). Recently, theories of long-term memories, as episodic and semantic memories, suggest the specific involvement of the hippocampus in the formation and retrieval of semantic memories (e.g., Dudai et al., 2015; Sekeres et al., 2017; Winocur et al., 2010), an argument that remains under discussion. In this context, further understanding the hippocampus's role may be an important step toward a more comprehensive approach to memory (Morris et al., 2006).

One of the seminal models on the neural substrates of memory, the Standard System Consolidation (SSC), argues that the hippocampus is necessary for and sustains recent memories only, regardless of their nature (semantic or episodic, see Squire, 1992). In this approach, hippocampus recruitment is time-limited and independent of the information to be processed (Squire & Alvarez, 1995). In contrast, the Multiple Trace Theory (Nadel & Moscovitch, 1997) and its later reformulation - the Transformation Account (Sekeres et al., 2017; Winocur et al., 2010; Winocur & Moscovitch, 2011) argues that this structure plays a role in the formation of episodic, but also semantic memories, in an experience-based manner. This approach suggests that episodic and semantic memories are dissociable systems, as proposed by Tulving (1972), and that experiences (not the time) are the relevant factor defining the episodic or semantic nature of memories (Nadel & Moscovitch, 1997). Specifically, our experiences can maintain memory representations vivid by means of contextual specificity, but they also enable the extraction of patterns from the cumulative experience, favoring the emergence of schematic knowledge (Winocur & Moscovitch, 2011). According to this approach, the hippocampal structures are necessary for binding the detailed multimodal representations of the experienced episodes, being involved in encoding and retrieving episodic memories while they last (even long-term) (Nadel & Moscovitchi, 1997; Winocur et al., 2010). Experiences accumulated over time favor the multiple representation of the event in the memory systems through a diversity of traits distributed and interconnected in the hippocampus-cortical network. Semantic memory emerges as a schematic version of the experiences allocated to neocortical structures (Winocur et al., 2010; Winocur & Moscovitch, 2011).

Moreover, according to the memory transformation approach, the transformation of memory traces from episodic to schematic constitutes a central feature of the consolidation process (Nadel et al., 2012; Winocur et al., 2010). Specifically, the hippocampus supports the abstraction (semanticization) of the original memory trace into a cortically allocated version – the transformation process required for consolidation (Nadel & Moscovitch, 1997; Winocur & Moscovitch, 2011). Once consolidated, previous knowledge (semanticized in nature) remains available in the cortical network to integrate newly learned traits that, in turn, may strengthen or update the existing ones (de Mendonça et al., 2020; Nadel et al., 2012, Sekeres et al., 2017). Furthermore, according to the Transformation account episodic and semantic memories may coexist and interact to further support knowledge acquisition and retrieval depending upon the conditions in which they are activated (i.e., retrieval cues) (Winocur et al., 2010).

However, the long-lasting dependence of episodic memories on the hippocampus is not well-accepted by the supporters of the classic consolidation approach (see Squire et al., 2015). This classic view of the limited role of the hippocampus in episodic memories is based on previous findings of preserved long-term episodic memories in cases of amnesic conditions due to Medial Temporal Lobe – MTL obstruction (i.e., including the hippocampus structures, as in Bayley et al., 2005; Squire, 1992).

Another evidence used by the SSC approach to circumscribe the role of the hippocampus to early processing stages is the regression gradient observed in patients with hippocampal lesions. In these patients, memories closer to the lesion period are more disrupted, while remote memories tend to be more resistant (see Reed & Squire, 1998; Squire & Alvarez, 1995). These findings were interpreted by the SSC defenders as supporting the hypothesis that remote memories overall are independent of the hippocampus (in a time-dependent manner).

Nevertheless, there is a relevant assumption in this argument against the transformation approach that is questionable, and that may change the whole perspective. In fact, the consolidation argument rests on a dissociative view of episodic and semantic systems, while the transformation account necessarily invites a new approach to those systems by the way they interact to produce, store, and reconstruct memory representations. In response to the criticism advanced by the classical view, the transformation account argues that the findings dissociating MTL obstruction from episodic deficits, like those observed in Bayley et al. (2005), can be explained by the nature of the representation involved in their task (i.e., autobiographical memories) that recruits simultaneously episodic and semantic representational systems (see Nadel & Moscovitch, 1997). Therefore, the transformation account assumes that it is the nature of the information to be represented in the brain that determines the "where" and "how" of the structures engaged (see Nadel & Hardt, 2011; Nadel et al., 2012; Robin & Moscovitch, 2017).

Neurocognitive evidence supporting the transformative approach can be found in studies of neural correlates of hippocampus-dependent memories (e.g., emotional memory, spatial navigation, motor learning, detailed scenes, and autobiographic memories) acknowledging the relevance of this structure in supporting detailed and contextualized memories while those traits persist (e.g., Gagné & Cohen, 2016; Sekeres et al., 2018; Robin et al., 2019). For example, a recent study from Gagné and Cohen (2016) reports the interference of a visuospatial declarative task (hippocampus-dependent) on the retrieval of consolidated motor skills memories (requesting the hippocampus as well as its connections to cortical regions). Furthermore, an increased cortical activity (i.e., mPFC – medial Pre-frontal Cortex) followed by a reduced hippocampal activity was observed while remembering videos encoded based on general aspects (i.e., their story content), but not those encoded based on their perceptive details (i.e. visual or auditory aspects) which activated hippocampus regions (Sekeres et al., 2018). These findings indicate that semanticized memories can be influenced by hippocampus structures and that retrieval may exempt hippocampus involvement when supported by abstract-based knowledge.

Additional neural evidence from EEG studies contributes to clarifying memory models of the declarative systems by showing a dissociated activation of brain oscillation frequencies (dynamic electrical waves produced to support brain functioning ranging from 0.1 to more than 100 Hz) according to episodic or semantic memory systems engagement (see Klimesch et al., 1994; Klimesch, 1996, 1999). Increased power activity in theta frequency (around 4–8 Hz) observed along fronto-temporoparietal regions is consistently referred to as a neural marker of recollection (Klimesch et al., 1994) and as an indicator of episodic memory systems involvement (Fellner & Hanslmayr, 2012; Klimesch et al., 1994; Klimesch, 1996). Notably, these studies report theta power changes (event-related) that increase specifically for contextual-based processing, prevailing around 450-625ms post-stimulus (Klimesch et al., 2001), and also for spatial processing in both animal, healthy and clinical samples (Chauviere et al., 2009; Cornwell et al., 2008; O´Keefe, 1993; see also Herweg et al., 2020 for a review). This increase in power for oscillatory theta in cortical regions is likely triggered by the hippocampal theta activity (Klimesch, 2000; Hanslmayr et al., 2010). In contrast, the decreased upper alpha frequency (around 9-12 Hz) power activity indicates increased demands on semantic memory systems in the formation and retrieval of memories (Klimesh et al., 1994; 1999; Klimesch et al., 2006). This upper alpha suppression should be more evident in fronto-central and midline regions (see Klimesch et al., 1997; Klimesch, 1999). In fact, a pronounced suppression of upper alpha (around 400- 500msec, mainly in left-side) was observed during the processing of semantic categories and reported as a marker of good semantic memory performance (Klimesch et al., 1997; 2005).

Moreover, the dissociated activity of alpha and theta bands was observed in the interface of language and memory processing, suggesting concurring episodic and semantic systems. For instance, theta power increased in response to ambiguities, and alpha power decreased related to the lexical-semantic integration and re-instantiation (e.g., Branzi et al., 2022; Ojemann et al., 1989; Piai et al., 2015; Piai & Zheng, 2019). Specifically, the role of the episodic system reflected in theta activity during a semantic task was observed in a study that asked participants to read a sentence and complete its ending by naming an image (e.g., sponge). Some of the sentences were restricted by the semantic context (e.g., He washed the dishes with…) and others were neutral (e.g., He walked until here with…) for naming an object (Piai et al., 2016). Increased theta activity in the temporal regions was observed for words bounded by a semantic-context relative to neutral ones, which might reflect hippocampal activation for context-based processing. This activation seems to indicate the involvement of the episodic system in semantic tasks to support some sort of episodic-like binding processing. We infer that the symmetric pattern of theta increase and alpha decrease observed in the mentioned studies may represent the complementarity between the hippocampus- and cortical-based systems.

The assumptions regarding the transformation in the nature of memories and related evidence of the selective role of the hippocampus in episodic memory emphasize the qualitatively distinct nature of declarative memories. The possible engagement of the episodic system (hippocampus-based) in encoding and retrieval of some types of semantic information opens the possibility for the concurrence and interaction of episodic and semantic representations.

Section summary:

This section briefly defined semantic and episodic memories and exposed early assumptions regarding their dissociation. We acknowledged the relevance of the dissociation perspective to understand the different contributions of these hypothetical neurocognitive systems in representing, retaining, and retrieving learned information. We also discussed the dual perspective of recollection and familiarity as mirroring the classic episodic and semantic memory dissociation and their neurocognitive correlates. Importantly, we anticipated that the expected interaction between episodic and semantic memories could be well captured using recognition tasks due to their likelihood of providing different and complementary measures based on their distinct recognition components. Although not exhaustively, we contrasted models of recognition memory and framed our work in the dual-process perspective, assuming that the dissociation between episodic and semantic memory is reflected in the familiarity and recollection components of episodic recognition. Finally, we considered the constraints in the recollection process expected in natural memory decline of older adults and how they might mirror the disrupted episodic system of autistic individuals.

Importantly, we advanced some criticism of a purely dissociative approach based on the most recent interactive approach between memory systems, suggesting how they can be interdependent. In our view, an idea of interaction necessarily depends on the existence of two different elements (as supported by a dissociative approach), and that such interaction reflects that the functional and structural properties of each system are working together to achieve a goal. As presented in the literature, the information available and the task requirements seems to be decisive in determining how and to what extent episodic and semantic memory systems interact and whether one or the other memory representation prevails (see Winocur et al., 2010; Robin & Moscovitch, 2017). Therefore, it is crucial to further understand the role of different types of information in declarative memories' interaction.

2.2. The role of conceptual knowledge in modulating retrieval processes

The role of conceptual knowledge in cognitive processes is not new in cognitive science. When trying to understand how children acquire knowledge, Piaget (1999) first referred to schemas as basic structured knowledge shaping learning and comprehension in interaction with the world. Likewise, Bartlett's schema theory (1932) suggests a constructive nature of memory by showing that new learning may be supported by mental constructions based on prior experienced knowledge and can be adapted to fit them. Later, Rumelhart (1980) clearly stated that schemas constitute a tangle of our general knowledge derived from an abstraction process of our experiences. Although the relationship between prior knowledge and new learning has been at the center of a schema definition, it is still unclear whether schemas might benefit both declarative memories. Previous studies are consensual in demonstrating that schemas help optimize learning and retrieval (e.g., Liu et al., 2016; Tse et al., 2007; van Kesteren et al., 2010; 2014). In contrast, there is also evidence showing that our prior schemas can sometimes be a source of mistakes/errors, generating increased false alarms, overgeneralization, and confabulation (e.g., Newman & Garry, 2014; Smith et al., 2000; van Kesteren & Meeter, 2020). For instance, in a recall task by categories, the categorical knowledge already formed increased false memories for categorical exemplars that were not presented in the list (Smith et al., 2000). The susceptibility for misattribution due to the interference of prior schemas is mainly observed as age increases (Chen et al., 2022; Li et al., 2022; Umanath & Marsh, 2014). These findings suggest that schemas are not always advantageous since they may enhance inaccuracy in memory retrieval.

In the following subsections, the role of prior knowledge in memories is examined, particularly in which conditions prior knowledge should constitute an advantage or an obstacle for memory retrieval.

2.2.1. Schemas in memories

Schematic memories are those abstract representations, semantic in nature, that went already through consolidation processes (Winocur et al., 2010). Concepts, categories, and meanings are all schematic memories (see Tulving, 1972). These types of memory representations seem to promote rapid learning (as in Bartlett, 1932). For instance, it is easy to learn that a new mobile phone is a type of phone based on its features and functions that are common to the phone category.

The advantage of conceptual knowledge, such as schemas, on episodic memory encoding and retrieval has been observed in both animal and human samples (e.g., Chen et al., 2022; Liu et al., 2016; Tse et al., 2007; Tse et al., 2011; van Kesteren et al., 2013a; van Kesteren et al., 2013b; van Kesteren et al., 2014; van Kesteren et al., 2020; Yamada & Itsukushima, 2013). For instance, recent study using an object-scene congruency task confirmed that schema knowledge ameliorated correct recognition in similar ways along aging, although influencing the enhancement of false alarms particularly in aging groups (Chen et al., 2022). Complementarily, the schema congruency during learning showed to be advantageous to improving memory integration, via MTL-cortical exchanges, and subsequent retrieval as the reactivation (by another occurrence of the event) of the memory traits also did.

When a schema is available, consolidation (i.e., cortical integration) of newly acquired traits of episodic nature runs faster when they conform to the schema (see Nadel et al., 2012; Tse et al., 2007). However, the semanticization of new memories that do not fit a schema (incongruent items) appears to be highly dependent on hippocampal activation and its interaction with cortical regions (van Kesteren et al., 2010; 2014). In this case, semanticization processes require more time for the transfer process from the hippocampus to cortical structures – expected during consolidation (see Tse et al., 2011; van Kesteren et al., 2013a). For example, a recent neurocognitive study endorsed this perspective showing that hippocampal regions and their connectivity with specific cortical regions (e.g., ventromedial prefrontal cortex - vmPFC and Fusiform Areas) are activated to support a facilitatory effect of prior knowledge about faces in the formation of new face-house associative memories (Liu et al., 2016).

By demonstrating the schema advantage in functional and neural levels, these studies emphasize the role of the hippocampus-based episodic system in binding and spreading information in cortical regions at the service of semanticization. However, it remains unclear if schema congruency facilitation is a generalized process in declarative memories or whether it is selective for memories that already present some degree of semanticization (transformed in nature) and for information that fits with prior available schema. In the following subsection, we present evidence supporting the selective role of schemas in declarative memories.

2.2.2. The selective role of schema in declarative memories

Recent evidence has put the generalized advantage of conceptual schemas into perspective, for instance, by showing the risk of overreliance on schemas in generating false memories (van Kesteren & Meeter, 2020; Chen et al., 2022).

In fact, not all types of knowledge structures are helpful for both episodic and semantic memory types (see Mäntyla, 1997). For example, a recent study contrasted the schema effect on item versus associative memory types in a time-dependent manner (immediate vs. after consolidation) (van Kesteren et al., 2013b). The results indicated that the advantage of a schema for item memories was only observed after consolidation, while for associative memories, this advantage was immediate and (although weaker) persisted over time (van Kesteren et al., 2013b). In this study, the differentiation in nature between memories was established using distinct tasks and delays for retrieval (consolidation process). Critically, some memories might preserve their episodic nature over time (e.g., personal memories, spatial memories, etc.). Yet, examining declarative memories using distinct tasks limits an effective differentiation/comparison between semantic and episodic memories since different measures/criteria are assigned for each task.

Further examinations using single tasks, like the Remember-Know paradigm, could help clarify the overall advantage of schema congruency on memories and provide possible insights about declarative memories interaction. Studies adopting the Remember-Know paradigm have the advantage of comparing, in a single task, different memory operations (i.e., recollection and familiarity) that reflect dissociable episodic and semantic memory systems (as previously argued in section 2.1.). These studies argued that prior acquired knowledge seems advantageous for familiarity-like memories but not for recollective ones, which are influenced by a more perceptually distinctive encoding of episodic source (Carr et al., 2013; Mäntylä, 1997; Rajaram, 1998).

Exploring the role of categorical schemas (abstract-based) in selectively affecting recollective and familiarity-based memories may help clarify the interaction between episodic and semantic systems. Moreover, prior studies comparing schemas with other types of prior knowledge in both declarative memories' performance are still missing. Therefore, it would be important to examine the influence of a specific type of conceptual knowledge on episodic and semantic memories.

2.2.3. Item-typicality: A different type of prior conceptual knowledge

As stated above, categories are types of schematic knowledge that help us organize new upcoming information (see Murphy & Medin, 1985; Ghosh & Gilboa, 2014 for details). We mentally categorize the world for understanding and adaptation purposes. To form a conceptual schema of a category, we recur to the commonalities across their members (Rosch & Mervis, 1975; Murphy, 2002). As soon as a category prototype is formed, it will be used to process new items based on similarities between the characteristics of the items and the available prototype (see Rosch, 1978; Rosch & Mervis, 1975; Rosch et al., 1976). Categorical schemas are, therefore, generic abstracted knowledge forming a conceptual prototype model regarding category belonging. Categories comprehend, in some sense, hierarchical organization structures of knowledge comprising more informative and easier-to-learn representations of different levels (see Rosch, 1975; Rosch et al., 1976). These organization structures serve the optimal function of the brain systems since we tend to preferentially use basic concepts of intermediary levels (as a dog) in supporting our understanding of the world in comparison to those of broad concepts (as animals) or too specific ones (like bulldog terrier; see Rosch & Mervis, 1975).

However, even within the same category, some items are not so similar to one another or too further away from the prototype, and some flexibility in the application of the prototype model is required to efficiently admit several different items within the same category (see Lambon Ralph et al., 2010). Each exemplar of a category presents an idiosyncratic combination of group of features from different modalities and categorization, as a complex processing, should allow accommodate those non-linear relations conciliating the need of generalizing and maintenance of the exemplar singularity. In this sense, a "finer categorization requires sensitivity to subtle variations" (see Lambon Ralph, 2015, pp. 25). The organizational structures of categories also include concept information about categories built at a more specific level. This very specific level of knowledge is called item-typicality, which is the goodness of an exemplar in representing its own category, with very good exemplars being the typical ones (Medin et al., 2007). This is the case because typical items, like a cow or a dog in the "mammals" category, share the main features of their category of belonging (Rosch & Mervis, 1975).

Item-typicality was already shown to be a relevant source of conceptual knowledge involving specific semantic information that can also influence categorization and memory processes (Hampton & Gardiner, 1983; Rosch, 1975; Schmidt, 1996). Concerning both declarative memories, lower item-typicality benefits recognition memories but is selective in helping recollection processes only (Alves & Raposo, 2015).

Previous studies have also shown that processing item-typicality information constitutes a challenge both for people with semantic deficits (e.g., Bozeat et al., 2003; Lambon Ralph & Howard, 2000) and for those with some degree of episodic memory impairment, such as autistic individuals (Carmo et al., 2016; Gatsgeb & Strauss, 2012). In this sense, it is plausible to assume that both the semantic and episodic systems could be involved in accessing this type of knowledge. The literature already provides some clues regarding the systems involved in processing typicality, namely, the engagement of semantic-related ATL structures as a core region for item-typicality processing (e.g., Fairhall et al., 2013; Lambon Ralph et al., 2016; Santi et al., 2015). A recent approach to semantic knowledge – the hub-and-spoke model – indicates that semantic processing involves both the content-specific (or modality) and the contextual information represented in the sensorimotor regions across the brain and in the anterior temporal lobe (ATL) region (Lambon Ralph et al., 2016; Rogers et al., 2004). The ATL region is argued to act as a hub component combining specific information to favor the emergence of non-modal abstract and coherent conceptual representations (Lambon Ralph et al., 2016; Rogers et al., 2004). Although not fully understood, there is already evidence of a bi-directional network interaction between the content-specific information and the semantic hub (ATL-related) regions as a function of the type of conceptual information to be processed (Chiou & Lambon Ralph, 2019). Interestingly, typical items relative to the atypical items implied a higher need to re-instantiate information from encoding to retrieval during episodic recognition tasks to surpass the interference of similarities between items, which seems to occur in the left ATL (Delhaye et al., 2022). Moreover, processing atypical items involves monitoring processes to compare how the low typical item matches the categorical prototype due to its distinctiveness (Delhaye et al., 2022; Santi et al., 2015).

These findings allow us to infer the complexity of the typicality representation, which seems to recruit episodic processing besides semantic operations. However, less is known about the way the episodic and semantic systems concur to allow the processing of item-typicality information.

Section summary:

The current section described how schemas might represent an economy in memory processing by circumventing the relevant neural network involved in contextual-based detailed representations and advancing the consolidation/semanticization process during learning. We also argued that the schema consistency advantage is not generalized in declarative memories but is circumscribed to the semantic memory system. Moreover, we referred to evidence suggesting that prior knowledge can sometimes obstruct memory vividness and result in worse episodic retrieval performance. We also argued that categorical schemas activation and item-typicality processing are apparently conflicting mechanisms since the incongruency of atypical information somehow violates the schema knowledge represented in the categorical prototype. This incongruency between the item (in its typicality) and schema seems to enhance episodic recollection. Therefore, understanding how memory encoding and subsequent retrieval operations are influenced by different types of conceptual knowledge, such as schemas and item-typicality, in the same experimental design, might help clarifying the influence the semantic system may exert in episodic memories, thus reflecting the interaction between both declarative systems.

The role of different conceptual knowledge during the encoding of episodic memories may provide relevant evidence to inform an interactive memory framework based on the influence of the semantic system in episodic retrieval. However, a broader comprehension of declarative memories interdependence can only be achieved by examining this interaction in the other direction, namely by examining how the episodic system influences semantic retrieval. Specifically, an in-depth examination of the interaction between declarative memories must also consider how contextually based information affects semantic tasks, which we will address in the following section.

2.3. Naming different semantic categories: A dissociation reflecting episodic and semantic interdependence

Although seemingly effortless, naming retrieval is a complex cognitive task involving specific cognitive processes such as recognition operations and their dependence on mnesic systems. Naming consists of labeling previously learned items in the presence of a cue (i.e., descriptions or pictures). Naming an item involves sensory-perceptive inputs, recognition, and lexical-semantic retrieval operations together with phonological articulatory processes (Glaser, 1992; Humphreys et al., 1999; Johnson et al., 1996; Levelt et al., 1999, 2001). Retrieving a recognized picture name activates a semantic network of related knowledge to select the appropriate label (see Humphreys et al., 1995; Levelt et al., 2001). Therefore, between perceptive encoding and the articulation of the phonological form of the label, important memory retrieval operations occur. Furthermore, inhibitory control from working memory is required to select and constrain information according to its relevance (e.g., Howard et al., 2006) and discard unsuitable and irrelevant content (i.e., both sensory and semantic).

Naming retrieval tasks have been traditionally adopted in neuropsychological studies (e.g., Benke et al., 2013; Evrard, 2002; Semenza et al., 2003; Semenza, 2006; 2011) as a consistent and comprehensive assessment tool, allowing the identification of declarative memories' patterns. Through naming retrieval tasks, it is possible to obtain, for instance, measures of specific lexical-based retrieval in the case of correct labeling, tip-of-the-tong (ToT) states in the case of recognition without naming retrieval, and semantic interference measures whenever naming errors arise. During the search for the item-label identity, recollection-based operations may be a crucial step to achieve accurate naming retrieval, particularly for unique item-label associations (as in items with an identity-based label, like a face-name association). In contrast, for the ToT states, the retrieval processes are based on partial information and on the sense of knowing the item that serves as a cue indicating the likelihood of the naming to occur (Schwartz & Metcalfe, 2011). In ToT states, recognition is likely to be supported through familiarity without naming (i.e., as in cases in which we feel that we know someone but do not remember their name). Therefore, ToT states cannot be equated with errors, as they involve some indicator of item recognition in the absence of naming.

As previously argued, naming retrieval seems to impose different demands on the episodic and semantic systems that seem to vary according to the type of knowledge to be retrieved. Additionally, since naming abilities are known to decline along life, a neurodevelopmental approach regarding naming semantic categories of common and proper names are also warranted. The following subsections explain these arguments in detail.

2.3.1. Proper vs. common names reflect declarative memories' dissociation

Behaviorally speaking, the process of proper names seems more challenging and demanding than common names (e.g., Brédart, 2017; Semenza, 2006; Semenza et al., 2003), particularly with aging (James, 2004; 2006). Common names are purely semantic representations of classes of items sharing defining features (e.g., "Vehicles" for all transports; see Semenza, 1997). Proper names (e.g., landmarks, people, brands), however, involve associations of identity and experiential base between the name and the entity (Semenza, 1997; 2009). Common names are essentially supported by a complex semantic system, as common object categories (see Lambon Ralph, 2015; Rogers et al., 2004). Instead, proper names are likely to recruit differentially the episodic system (contextual-dependent) and a large network also involving structures supporting the semantic system (see Brédart, 2017; Liu et al., 2018; Martins & Farrajota, 2007; Provérbio et al., 2001; Renoult et al., 2010; Semenza, 2006; 2009). The differential engagement of the episodic system while naming proper names is related to the processing of unique identity-based associations (see Brédart, 2017; Provérbio et al., 2001). Therefore, common and proper names are behaviorally and functionally dissociated. However, the structures involved in retrieval those names are still controversial in the literature.

A group of evidence of case studies of anomia raised the hypothesis of the crucial involvement of the left temporal sites (i.e., in the Anterior Temporal Lobe- ATL, including the Temporal Pole) in proper naming due to the ATL role as a hub between concept and lexical processing (e.g., Damasio et al., 1996; Lambon Ralph et al., 2012; Miceli et al., 2000; Papagno & Captani, 1998; Tranel, 2009, but see also Gainotti et al., 2007, for cases review). However, the ATL structures involvement is not exclusively to support proper name retrieval, given their essential role in semantic representation overall (as shown above; see also Lambon Ralph, 2014; Lambon Ralph et al., 2016), independently of how unique the association between the item and its label is. Furthermore, there is evidence pointing to a more distributed and specialized network (e.g., Damasio et al., 2004; Douville et al., 2005; Gorno-Tempini et al., 1998; Semenza, 2006; see Semenza, 2011, for a review), likely comprising other memory-related structures (Hodges & Graham, 1998; Martins & Farrajota, 2007) to process proper name items. This appears to be the case, as only proper name categories seem to recruit specific MTL regions, including hippocampal structures, during naming (see Martins & Farrajota, 2007, for a double dissociation).

Neurocognitive studies have substantially corroborated the role of the distinct structures supporting the processing of common and proper names items, as objects, faces and places (e.g., Engst et al., 2006; Gorno-Tempini et al., 1998; Provérbio et al., 2001; 2009). Neural studies of event-related potentials (ERPs), for instance, conformed with the behavioral and functional dissociation perspective suggesting that proper name items are cognitively more demanding and neurally distributed than common names items due to the specific properties of the information they entail (Adorni et al., 2014; Provérbio et al., 2001), suggesting their dependence on the episodic memory system.

Brain localization outputs suggest that common names items, understood as purely semantic, seem to be cortically established (ATL; Lambon Ralph et al., 2016), while processing proper names items requires a large and complex neural network involving semantic and episodic interactive systems (i.e., ventro-medial Prefrontal cortex, Anterior Temporal Cortex, Hippocampus), specialized perceptive- and modality-based areas (i.e., Fusiform Face Area; Parahippocampal Place Area) and socio-emotional related structures (e.g., Limbic system) (see Cohen et al., 1994; Douville et al., 2005; Gorno-Tempini et al., 1998; Liu et al., 2018; O´Rourke & de Diego Balaguer, 2020; Semenza, 2011). This complex network is fragile and sensitive to neural alterations due to lesions, aging, or pathological conditions (Benke et al., 2013; Semenza et al., 2003; Semenza, 2009).

Together, these findings point to the special role of hippocampus structures in naming proper name items, challenging the core role of the temporal cortex in naming retrieval. In this manner, the literature suggests that common and proper names are differentially recruiting the semantic and episodic systems, respectively (see also Semenza et al., 2003), which seems to occur as a function of the presence or not of contextual-based information. Since they reflect dissociable mnesic functions and mechanisms (Provérbio et al., 2001; Semenza et al., 2003; Semenza, 2006), naming retrieval of common vs. proper names may also mirror, to some extent, semantic and episodic memory dissociation. The cumulative evidence of dissociation between those categories contributes also to the transformation approach of memories when suggesting the prevalence of episodic-based representations (supported by, among other areas, the hippocampus structures) in semantic knowledge (Moscovitch et al., 2016; Nadel, 2020; Winocur et al., 2011). Although category differences have been extensively explored in items of common names (e.g., Caramazza & Sheldon, 1998), the specific processing regarding categories of proper names has barely been addressed.

2.3.2. Proper names categories: Characteristics, differences and neurodevelopmental aspects of naming places vs. people

Places items are more difficult to process than people items, presenting longer response latencies and more errors in recognition and categorization (Engst et al., 2006; Fairhall et al., 2013), likely because they are differently supported by contextual knowledge. Moreover, the representation of places items comprises topographical and spatial knowledge largely dependent on hippocampus-based spatial and navigation systems (Moscovitch et al., 2005; 2006). Neural data confirm those category differences by showing that topographical-based representations seem to involve a complex neural network of medial parietal, occipital-temporal regions, and the medial temporal lobe (MTL) (Maguire et al., 1997). In addition to the common recruitment of the ATL regions (particularly the left temporal pole) in both categories, processing well-known places additionally seems to require parahippocampal involvement, while famous people processing is supported by the fusiform face area - FFA (Damasio et al., 2004; Engst et al., 2006; Fairhall et al., 2013; Gorno-tempini & Price, 2001; Tranel, 2005; 2009).

People and places are complex and multidimensional representations involving episodic and semantic system requirements. Nevertheless, it is almost intuitive that retrieving the name of a place will require more episodic effort than retrieving a person's name due to the additional spatial and contextual information involved in place items. Based on the interactive memory perspective, these categories could constitute a challenge to older people since their episodic system (required to process contextual-based information from those categories) is compromised. Thus, the neuropsychology of aging (namely, the pattern of increased semantic memory and reduced episodic memories) may constitute an interesting research avenue to uncover the episodic and semantic system's interaction.

As we get older, our cognitive competencies change naturally. Although these changes are usually referred to as cognitive deterioration, it is important to emphasize that some of these skills can be reduced while others may be amplified. For instance, a significant and linear change is observed through cross-sectional studies in declarative memories after 60 years old (Nilsson et al., 1997; Rönnlund et al., 2003). Episodic memory seems more affected by aging, while semantic memory remains more stable, although those changes proved to be linked (Lövdén et al., 2004). The decline in episodic memory abilities along with natural aging is referred to be at the core of relevant naming retrieval impairments (Marful et al., 2013; Neumann et al., 2018; Yang & Zhang, 2019), irrespectively of the influence of other memory abilities (e.g., working memory).

While picture naming is typically known as a semantic memory task, it may recruit associative/ contextual features related to the representations and processes of the item itself (see Snodgrass & Vanderwart, 1980). This is what is expected to occur in people and places categories that comprise an item-context association of identity and topographical domains, respectively. In this respect, the type of category will likely determine the emergence and aggravation of memory decay in older adults. Therefore, the performance in naming retrieval tasks in older adults is likely to imply contributions of both a declining episodic system together with a preserved semantic memory system to achieve a successful retrieval, affecting differently naming common and proper names categories.

However, little is known about the functional and structural aspects involved in the differences between people and places in naming retrieval. Exploring those categories might complement the analysis of the interdependence of the episodic and semantic systems. Moreover, neural oscillatory signatures of naming retrieval of those two types of categorical knowledge have not been examined in the literature. Furthermore, the memory-related dissociable theta vs. alpha activity in naming retrieval as reflecting different declarative memory demands during picture-naming tasks is yet to be clarified.

Section summary:

In this section, we discussed the parallel between common and proper names classes and declarative memory systems by showing that the retrieval of proper names engages the episodic system (hippocampus-based). People and places are also argued to present varying interactions with the episodic system according to the specific knowledge associations to be retrieved. Additionally, we addressed the neural-based differences regarding people and places, showing that those semantic categories entail different specialized cortical and other brain regions. We also acknowledged the relevance of further examining the neural correlates of naming retrieval across different categories varying in their contextual demands, such as people and places.

Based on these considerations, our remaining question is whether the prior dissociation between common and proper names constitutes a by-product of a fine-grained level of specific knowledge that engages memory systems. In other words, is the type of information embedded in each category the basis of the common and proper names class dissociation? Likewise, it could be interesting to explore the neural underpinnings of the above-mentioned known dissociation of categories considering the oscillatory dynamics between episodic theta increase and semantic alpha suppression as reflecting the distinct memory requirements of different semantic categories in naming.

2.4. Scope of the work

In the current chapter, we showed that conceptual knowledge might impose different requirements over episodic and semantic memory systems as a function of the information to be processed (if more or less contextual-based). Therefore, episodic and semantic systems can interact to process specific types of knowledge (as in item-typicality and proper names). However, how this interdependence between episodic and semantic systems occurs to support memory functions (including encoding and retrieval processes) during conceptual knowledge use requires further examination. To accomplish the goal of providing evidence for the interdependence hypothesis of declarative memories, we propose two complementary approaches; 1) to examine the contribution of the semantic system in the encoding and retrieval of episodic content and 2) to explore the role of the episodic system and its neural substrates in the retrieval of conceptual knowledge. Those complementary approaches could be informative about the interaction of memories. The main assumptions are summarized below.

i. The theoretical arguments and empirical evidence presented in the current chapter suggest that the episodic and semantic systems, although dissociable in function and neural substrates, may interact to support encoding and retrieval processes. Based on the transformation account of memories, the nature of the information to be processed (i.e., context of encoding, retrieval cues, and task demands) will drive the interplay between these interactive systems. Therefore, the involvement of the episodic system might always be required to process even long-term contextual-dependent information. Moreover, the interplay between episodic and semantic systems in the presence of conceptual knowledge optimizes learning and influences retrieval.

ii. We also reviewed evidence favoring the idea of interactive systems by arguing that prior schema and item-typicality effects might exert a distinct influence on recollection and familiarity-based memories. Moreover, we referred to the characteristic profile of declarative memories (constrained episodic and preserved semantic) in cases of episodic memory constraints, like autistic individuals and healthy aging as model to examine episodic and semantic interaction.

iii. Furthermore, we argued that semantic representations are not all equal and that different categories (i.e., objects, people, and places), although constituting semanticized knowledge, also seem to require episodic-like contextual traits to support a more specific item-name associations. Therefore, the interaction between episodic and semantic systems is likely to support specific semantic representations. We also claimed that aging groups differ from younger adults in their semantic memory patterns, potentially influencing their capabilities to overcome episodic memory difficulties. Notably, the presented arguments also suggest that episodic and semantic memories, as engaged according to the type of information, could be functionally and structurally interchangeable when the interplay between memory systems is essential to the success of the task.

iv. Considering the well-known dissociation between alpha and theta power activity as reflecting different declarative memory engagements, we argued that picture-naming retrieval would be supported differently according to the type of content to be retrieved, showing a different oscillation dynamic across categories of objects, people and places according to their contextual requirements.

Based on these theoretical arguments and some supporting evidence, the current work combines behavioral and neural approaches to examine the episodic and semantic memory system concurrence and interaction during the encoding and retrieval of conceptual knowledge. Specifically, we examined the involvement of the episodic system in (influencing or being influenced) conceptual knowledge during encoding and retrieving of declarative memories. To explore these research avenues, the interdependence between episodic and semantic memory systems was systematically examined in two main tasks at behavioral and neural levels.

We first conducted a systematic review to identify relevant variables in processing common objects and also two normative studies, one for common objects images and the other for people and places images. These studies enabled us to select the stimulus materials for our experimental tasks and control for relevant variables, namely cultural and age-specific.

To test the assumption of the interdependence between episodic and semantic memories, in a more episodic memory task, we first examined how the availability of the different type-levels of categorical knowledge during encoding may influence subsequent episodic recognition and their related operations of recollection and familiarity. Therefore, we used the classic Remember-Know paradigm manipulated by encoding type (i.e., categorical x perceptive) and item-typicality (i.e., high-typical x low-typical) in a study conducted with young adults. The assumption that episodic impairments could influence the use of those semantic content during encoding was tested with the same design in two additional studies: a developmental (old vs. young) and a clinical (ASD vs. healthy controls). Overall, it was hypothesized, for healthy participants, that both the availability of categorical schemas and highly typical items would improve familiarity processes by-passing structures involved in processing novelty information (Dudai et al., 2015). In contrast, perceptual and low-typical items, requiring specific mechanisms for processing novelty-based incongruent information, would improve recollection-based memories (Bonasia et al., 2018; Dudai et al., 2015). Moreover, low-typicality (HP-cortical network) would influence episodic-like and semantic-like memories differently by encoding types. Finally, from a neuropsychological and developmental perspective, the atypical pattern of declarative memories documented in individuals with autism spectrum disorders and healthy aging people is taken into perspective to further explore the declarative memories functioning and their interdependence. Therefore, lower performance in recollective-based memories was expected with aging and for ASD, particularly for low-typical items. However, healthy aging people were expected to present some advantage of semantic knowledge in surpassing episodic system-based difficulties.

In the second stage and supported by neurocognitive evidence of a dissociation between proper and common names, we examined the influence of contextual richness across the semantic categories of objects, people, and places during retrieval in a semantic task. Furthermore, our assumption was that declarative memory systems support differently the retrieval of semantic labels according to the uniqueness of the association between the item and its label (contextual-based). To test this assumption, we conducted two studies using a naming retrieval task exploring the dissociation between common objects (general semantic knowledge; cortically supported) and proper names of people (individual semantic knowledge; hippocampus-cortical network) and places (topographical-based semantic knowledge; higher hippocampus recruitment). Comparing young vs. older adults, we expected decreased retrieval of proper names in the latter (see also Martins & Farrajota, 2007; Semenza et al., 2003), particularly for places likely due to the high hippocampus requirements involved in their processing. Finally, the neural correlates of such dissociation were inspected by EEG recordings in young adults. It was hypothesized that the involvement of the episodic system would increase as the degree of contextual information increases (common < people < place), reflected in a highest increase of theta activity for places (more contextual).

The cumulative examination of the differences between semantic and episodic memory at the task, population, and neural levels may favor a robust understanding of their interaction.

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PART II | COLLECTION OF ARTICLES

CHAPTER 3.

Conceptual knowledge organization and assessment: Categories and their properties

Prior conceptual knowledge, a widely examined variable in the study of memories, allows us to observe the features of conceptual learning and how people use knowledge to support new experiences. Categories constitute a class of prior knowledge that is socially shared and are common in memory studies as they entail easy-to-find items in everyday life (e.g., Beck et al., 2021; Carmo et al., 2016; De Brigard et al., 2017; Sakamoto & Love, 2004; Santi et al., 2016). For example, common objects of different categories are widely applied in several areas of research and intervention. However, to select categories and items that are suitable for experimental manipulation, it is critical to consider several factors, such as commonalities and differences between items, variants due to the cultural context, essential variables that affect their processing, and correlated confounding variables.

The first study in this chapter, “A systematic review of normative studies using images of common objects”, took on the challenge of exploring the characteristics of categories and their items, as well as the factors that influence their processing. In this systematic review, we examined and summarized published normative studies on images of common objects regarding stimuli characteristics, variables of interest, and standardization procedures. Subsequently, in the normative study “RealPic: Picture norms of real-world common items”, 596 real-world pictures of common objects distributed into 12 categories were normed in the Portuguese context on nine dimensions of interest previously identified as relevant according to the stimuli requirements. Correlations between dimensions are provided, particularly controlling for category influence. Additionally, linguistic and domain effects are inspected across our database and others previously normed with other samples. These stimuli were then used in the subsequent empirical studies.

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3.1. A Systematic review of normative studies using images of common objects

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Abstract

Common objects comprise living and non-living things people interact with in their daily-lives. Images depicting common objects are extensively used in different fields of research and intervention, such as linguistics, psychology and education. Nevertheless, their adequate use requires the consideration of several factors (e.g., item-differences, cultural-context and confounding correlated variables), and careful validation procedures. The current study presents a systematic review of the available published norms for images of common objects. A systematic search using PRISMA guidelines indicated that despite their extensive use, the production of norms for such stimuli with adult populations is quite limited (N=55), particularly for more ecological images such as photos (N=14). Among the several dimensions in which the items were assessed, the most commonly referred in our sample were familiarity, visual complexity and name agreement, illustrating some consistency across the reported dimensions while also indicating the limited examination of other potentially relevant dimensions for image processing. The lack of normative studies simultaneously examining affective, perceptive and semantic dimensions was also documented. The number of such normative studies has been increasing in the last years and published in relevant peer-reviewed journals. Moreover, their datasets and norms have been complying with current open science practices. Nevertheless, they are still scarcely cited and replicated in different linguistic and cultural contexts. The current study brings important theoretical contributions by characterizing images of common objects stimuli and their culturally-based norms while highlighting several important features that are likely to be relevant for future stimuli selection and evaluative procedures. The systematic scrutiny of these normative studies is likely to stimulate the production of new, robust and contextually-relevant normative datasets and to provide tools for enhancing the quality of future research and intervention.

Keywords: norms, images of common objects, semantic, perceptive, affective.

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Introduction

Objects constitute a distinctive type of stimuli that entail specific visual processing as compared, for example, to faces or words (e.g., Farah, 1992; 2004; Tanaka & Taylor, 2001). Images of objects are frequently used in research and interventional practices, particularly those objects that are commonly encountered in everyday-life (e.g., Brady et al., 2008; Farah, 1992; Kouststaal, et al., 2003; Palmer, 1975; Reber et al, 2004; Souza et al., 2016; Treisman, 1986). Common objects comprise concrete and depictable items from living things (e.g., a "cat" for "Mammals") and non-living things (e.g., a "car" for "Vehicles") (see Borghi et al., 2017; Capitani et al., 2003). They differ from other types of objects (e.g., novel, artificial or abstract, see Kouststaal, et al., 2003 for an example) especially regarding the type of conceptual knowledge associated to them. According to objects categorization frameworks, common objects are linked to categories from distinct levels of abstraction, from high (e.g., "Vehicles") to low (e.g., "City bus") with basic categories (e.g., "car") being the most inclusive ones (since their members share more conceptual, motor and/or perceptual attributes/characteristics) and often presenting an advantage in learning, classification and retrieval (Rosch et al., 1976; Tanaka & Taylor, 2001). Thus, because they are meaningful, common objects involve associated general knowledge that is recurrently present in our daily-life experiences (i.e., learning, talking, cooking, identifying/finding objects, etc.), and that is highly relevant when trying to understand and interact with the world. These particular characteristics of common objects make them extremely useful for affective and neurocognitive tasks that require participants to recognize items and to make categorical decisions about them (e.g., Konkle et al., 2010; VanRullen and Thorpe, 2001).

However, images of objects may vary in several dimensions such as surface details, the categories and even the cultural background of the perceivers. In addition to their associated semantic knowledge, the mental representation of such visual items can include several item-attributes, namely perceptual features (contrast, color, multi-D shape, reflectance, luminance, moving, and orientation), contextual occurrence and also the emotions they elicit (see Brady et al., 2008; Palmer, 1975; Reber et al, 2004; Treisman, 1986). For instance, different exemplars of the same object (e.g., different types of cats or different exemplars of cars) have distinct perceptual characteristics (e.g., different colors, luminance, viewpoint or distinct shapes). For example, a specific exemplar of a given category may be more frequent in one culture than in other (e.g., Peterbald cats are more frequent in Russia and a Tuk-Tuk vehicle is common in India but not in England or Brazil) or may be differently processed according to the categorization context (i.e., a boot may be considered as clothes or as work equipment depending on their function). Therefore, their visual representation combines surface features with our predictive capabilities (expectancy) derived from our previous experience (that are both meaningful and emotional). In fact, a recent Bayesian meta-analytic study about picture-name norms of line-drawings of objects indicated that several subjective dimensions, namely image agreement, name agreement, familiarity, imageability and age-of-acquisition, constitute strong predictors of picture-naming abilities that may influence pre or pos lexical processing (Perret and Bonin, 2019). Moreover, differences regarding the cultural background and linguistic variations also provided intriguing outputs (Boukadi et al., 2016; Dell´Acqua et al., 2000; Duñabeitia et al., 2018). These findings converge in suggesting that the same image of an object can be processed differently depending upon many aspects.

The widespread use of images of common objects in research and intervention must acknowledge the high variability of these items and their related properties, which require careful selection procedures and control for the possible influence of several dimensions potentially co-occurring during the manipulations of interest. This can only be ensured through careful standardization procedures. Normative studies have become increasingly more sophisticated and innovative, integrating theoretical and methodological knowledge from several other areas such as Psychometrics, Computer Sciences, Neuroscience, Psycholinguistics or Visual processing. However, review studies may also constitute valuable guidelines in selecting relevant datasets, clarifying standardization methodologies and identifying factors to be controlled (Perret and Bonin, 2019). In the current review, we critically summarize the main features of normative studies using images of common objects, with particular emphasis on the stimuli dataset characteristics and standardization procedures.

Why is it important to normalize images of common objects?

Images of common objects are frequently used as stimulus materials because such items are easily and generally accessed and understandable. Furthermore, there are specific research and intervention areas such as linguistics, developmental neuropsychology and cognitive neuroscience, in which such images are particularly useful and required. For example, images of common objects are extensively used in the examination of naming abilities and in memory research (e.g., Kavé et a., 2018; Semenza, 2009), in the examination of neurocognitive performance related to categorical processing (e.g., Martin et al., 1996), in visual perception studies with well-known items (e.g., Brady et al, 2009) and also in emotional processing research (e.g., Kensinger and Schacter, 2006).

However, the use of visual stimuli in research requires the careful examination of their image properties and how they can impact several mental functions (see Snodgrass and Vanderwart, 1980). Image attributes (color patterns, valence, familiarity, etc.) are known to influence performance in several cognitive tasks (Holmes and Ellis, 2006; Mendonça et al., 2020; Taylor et al., 1998; Ullman et al., 2002). For example, several studies have shown the facilitating effect of perceptual details (color, shape, brightness, visual complexity) in object naming, categorization and recognition (see Price and Humphreys, 1989; Ullman et al., 2002, for more details). Likewise, affective dimensions such as arousal and valence were shown to modulate cognitive processes such as memory and semantic judgment (Kensinger, 2007; Kensinger and Schacter, 2006). The influence of semantic variables on the processing of these items was also evidenced by the effects of different categories and their distinct domains (Moss and Tyler, 1997; Warrington and Shalice, 1984) as well as by the influence of typicality in object processing (Holmes and Ellis, 2006). It has also been shown that different types of stimuli require their normalization in different dimensions (see Garrido et al., 2016; Prada et al., 2010; Prada et al., 2017) that may enhance their applicability. For example, meaningfulness is important for symbols' processing but not so much for facial stimuli. Likewise, distinctiveness might be more relevant for processing uncommon-discriminative items such as unlikely events, landmarks, or people's faces in comparison with images of common objects.

The standardization of images of common objects assumes particular relevance since they are usual, frequent and expected in everyday life and recurrently used in scientific studies. This was long acknowledged in the classic work by Snodgrass and Vanderwart (1980) that constitutes a landmark in the production and normalization of visual databases of common objects for research purposes. The authors argued that visual material (alike verbal items) should also be standardized to avoid potential biases in research. Based on a sample of 219 English-speaking graduate students, they provided norms for 260 black-and-white line-drawing illustrations of common objects regarding naming and familiarity for the semantic domain as well as visual complexity and image agreement for the perceptive domain. The relevance of their findings rests on the identification of subjective independent attributes of images that potentially influence several cognitive tasks – like free-recall, go-no go and emotional processing tasks – and constituted an important step towards a proper validation of visual stimuli. Moreover, Snodgrass and Vanderwart's work (1980) was critical for emphasizing the importance of conducting normative studies with images.

The work of Snodgrass and Vanderwart (1980) has been subsequently extended, across different age samples (Berman et al., 1989; Yoon et al., 2004), distinct cultures (Alario and Ferrand, 1999; Boukadi et al., 2016; George and Mathuranath, 2007; Manoiloff et al., 210; Nishimoto et al., 2005; Pind et al., 2000; Pompéia et al., 2001), with increased variety of visual stimuli (Cycowicz et al., 1997; Morrison et al., 1997) and with refined parameters (e.g., surface details and texturized or colorized stimuli in Rossion and Pourtois, 2004). The repeated and consistent application of the Snodgrass and Vanderwart (1980) database has turned it into a well-established image dataset that constitutes a main reference in the field, as well as an important resource for researchers and other professionals. However, aside from these pictographic studies, other databases of images of common objects seem to have been poorly widespread despite of their great scientific relevance.

Why is it relevant to summarize the development of standardization practices?

The selection of stimuli constitutes an important step during the planning of experimental studies (see Brodeur et al., 2014; Snodgrass and Vanderwart, 1980). Moreover, the use of previously standardized stimulus should permit the comparison between different studies and allow the reproduction of the materials and methods across research teams, as requested for replicability purposes (Wilcox and Claus, 2017). In contrast, an inconsistent use of the stimuli across studies in a given research field along with the lack of careful stimuli standardization procedures makes any comparison between outputs unfeasible or, at best, little informative. Recently, researchers have been increasingly concerned about the quality of the visual stimuli used in their studies and the knowledge of their properties (with more than 200 normative studies published between 1996 to 2016). As highlighted by Brodeur et al. (2014), normative studies have been crucial to increase the adjustment of the stimuli to the research purposes, allowing a more precise characterization of the stimuli, the control of confounding effects as well as a better manipulation of the variables of interest. In addition, the establishment of norms also provides important insights about the items processing and their cultural appropriateness (Brodeur et al., 2012; Prada et al., 2016).

Nevertheless, the careful standardization procedures required for using such images are not always conducted, once they imply time, knowledge and resources. Standardization involves stimuli construction and selection, as well as extensive data collection and analysis. Additionally, it may also require expertise in specific metrics (e.g., computational models for surface features, h-index of naming, mediation models, item characteristics curves, etc.) as well as cross-country evaluations that consider the influence of language variations and cultural specificities. Moreover, the norms already produced are not always available, and even when they are, the stimuli selection must often be adapted to the researchers' goals and to the specific cultural contexts. However, the current demands of scientific practice and the pressure for publication often conflict with the time-consuming steps prior to experimental studies. As a consequence, the control for stimuli diversity and related confounding factors established in previous normative procedures are often misinterpreted as an obstacle instead of a step towards increasing quality in research.

In sum, the process of producing and selecting stimuli constitutes an important but also complex and costly task. Therefore, a systematic review of the standardization studies of interest might be highly relevant in assisting this first and essential phase of planning the research in order to identify, access and select adequate stimuli and potentially relevant dimensions. Given its particularities and its widespread use, it is crucial to systematically examine the available normative studies using image datasets of common objects to uncover their specificities, their standardization practices as well as the potential gaps in those studies. Finally, the systematic information about which normative studies have been produced for common objects constitutes a valuable resource for electing adequate procedures and databases as well as acknowledge common objects as a relevant general category.

The current study

The systematized knowledge from these normative studies, constitutes an important resource regarding the stimuli characteristics but also a valuable asset to identify well-established practices.

A systematic review of the literature was conducted using the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses; see Liberati et al., 2009, for details about this methodological procedure) on standardized norms for images of common objects obtained with adult populations in order to establish the current state of the art in research on normative studies using images of common objects (see PICOS format in our online protocol at https://protocols.io/view/a-systematic-review-of-normative-studies-using-ima-bbysipwe [doi: dx.doi.org/10.17504/protocols.io.bbysipwe]).

Specifically, the present systematic review aimed to:

1) Identify and characterize the published normative studies of images of common objects with adults, in order to assist the selection and further production of such stimuli and new databases [How many normalized datasets are available in peer-reviewed literature? What are their sources (i.e., journals, journals h-index, temporal distribution)? What are their general characteristics (sample characteristics, type of stimuli, stimuli production procedures, linguistic and cultural-based examinations)? Are these studies using different categories of common objects? If so, are they addressing the effects of category and domain?]

2) Determine and critically examine the most reported evaluative dimensions and their parameters in common objects normative studies, to uncover the most relevant properties to examine in normalizing images of common objects [Which are the main dimensions reported, their scales and task instructions? Is there consistency in the evaluated dimensions and their parameters?]

3) Critically appraise the reliability of the norms produced, without losing their cultural specificity, by inspecting the coherence of ratings and their correlations reported across normative studies of imagens of common objects [How are images of common objects rated across studies? How are the main evaluative dimensions correlated across studies?]

4) Uncover the application potential of each elected normative study by an exploration of the availability of the databases (i.e., whether the dataset and their norms are publicly available) and their impact (i.e., citation score) as potentially relevant indicators for selecting, producing or replicating normative studies [How accessible and widespread these databases are (availability and impact)?].

Method

Protocol, search strategy and eligibility criteria

The systematic review conducted followed the PRISMA guidelines (Liberati et al., 2009). Further details on previously defined methodological guidelines are available in our protocol page (https://protocols.io/view/a-systematic-review-of-normative-studies-using-ima-bbysipwe [doi: dx.doi.org/ 10.17504/protocols.io.bbysipwe]). The PRISMA checklist is included as Supplemental Material, S1.

The search strategy included a first stage of systematic electronic search in online sources to identify the relevant normative studies published in English in academic peer-reviewed journals. Four databases were explored in the EBSCOhost platform to find potentially relevant studies: Academic Search Complete (1976-2019), PsycINFO (1948-2019), Psychology and Behavioral Science (1950-2019), and PsycARTICLES (1948-2019). The search terms entered in a Boolean phrase search mode using all possible combinations were the following: a) validation OR norms; AND b) pictures OR images; AND c) typicality OR familiarity OR name-agreement OR valence OR arousal OR aesthetic OR "visual complexity" OR categories; d) NOT social OR body parts OR face OR emotion* OR *MRI OR neuroimaging. The search terms used in c) were based on dimensions commonly reported in the literature. The d) search entries were included to filter an extensive list of articles that refer to the words "image", "picture" and "norms". The search was conducted without year restrictions or entry boundaries (title, subjects/keywords or abstract). An additional search was conducted on Scopus and on Web of Science databases with the same Boolean criteria and without year parameter, defining as search criteria: type of document "article" and "English" language. On Scopus, the search was conducted in title, abstract and keywords. On WoS, the search was limited to the title. The analysis of overlapping articles and the management of the selected articles was made using EndNote X8 software. A complementary hand search phase was also conducted based on known authors/papers including pertinent normative studies using images of common objects not captured by the automatic search. The search procedures and the collection of the articles were completed by June, 2019.

The inclusion criteria for electing potential studies involved three cumulative conditions: (1) the inclusion of healthy adult participants (minimum of 18 years-old); (2) the standardization of images of common objects into categories of the living and/or non-living domains (not social or emotional representations, not action scenes, not objects in context, not human images); (3) at least one the following dimensions as independent variable: semantic dimensions (i.e., name-agreement, category-agreement, familiarity, typicality), affective dimensions (i.e., aesthetic appeal, arousal, valence) and perceptive dimensions (i.e., visual complexity, picture-name agreement)[1]. On EBSCOhost platform, the age restriction (>=18 years old) was introduced during the online search. The inclusion criteria (image type and dimensions) were also confirmed during a subsequent inspection of the data by the title and the abstract to select the relevant studies.

Selection of studies, risk of bias and data treatment

The second stage of the search (see PRISMA guidelines) involved the screening of the data by title, abstract and full text, by three independent judges using the Rayyan QCRI (Qatar Computing Research Institute, Hamad Bin Khalifa University) web application. The selection by title and abstract intended to control for subjective bias in the selection of the articles as well as to efficiently filter the relevant articles, confirming the inclusion criteria. With this procedure, articles from the previously comprehensive search that did not include image validation studies (e.g., validation of instruments, self-image studies) or studies that were not pertinent to the current review (e.g., images of emotional expressions of disgust or fear, parts of the body, objects in a scenery, pairs of objects) were excluded. Subsequently, the full-text examination ensured the eligibility of the selected studies to be retained based on all inclusion criteria. Disagreements on retaining or excluding on each screening phase were discussed until a consensus was reached.

To our knowledge there is no specific standardized tool available for quality assessment in

[1] These dimensions were chosen based on a multifactorial perspective of visual processing, in which visuo-perceptive, affective and semantic components contribute to perception and visual recognition of everyday items (see Brady et al., 2008; Kensinger and Schacter, 2006; Konkle et al., 2010). Moreover, they constitute recurrent assessed variables from affective, semantic and perceptive domains.

normative studies. In the present research the Cochrane Collaboration Risk of Bias tool (Higgins and Altman, 2008) was used as a consistent parameter in quality assessment. Our goal was to provide a broad and comprehensive analysis of the methodological procedures. However, excluding articles by methodological reasons could constitute a bias. Therefore, the quality assessment is provided in a qualitative manner and is merely informative instead of a requisite for maintaining an article in the sample (see Supplemental Material, S3).

Data extraction was performed using a qualitative systematization of the relevant information for answering the previously defined research questions. Two coders extracted and systematized information from each study included to complete a previously established resume-table. When appropriate, complementary variables were included to guarantee the specificity of the information (e.g., for the type of categories, the "category name" as well as the "semantic level type" were extracted). The extracted information included: a) bibliometric information and indicators (journals, journals h-index, temporal distribution); b) general characteristics and standardization practices of images of common objects (sample characteristics, language and cultural variations, procedures, stimulus characteristics); c) dimensions reported in the standardization of images of common objects (main dimensions reported, scales and task instructions, and their consistency across studies); d) assessment of images of common objects (mean ratings and correlational results, reliability of the datasets); e) accessibility and application potential of the normative databases (availability and citation impact).

For the general characteristics of the studies, sample characteristics comprised N of participants, mean age, age range, schooling, schooling range; language and cultural variations included language/cultural context and cross-cultural comparisons; procedures entailed data collection procedure; and stimulus characteristics discriminated if it was S&V stimuli replication/adaptation/extension, the stimuli description, stimuli type, image resolution, number of stimuli, number of stimuli/participant, categories of the items –number and types. Moreover, the cross-cultural comparisons described the presence of comparisons, the type of comparison (if between or within studies), the sample source (if they compared the same database or not) and the statistical methods used for cross-cultural analysis (i.e., correlations, multiple regression, t-test, ANOVA). In (c), a qualitative appraisal of item norms was provided by examining the dimensions reported (evaluated dimensions; instructions and scales). Main findings for the most reported dimensions were also included in (d), namely assessment of images (mean ratings by study; correlational results by study – r and p-values) of all studies reporting overall results for imagens of common objects. Correlational results for each dimension between studies were also considered for the main dimensions. Finally, information about the impact (i.e., number of citations) and availability (i.e., whether the database and their norms are freely available) of the database was also collected (e). Such indicators are predictors of the scientific impact of the articles in their respective areas (i.e., applicability) and also reflect their potential for replication. The overall findings were summarized in qualitative (i.e., descriptive) and quantitative (i.e., frequencies and percentages) tables and figures.

Retrieval of the studies and literature selection

The first stage of the systematic electronic search produced a combined result of 648 articles: 558 from the EBSCOhost database (334 from Academic Search Complete, 187 from PsycINFO, 25 from Psychology and Behavioral Sciences Collection and 12 from PsycARTICLES), 69 from Scopus and 21 from WoS. Four additional relevant studies were inserted on the data (i.e., Brodeur et al., 2014; Prada et al., 2010; Prada et al., 2014; Prada and Ricot, 2010) during the hand search phase. Despite not meeting all the inclusion criteria (some were not written in English) or not being retrieved in the systematic search (i.e., Brodeur et al., 2014), the inclusion of these articles was justified by their reporting of affective dimensions that were not explored in the elected papers (i.e., valence and arousal examined in Prada et al., 2010; Prada and Ricot, 2010) or because of the high number of images of common objects included (Brodeur et al., 2014). After removing duplicates, the number of articles to be screened was reduced to 494 (see PRISMA flow diagram in Figure 1).

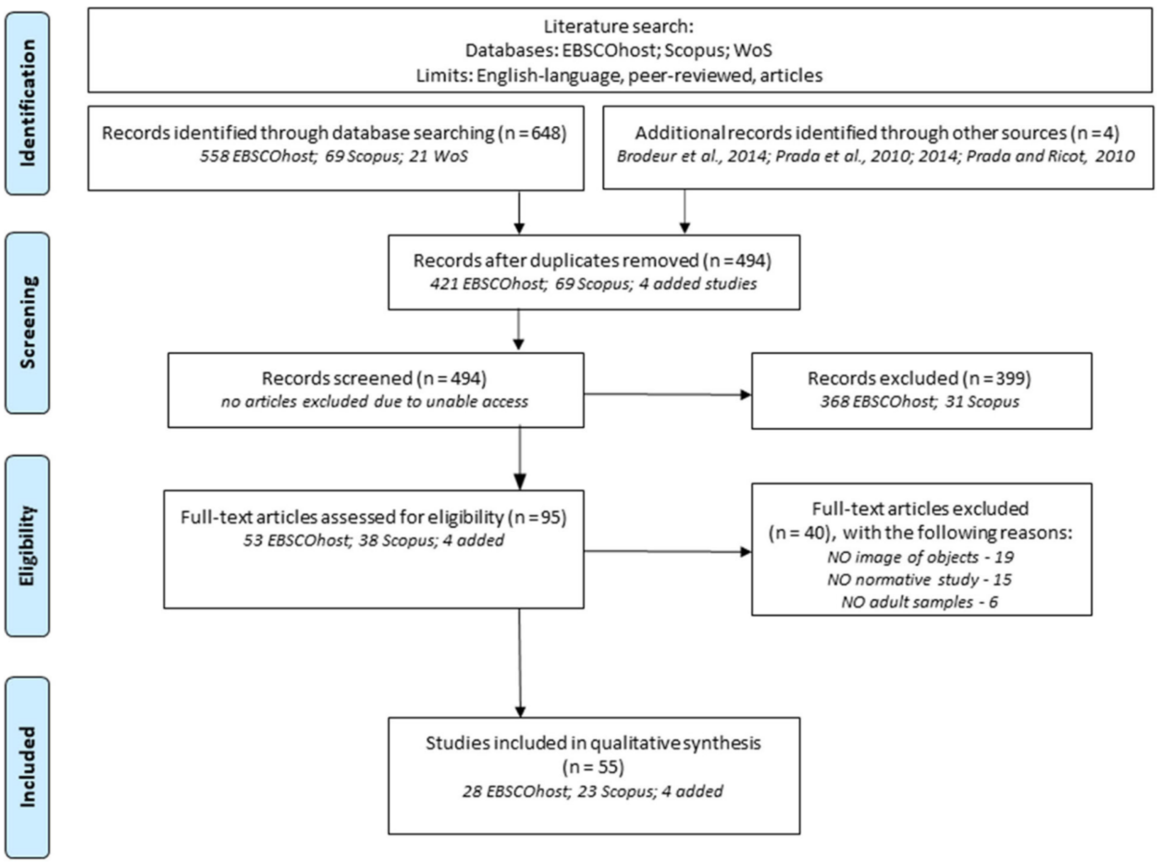

Figure 1. Flow diagram of studies' selection process, using the PRISMA method (adapted from Liberati et al., 2009).

The results from screening by title and abstract lead to the retention of 95 (53 from EBSCOhost, 38 from Scopus and 4 hand-search) and the elimination of 368 articles from EBSCOhost and 31 from

Scopus. Finally, a full-text analysis of the 95 articles, lead to the exclusion of 40 (see Supplemental Material, S2, for excluded articles list) and narrowed the sample to 55 full-text elected articles (28 from EBSCOhost, 23 from Scopus and 4 from the hand-search) for a qualitative synthesis. The exclusion of articles was motivated by the following reasons: different stimuli type (faces, body parts, neural image, sounds, words, action pictures, food images, etc.); not normative study (e.g., literature review or correlational studies); incongruent theme (e.g., neural network, pelvis fracture images); samples (e.g., children or clinical).

Results

The qualitative appraisal of the retained studies focused on the identification and categorization of their characteristics that were relevant to our aims. Overall, the final sample included a reasonable number of papers (n= 55) presenting norms for images of common objects grouped in two distinct types of visual representations: line-drawings (*n*=39, 70.9%), photographs (*n*=14, 25.5%) or both (*n*= 2, 3.6%). The analysis of the publications examining the different stimuli type (i.e., line-drawings, photos or both) across the years (i.e., older articles – up to 2009 vs. recent articles – from 2010-2019) revealed an earlier trend for publishing datasets using drawings (line-drawings: 95.8%; photos: 4.2%) and an increased interest in ecological stimuli or its comparison with drawings in recent years (line-drawings: 51.6%; photos: 41.9%; both: 6.5%). The following subsections present the systematization of the information available in the studies sample considering the previously reported categories of data treatment. For each of these categories, the results of normative studies using photographs are emphasized because of their relevance in introducing ecological validity and the documented increased interest in this type of stimuli. A descriptive summary of the results is presented in Table 1. A qualitative summary of the main reported dimensions (with their instructions, scales and instruction focus) is also provided in Table 2. Supplementary tables with all the data extracted and the distribution of quantitative norms results (i.e., item norms by dimension) for each relevant dimension and their correlations in each study is also provided in S3 and S4, respectively.

Table 1. Summary table of the main characteristics of the studies sample by Stimuli Type (absolute frequencies and percentage).

	Overall		**Stimuli Type**					
	(n = 55)		**Line-drawing (*n* = 39)**		**Photographs (*n* = 14)**		**Both (*n* = 2)**	
	N	*%*	*N*	*%*	*N*	*%*	*N*	*%*
Age								
Young adults	30	54.5	21	53.8	8	57.1	1	50.0
Mid-age Adults	10	18.2	6	15.4	4	28.6	0	0.0
Older adults	1	1.8	1	2.6	0	0.0	0	0.0
Multiage	14	25.5	11	28.2	2	14.3	1	50.0

Schooling level								
High school	1	1.8	1	2.6	0	0.0	0	0.0
Undergraduate	36	65.5	27	69.2	7	50.0	2	100.0
Graduate/Postgraduate	1	1.8	1	2.6	0	0.0	0	0.0
Undergraduate and Graduate	5	9.1	4	10.3	1	7.1	0	0.0
n.d.	12	21.8	6	15.4	6	42.9	0	0.0
Language								
English	14	25.5	9	23.1	3	21.4	2	100.0
French	6	10.9	5	12.8	1	7.1	0	0.0
Spanish	6	10.9	3	7.7	3	21.4	0	0.0
Portuguese	4	7.3	1	2.6	3	21.4	0	0.0
Italian	3	5.5	2	5.1	1	7.1	0	0.0
Turkish	2	3.6	2	5.1	0	0.0	0	0.0
Russian	2	3.6	2	5.1	0	0.0	0	0.0
Arabic	2	3.6	2	5.1	0	0.0	0	0.0
Chinese	2	3.6	1	2.6	1	7.1	0	0.0
Japanese	2	3.6	2	5.1	0	0.0	0	0.0
Dutch	2	3.6	1	2.6	1	7.1	0	0.0
Thai	1	1.8	0	0.0	1	7.1	0	0.0
Greek	1	1.8	1	2.6	0	0.0	0	0.0
Indian	1	1.8	1	2.6	0	0.0	0	0.0
Persian	1	1.8	1	2.6	0	0.0	0	0.0
Icelandic	1	1.8	1	2.6	0	0.0	0	0.0
Cross-linguistic	5	9.1	5	12.8	0	0.0	0	0.0
Data collection environment								
Experimental	25	45.5	15	38.5	10	71.4	0	0.0
Survey	18	32.7	13	33.3	4	28.6	1	50.0
Both	10	18.2	9	23.1	0	0.0	1	50.0
n.d.	2	3.6	2	5.1	0	0.0	0	0.0
Online resources								
Yes	2	3.6	1	2.6	0	0.0	1	50.0
No	51	92.7	36	92.3	14	100.0	1	50.0
n.d.	2	3.6	2	5.1	0	0.0	0	0.0
S&V (original. adaptation or extension)								
Yes	31	56.4	29	74.4	0	0.0	2	100.0
No	24	43.6	10	25.6	14	100.0	0	0.0
Stimuli color								
Color	16	29.1	5	12.8	11	78.6	0	0.0
Black and white	35	63.6	32	82.1	3	21.4	0	0.0
Both	4	7.3	2	5.1	0	0.0	2	100.0
Stimuli size/Resolution								
Medium (Up to 500px)	15	27.3	9	23.1	4	28.6	2	100.0
High (from 501px)	15	27.3	8	20.5	7	50.0	0	0.0
n.d.	25	45.5	22	56.4	3	21.4	0	0.0
N of stimuli								
Up to 50	1	1.8	0	0.0	1	7.1	0	0.0
51-100	5	9.1	4	10.3	1	7.1	0	0.0
101-200	5	9.1	3	7.7	2	14.3	0	0.0
200+	44	80.0	32	82.1	10	71.4	2	100.0

N stimuli/participant								
Up to 50	4	7.3	2	5.1	2	14.3	0	0.0
51-100	5	9.1	4	10.3	1	7.1	0	0.0
101-200	9	16.4	4	10.3	5	35.7	0	0.0
200+	33	60.0	26	66.7	6	42.9	1	50.0
n.d.	4	7.3	3	7.7	0	0.0	1	50.0
N category								
1-5	8	14.5	6	15.4	2	14.3	0	0.0
6-10	4	7.3	2	5.1	2	14.3	0	0.0
11-15	27	49.1	22	56.4	4	28.6	1	50.0
16+	7	12.7	1	2.6	5	35.7	1	50.0
n.d.	9	16.4	8	20.5	1	7.1	0	0.0
Category-level								
Basic level	10	18.2	4	10.3	6	42.9	0	0.0
Domain and basic level	2	3.6	2	5.1	0	0.0	0	0.0
Superordinate level	24	43.6	19	48.7	3	21.4	2	100.0
Basic and superordinate level	9	16.4	7	17.9	2	14.3	0	0.0
Domain. basic and superordinate level	1	1.8	0	0.0	1	7.1	0	0.0
n.d.	9	16.4	7	17.9	2	14.3	0	0.0
Cross-cultural comparison								
Yes	34	61.8	27	69.2	6	42.9	1	50.0
No	21	38.2	12	30.8	8	57.1	1	50.0
Dataset comparison of cross-cultural comparison								
Direct	26	47.3	21	53.8	5	35.7	0	0.0
Indirect	4	7.3	3	7.7	0	0.0	1	50.0
Both	4	7.3	3	7.7	1	7.1	0	0.0
Absent	21	38.2	12	30.8	8	57.1	1	50.0
Samples source of cross-cultural comparison	(*n* = 34)		(*n* = 27)		(*n* = 6)		(*n* = 1)	
Between studies	29	85.3	22	81.5	6	100.0	1	100.0
Within studies	4	11.8	4	14.8	0	0.0	0	0.0
Both	1	2.9	1	3.7	0	0.0	0	0.0
Statistical method for cross-cultural analysis	(*n* = 34)		(*n* = 27)		(*n* = 6)		(*n* = 1)	
Correlations	24	70.6	19	70.4	5	83.3	0	0.0
Correlations and Multiple Regressions	3	8.8	3	11.1	0	0.0	0	0.0
ANOVAS/T-tests	4	11.8	3	11.1	0	0.0	1	100.0
ANOVAS/T-tests and Correlations/Regressions	3	8.8	2	7.4	1	16.7	0	0.0
Journal								
Behavior Research Methods	27	49.1	24	61.5	2	14.3	1	50.0
PLoS ONE	4	7.3	0	0.0	3	21.4	1	50.0
Laboratório de Psicologia	3	5.5	0	0.0	3	21.4	0	0.0
Journal of Psycholinguistic Research	2	3.6	1	2.6	1	7.1	0	0.0
Journal of Clinical and Experimental Neuropsychology	2	3.6	1	2.6	1	7.1	0	0.0
Frontiers in Psychology	2	3.6	0	0.0	2	14.3	0	0.0
Quarterly Journal of Experimental Psychology	1	1.8	1	2.6	0	0.0	0	0.0

Quarterly Journal of Experimental Psychology Section A: Human Experimental Psychology	1	1.8	1	2.6	0	0.0	0	0.0
Applied Neuropsychology	1	1.8	1	2.6	0	0.0	0	0.0
Frontiers in Human Neuroscience	1	1.8	0	0.0	1	7.1	0	0.0
Annals of Indian Academy of Neurology	1	1.8	1	2.6	0	0.0	0	0.0
Brain and Cognition	1	1.8	1	2.6	0	0.0	0	0.0
Neurological Sciences	1	1.8	1	2.6	0	0.0	0	0.0
Aging. Neuropsychology. and Cognition	1	1.8	0	0.0	1	7.1	0	0.0
Journal of Experimental Child Psychology	1	1.8	1	2.6	0	0.0	0	0.0
Scandinavian Journal of Psychology	1	1.8	1	2.6	0	0.0	0	0.0
Arquivos de Neuro-Psiquiatria	1	1.8	1	2.6	0	0.0	0	0.0
Perception	1	1.8	1	2.6	0	0.0	0	0.0
Acta Psychologica	1	1.8	1	2.6	0	0.0	0	0.0
Journal of Experimental Psychology: Human Learning and Memory	1	1.8	1	2.6	0	0.0	0	0.0
Journal of Memory and Language	1	1.8	1	2.6	0	0.0	0	0.0
Citations Google Scholar								
Up to 50	32	58.2	20	51.3	10	71.4	2	100.0
51-100	9	16.4	6	15.4	3	21.4	0	0.0
101+	14	25.5	13	33.3	1	7.1	0	0.0
Citations Scopus								
Up to 50	38	69.1	25	64.1	11	78.6	2	100.0
51-100	6	10.9	4	10.3	2	14.3	0	0.0
101+	11	20.0	10	25.6	1	7.1	0	0.0
Citations WoS								
Up to 50	40	72.7	25	64.1	13	92.9	2	100.0
51-100	4	7.3	4	10.3	0	0.0	0	0.0
101+	11	20.0	10	25.6	1	7.1	0	0.0
Paper availability								
Available online	54	98.2	38	97.4	14	100.0	2	100.0
Conditionally available online	1	1.8	1	2.6	0	0.0	0	0.0
Dataset availability								
Freely available	42	76.4	30	76.9	10	71.4	2	100.0
Conditionally available	4	7.3	3	7.7	1	7.1	0	0.0
Not available	9	16.4	6	15.4	3	21.4	0	0.0

Table 2. Generic definitions of relevant dimensions, examples of instructions and their scales

Dimension	Short Definition	Instruction example	Scale
Aesthetic appeal	The pleasantness of the image	Participants are asked to consider how visually appealing the image is in regard to its visual characteristics.	1-visually unpleasant/unappealing to 7- visually pleasant/appealing
Age-of-acquisition	The estimated age of learning a given concept/name	Participants are invited to estimate the age they thought they learned each of the concept names in its written or oral form.	age ranges from 0 to 12 years old (with different intervals)
Arousal	The activation capacity of the object	Participants have to indicate to which extent an object represents something active/intense or passive/calm.	1-very passive/calm to 7- very active/intense

Category agreement	The most appropriate category	Participants have to indicate the object category (e.g., to identify a "car" as part of the category "vehicles"). If they are unable to identify a category, they have to indicate that they don´t know or they know but do not remember the name at the moment.	% or H-value (written/typed/oral form; in some cases, can be done as forced choice).
Familiarity	The frequency of the object in the participant's personal life, that reflects the likelihood of encountering the item in everyday life	Participants are asked to consider how often they encounter the item represented in the picture in their daily-life, indicating how familiar the stimulus is.	1-unfamiliar to 7-very familiar
Image Agreement	The imageability of the concept and its agreement with the picture	Participants are invited to elaborate a mental image based on a concept and, subsequently, rate if the picture presented match the previous formed mental image.	1- low agreement to 7-high agreement
Manipulability	The level of interaction required by the object	Participants are invited to rate each item/object based on the degree to which the object requires the use of a human hand to perform its function.	1 - never necessary to 7 - totally indispensable
Name agreement	The most common name/ modal name	Participants are invited to provide in one or more words what they think is the best name for the item/object represented in the picture as fast and accurately as possible. When they are not able to provide a name, they have to indicate if they don´t know or if they recognize the object but are not able at the moment to remember its name.	% or H-value (written/typed/oral form)
Picture-name agreement	The congruence between the image and the name	Participants are asked to evaluate the goodness of an image in representing the name presented.	1-very poor representation of the name to 7-excellent representation of the name
Typicality	The representativeness of the item in its own category	Participants have to evaluate if the object represented in the picture is a good example of the category presented, regardless of the occurrence of the object in their everyday life or their personal preferences.	1-very bad example of its category to 7-excellent example of its category
Valence	The pleasantness or emotional weight of the object	Participants are requested to evaluate if the item/object refers to something positive/pleasant or negative/unpleasant.	1-very negative/unpleasant to 7-very positive/ pleasant
Visual complexity	The amount of visual details of an image	Participants have to evaluate to which degree the picture is easy to reproduce, in regard to the amount of visual details (e.g., lines, colors) considering the picture itself and not the actual object/concept represented.	1-very simple to 7-very complex

Bibliometric information and indicators

The evolution over the years of published normative studies using images of common objects is notable, although the number of studies is still scarce. The studies selected were published in the last 38 years (from 1980 to 2018), but mostly in the last 10 years (47 studies, 85.45%, between 2000 and 2019; see Figure 2).

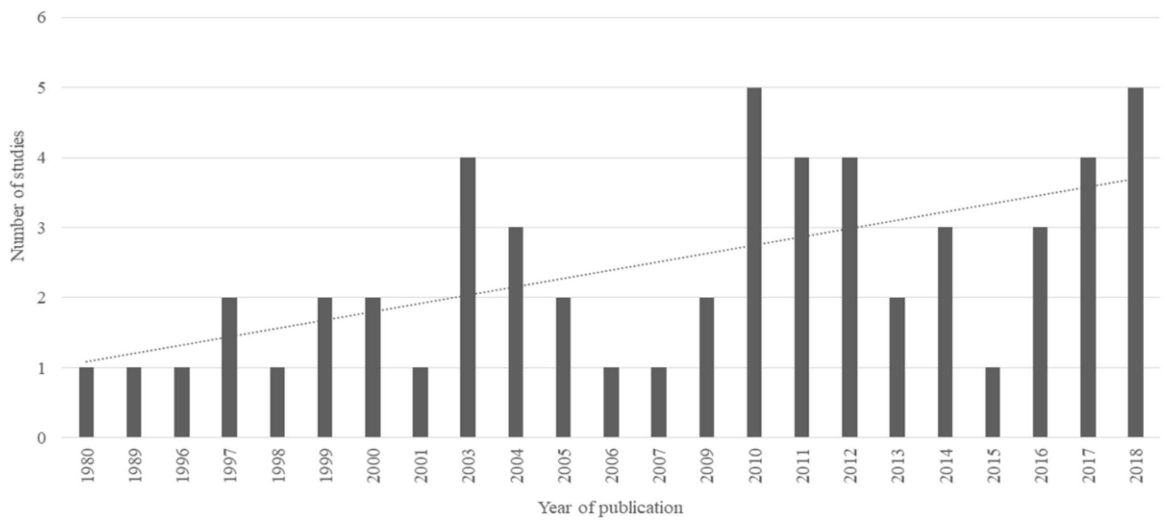

Figure 2. Temporal distribution of reviewed normative studies using common objects across years (%)

The main journal for publishing such type of articles was *Behavior Research Methods* (*n*= 27), which is not surprising given the scope of this publication. However, several recent normative studies with photos have been published in open access journals, such as *PLoS one*, *Frontiers in Psychology* and *Frontiers in Human Neuroscience*. To assess the impact of the journals in which the reviewed articles were published, the h-indexes were obtained using the SCImago platform (www.scimagojr.com) (see Masic, 2016). The h-index values obtained during March 2020 ranged from 22 to 268. Moreover, only three journals were ranked below h-index of 50 and one journal did not present h-index values. A google h5-index is also provided. These indicators suggest that normative studies using images of common objects have been increasingly published in the last years in relevant peer-reviewed journals (see Table 1 and Supplemental Material, S3).

General characteristics and standardization practices of images of common objects

The main characteristics of the revised studies were organized into four subsections: Sample characteristics; Language and cultural variations; Procedures; Stimulus characteristics. The main results are summarized in Table 1 (for detailed descriptions, please see the Supplemental Materials, S3).

Sample characteristics

Overall, the majority of the studies (*n*= 42; 76.4%) reviewed used samples of university students (i.e., undergraduate, graduate, post-graduate levels or both), with fewer studies recruiting participants outside the academic environment (e.g., Boukadi et al., 2016). Some studies did not provide specific information about the education level of their samples (*n*= 12; 21.8%). This review also indicated that most of the studies included young adults (with ages between 18 and 35 years old) and only 14 studies (24%) included broader age samples (e.g., larger age ranges as Brodeur et al., 2010; 2014, or age subsamples, as George and Mathuranath, 2007). Notably, there were studies in which detailed age-related information was not provided (*n*= 13; 24%). Studies using photographs were mostly conducted with undergraduate student samples, with a narrow age range (see Supplemental Materials, S3). While some cognitive abilities are known to decline with age and to vary with education level (Brucki and Rocha, 2004; Faubert, 2002), the current review indicates that the comparison between different education levels and different age groups in normative studies of images of common objects was not frequent, particularly for more ecological stimuli (see Table 1). None of the 55 elected studies reported education differences and twelve from the 14 studies using samples from different developmental stages, such as children, young adults, older adults, considered age variability for at least one of the dimensions (Berman et al., 1989; Cycowicz et al., 1997; Ferraro et al., 1998; Ghasisin et al, 2014; George and Mathuranath, 2007; Liu et al., 2001; Morrison et al., 1997; Pind et al., 2000; Pompéia et al., 2001; Saryazdi et al., 2018; Sirois et al., 2006; Yoon et al., 2004). In such cases, the exploration of the differences between adults versus older participants (Ferraro et al., 1998; Ghasisin et al., 2015; Yoon et al., 2004) or adults versus children (Berman et al., 1989; Cycowicz et al., 1997; Pompéia et al. 2001) were referred. Sirois et al., 2006, reports sociodemographic-based norms. Other studies controlled the impact of sociodemographic information, like age, schooling and gender differences (Kremin et al., 2003; Moreno-Martinez et al., 2011; Moreno-Martinez and Montoro, 2012).

Language and Cultural variations

In the 55 studies reviewed, 16 distinct languages were considered for standards and contemplated a variety of contexts (e.g., Dutch in the Netherlands and in Belgium, Duñabeitia et al., 2018, and Portuguese from European and Brazilian contexts examined in Prada et al., 2010; 2014, and Pompéia et al., 2001 respectively). Native speakers of English (*n*= 14; 25.5%) were the most recruited samples. Other languages referred across the study sample were: Indian, Greek, Persian, Icelandic, and Thai. Only, five studies (9.1%) examined more than one language/culture and three did not specify the native language of the sample. The 14 studies using photographs of common objects were mostly conducted in English, Spanish and Portuguese (*n*= 3, each; 64.2%), and the remaining in other language communities (see Supplemental Materials, S3). The advances in the field are also reflected in the increased variety of languages/cultures in which recent norms have been produced (see Table 1).

While most studies presented a contrast with other normative results (i.e., between studies) for validity and reliability purposes, studies with a specific purpose of cross-cultural comparisons (i.e., collecting data in the same study for the same dataset using samples from distinct cultures) were rare. In addition to the scarce examination of cross-linguistic/cultural reported in the entire sample of studies (Duñabeitia et al., 2018; Kremin et al., 2003; Székely et al., 2004; Torrance et al., 2017; Yoon et al., 2004), from the studies using photographs only the BOSS database was evaluated across different native languages and cultures in distinct studies (i.e., French - Brodeur et al., 2012; English-Canadian – Brodeur et al., 2010; Brodeur et al., 2014; Thai – Clarke and Ludington, 2018).

Procedures

Overall, data collection procedures included multiple tasks with careful and systematic procedures (i.e., controlling presentation times, using well-designed stimuli, balancing the number of stimuli per participant, previously planned task order, inspecting co-occurring variables, consistency in instructions and ratings, applying consistent measures) to avoid fatigue and bias in the ratings across dimensions (see Adlington et al., 2009; Brodeur et al., 2014; Brodeur et al., 2012; Nishimoto et al., 2012; Rossion and Pourtois, Shao and Stiegert, 2016; Snodgrass and Vanderwart, 1980). In the majority of the studies all or a large number of items (up to 200) were evaluated by the same participants in a limited number of dimensions. However, in some of the studies, participants were asked to evaluate a smaller subsample of images in a wider range of dimensions (see Foroni et al., 2013 for an example).

Recent studies have also been using more controlled designs and more sophisticated experimental procedures (e.g., controlling presentation times and inter stimulus intervals), even when response times were not a variable of interest (Moreno et al., 2011; Prada and Ricot, 2010; Saryazdi, 2018; although such concerns were already present in Sanfeliu and Fernandez, 1996). Recently, we have also been witnessing the emergence of alternative procedures in data collection with the use of online platforms (Survey Monkey, Qualtrics, Creative Commons, Google form, Amazon Mechanical Turk, etc.). In the present studies sample, the use of in-lab surveys and experimental procedures was predominant and only two (Saryazdi et al., 2018; Székely et al., 2003) out of the 55 studies used some online tool for collecting data. Specifically, in the study of Saryazdi and colleagues (2018) the goal was to compare norms produced using online and in-lab collection procedures, and they attested the similar quality of these practices. Although more studies are required to confirm it, these online resources seem promising in overcoming emerging obstacles in recruiting participants for such extensive studies.

Stimuli characteristics

The selected studies included different types of common objects stimuli, using line-drawings (n =39; 71%) or photographs (*n* = 14; 25.4%) or both (*n* = 2; 3.6%). From the line-drawing´s studies sample, the majority (*n* = 29; 74.4%) included the Snodgrass and Vanderwart (1980) or some adaptation/extension. The remaining line-drawing studies used other stimuli created by the authors or selected from other sources (e.g., Duñabeitia et al., 2018; Ferraro et al.,1998). Among the photographs' studies sample, half used stimuli from the BOSS database (7; 50%) and the remaining used variations of common objects as stimuli embedded in contextual scenes (Shao and Stiegert, 2016), modified versions of object images (Prada and Ricot, 2010) and animals with negative valence (Prada et al., 2014). Moreover, two studies produced norms for both line-drawings and colored photographs (O´Sullivan et al., 2012; Saryazdi et al., 2018) comparing norms from Snodgrass and Vanderwart's (1980) and the BOSS (Brodeur et al., 2010; 2014) databases. These two datasets were also identified as the most used in the whole sample.

As for the number of stimuli in each database, the 55 studies reviewed ranged from 50 (Prada et al., 2014) to 930 (Brodeur et al., 2014) stimuli. This range was also observed in the 14 studies using only photographs of common objects (Supplemental Materials, S3). Another feature of stimuli characteristic is image quality, which is a specific and important concern in studies using more realistic images (i.e., high-quality photographs). Our analyses indicated an absence of standards for image resolution across studies (ranging from 150X150 to 2000X2000 pixels), with almost half (45.5%) of the articles missing this specific information. Critically, objective assessments of image quality parameters (color - RGB and luminance) have been scarcely addressed (Foroni et al., 2013; Forsythe et al., 2017; Shao and Stiegert, 2016). Likewise, the dimensions of color diagnosticity (Adlington et al., 2009; Rossion and Pourtois, 2004) and goodness of depiction (Székely et al., 2003) are almost absent. However, a few recent studies have been implementing specific procedures to produce high-quality photos of common objects controlled for their surface parameters (Brodeur et al., 2014; Brodeur et al., 2012; Saryazdi et al, 2018). Other recent studies (Forsythe et al, 2017; Torrance et al., 2017) also used automated measures of visual complexity. The use of refined measures for surface parameters of the images constitutes an improvement in standardization practices since the classic Snodgrass and Vanderwart´s norms (1980) and requires sophisticated technological resources that are currently available (i.e., scripts and image processing programs).

Finally, the majority of the studies distributed the stimuli into categories (e.g., animals, vegetables and tools; verbs and nouns). The number of categories varied across studies ranging from one broad concept (i.e., concrete names in Paolieri and Marful, 2018) to 32 distinct categories (i.e., Brodeur et al., 2014) that included concepts from living and non-living domains. Overall, the studies used a low to moderate number of categories, with 31 studies referring between 6 to 15 categories (56.4%) and 8 studies including less than 5 categories (14.5%). However, studies reporting less than 5 categories only made generic reference to categories and/or domains. For example, Berman et al. (1989) used one general category to group basic-level concepts (e.g., dolphin, chair) and Sirois and collaborators (2006) used the living domain as a unique animate macro category in contrast to man-made, body parts and professions as inanimate categories. Only seven studies reported more than 15 categories (see Table 1), particularly when norming photographs. Some authors also considered the item distribution into the categories by domains. Moreno-Martinez and Montoro (2012), for example, presented 10 categories from the living domain (e.g., birds, insects) and 12 categories from the non-living domain (e.g., weapons, tools). Also, the norms by Prada et al. (2010) included four categories containing items from the living and six from the non-living domain.

The semantic organization effect of categories and domains (living vs. non-living) across dimensions was not consistently examined, particularly in those using real-world photographs (but see Laiacona et al., 2016; Magnié et al., 2003). Moreover, the few normative studies that systematically explored those effects presented interesting results showing the influence of distinct semantic content across specific dimensions (Adlington et al., 2009; Brodeur et al., 2012; Clarke and Ludington, 2018; Foroni et al., 2013; Laiacona et al., 2016; Magnié et al., 2003; Rossion and Pourtois, 2004). Of special relevance, Adlington and colleagues (2009) provided evidence for the effect of semantic organization on naming performance (with better naming for categories from non-living things) as well as the modulation of this effect by gender (women were better at naming living things while men were more accurate in naming non-living things).

Dimensions reported in the standardization of images of common objects

The final sample of 55 studies was then examined regarding the dimensions consistently reported from the semantic (i.e., Name-agreement; Category-agreement; Familiarity; Typicality), perceptual (i.e., Visual complexity Picture-name agreement), and affective (i.e., Aesthetic appeal; Arousal; Valence) domains (see Table 2 for generic definitions, examples of instructions and scales for each relevant dimension).

The inspection of the instructions and measures of the most referred dimensions revealed some consistency across studies, mostly for name agreement and visual complexity tasks. However, the instructions for familiarity and image agreement dimensions, differed in their focus (e.g., on picture, object or concept) or in some cases presented inconsistencies between the instruction focus (e.g., concept-based) and scale (e.g., object-based) (see Bonin et al., 2003; Janssen et al., 2011). The instructions also varied reflecting the developments on the definition of the dimensions. For instance, studies evaluating familiarity based on encounter/frequency and also examining image agreement based on object agreement and viewpoint were documented (see Brodeur et al., 2010 for an example). The necessity to disentangle dimensions is also referred in some normative studies, when comparing different definitions of the same dimension (e.g., Adlington et al., 2009 measurement of familiarity based on picture versus based on the concept) or contrasting potentially confounding dimensions (e.g., Snodgrass and Vanderwart 1980 examination of Image agreement and Picture-name agreement). These issues have been recently addressed in attempts to provide more specific definitions, such as the clearer definition of familiarity presented in Saryazdi et al., 2018, or the requirement for a specific name (Moreno-Martinez et al., 2011) or for the most correct spelling of first language labels (Torrance et al., 2017) in name agreement. The comparative table of instructions from the most reported dimensions and their scales across studies can be found in Supplemental Materials, S4, Table 1.

Among the semantic dimensions addressed in the 55 studies retained, norms for Name-agreement were quite frequent across studies (87.27%), in both articles norming photographs and line-drawings. Only a few exceptions did not examine this dimension (e.g., Ferraro et al., 1998; Forsythe et al., 2017). The main measures considered for Name-agreement were: the modal name (the name more frequently reported and its percentage of agreement) and the h-index (a statistical score that takes into account the influence of the number of correct names given for each item and their frequency). Notably, a recent study from Torrance and colleagues (2017) established norms and procedures for a variety of innovative dimensions such as naming abilities by adding typed name; spelling agreement index (that follows the same rational of the h-index used in naming but for spelling variations); modal spelling; timing of written naming; and length of modal name. Additionally, in some of the studies the naming task was previously applied to a different sample as a pre-validation study (e.g., Brodeur et al., 2010; Clarke and Ludington, 2018). Although less usual, an *a priori* judgment procedure (see Khwaileh et al., 2018) might constitute a good alternative for previously defining the name and the cultural appropriateness. This procedure usually involves different judges (linguistic experts or culturally-based elected) invited to evaluate the items independently (e.g., name, category, quality of the image, etc.).

Norms for Familiarity were reported in 83.64% of the 55 studies (e.g., Bonin et al., 2003; Cuetos et al., 1999; Zhou and Chen, 2017). Familiarity was always reported in studies using photographs (see Supplemental Materials, S3). Age-of-acquisition was reported in almost half (49.09%) of the studies. In contrast, only 9.09% (e.g., Dell´Acqua et al., 2000) of the studies considered Typicality ratings from which three where from norms for photographs (5% of the 14 studies). In most normative studies (92%), categories were previously defined by the researchers using mainly superordinate and basic-level categories. Category-agreement was not explored in line-drawings and only four studies with photographs evaluated this dimension.

Regarding the perceptual dimension, Visual Complexity (*n* = 33 out of 55, 60%; *n* = 10 out of 14 with photos, 71%) and Image Agreement (*n* = 19 out of 55, 34.55%; *n* = 4 out of 14; 28%) were the most reported dimensions. Moreover, Imageability (*n* = 8 out of 55; 14.55%; *n* = 1 out of 14; 7%) and Picture-name agreement (*n*= 4 out of 55; 7.27%; *n*= 0 out of 14; 0%) were also examined. Additionally, a few studies (*n* = 7; 13%) addressed Manipulability, particularly for objects and tools (i.e., Brodeur et al., 2010; Brodeur et al., 2012; Brodeur et al., 2014; Laiacona et al., 2016; Magnié et al., 2003; Moreno-Martinez et al., 2011; Moreno-Martinez and Montoro, 2012). While providing norms for Manipulability using photos of common objects, Moreno-Martínez et al. (2011) showed the significant influence of this dimension in other variables such as naming, h-index, familiarity and visual complexity. Several other perceptual-related dimensions were also reported but were scattered across studies (e.g., color diagnosticity, vividness, viewpoint agreement).

Affective dimensions were scarcely reported across studies, with Arousal (*n* =1, 1.82%) and Valence (*n* = 4 out of 55; 7%) being examined but only in real-word photographs of common objects (Foroni et al., 2013; Prada and Ricot, 2010; Prada et al., 2010; Prada et al., 2014). However, from those studies only Foroni et al., 2013, was retrieved from the automatic search. Other Affective/Emotional dimensions (i.e., disgust, fear, dangerous) and Beauty were only documented in one study each (Prada et al., 2014; Magnié et al, 2003, respectively). Norms for Aesthetic Appeal were not reported in the elected studies, even though this dimension is known to significatively influence the processing of visual items (Reppa and McDougall, 2015).

Finally, there were some other dimensions sporadically addressed across studies, as action content, ambiguity, image variability, body-object interaction, vividness, index recollection, verb generation, word length, as subdimensions of familiarity such as frequency of the concept and likelihood of the object in daily life (see Barry et al., 1997; Kremin et al., 2000; Saryazdi et al., 2018) but they remain rather unexplored in images of common objects norms. The distribution of the dimensions across studies is presented in Figure 3.

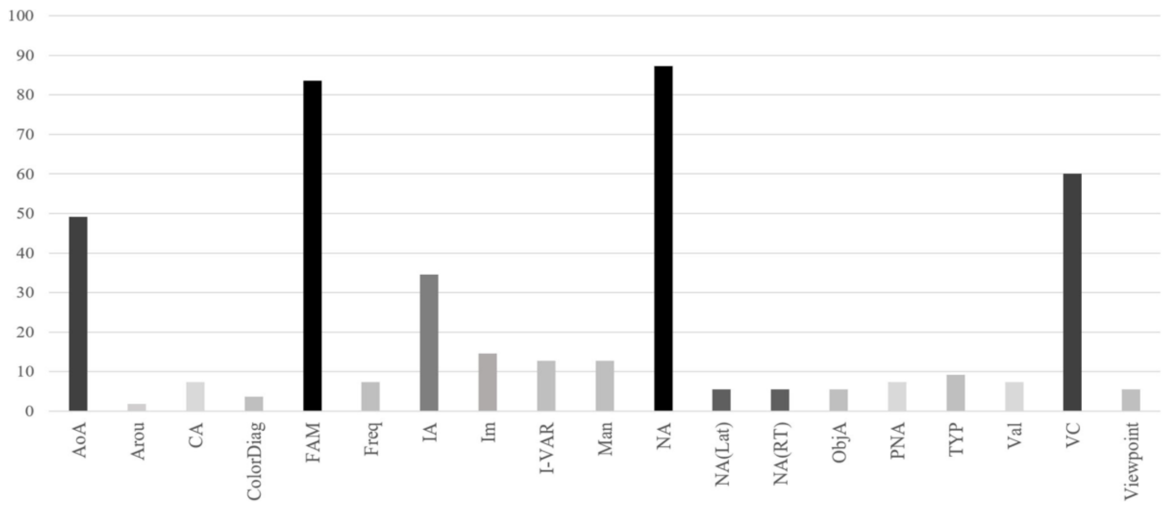

Figure 3. Representativeness of each dimension across studies (%)

Assessment of images of common objects

Qualitative appraisal of norms

A qualitative inspection of the ratings across studies indicated that images of common objects are rated as moderately to highly familiar (Brodeur et al., 2014; Brodeur et al., 2012; Moreno-Martinez and Montoro, 2012; Pompéia et al., 201; Raman et al., 2014; Rossion and Pourtois, 2004, but see also Shao and Stiegert, 2016), and low to moderate in complexity (e.g., Adlington et al., 2009; Brodeur et al., 2014; Dimitropoulou et al., 2009; George and Mathuranath, 2007; Shao and Stiegert, 2016). A study contrasting both types of items showed that photos obtained higher name agreement and picture-name agreement scores as well as lower familiarity, visual complexity and less variability in naming (h-value) than line-drawings stimuli (see Saryazdi, et al., 2018). The majority of the studies reported a reasonable agreement (higher than 65%) regarding their modal name (e.g., Cuetos et al., 1999; Nishimoto et al., 2012; Paolieri and Marful, 2018). However, the h-value of naming presented a high range across studies. Category agreement was higher than 68% across studies, although few studies reported norms on this dimension (Brodeur et al., 2012; Brodeur et al., 2014), and typicality was rated as moderate to high (Moreno-Martinez and Montoro, 2012; Moreno-Martinez et al., 2011). Age-of-acquisition was measured in different ways across studies (e.g., some studies used 2 or 3 age bands and others simply asked to type that age). The ratings of valence and arousal were not enough to capture possible trends in the reports across studies (Prada et al, 2010). Moreover, arousal and valence showed to be sensitive to category variations (i.e., tools, animals, vegetables) and also to vary depending on typicality and familiarity ratings (Foroni et al., 2013).

Overall, and despite the relevance of mapping the distribution of evaluative scores across dimensions, these trends should be interpreted with caution and consider the specific characteristics of the database normed. See Supplemental Materials, S4, Table 2, for obtaining the distribution of scores by study.

Correlations

All the reviewed studies that report correlations are referring to associations of some semantic (predominantly, name-agreement and familiarity) and perceptive dimensions (mostly, visual complexity), but affective variables were rarely examined. Additionally, none of the reviewed studies simultaneously explored the relations between dimensions of these three domains. The most frequent combinations were the perceptive and semantic domains. The semantic and affective or perceptive and affective combinations were also found, albeit scarce. Interestingly, the simultaneous examination of affective and other domains was only present in photographs of common objects norms. The results of the association between dimensions in the reviewed studies and the comparisons between stimuli type (line-drawings vs photographs) are presented in Table 3[2].

Table 3. Significant correlations between dimensions in normative studies of line-drawings and photographs.

	AoA	**CA**	**Fam**	**IA**	**I-var**	**NA%**	**NA(H)**	**PNA**	**Typ**	**VC**
AoA		NR	$-.91^{**p}$ $-.37^{**q}$	$-.13^{*s}$	NR	$-.25^{**q}$ $-.82^{***u}$	$.17^{*t}$ $.75^{**p}$	NR	$-.72^{**r}$ $-.91^{**p}$	$-.26^{**p}$ $.34^{**x}$
CA	NR		$.30^{*r}$ $.22^{**q}$	$.14^{**q}$	NR	NR	$-.93^{**p}$	NR	NR	NR
Fam	$-.38^{**a}$ $-.64^{***b}$	NR		$-.19^{**s}$ $.46^{**t}$	NR	$.35^{**q}$ $.89^{***u}$	$-.29^{**v}$ $-.71^{***u}$	NR	$.75^{**x}$ $.92^{**p}$	$-.21^{**q}$ $-.57^{**x}$
IA	$-.30^{**c}$ $-.14^{**d}$	NR	$-.15^{**e}$ $.44^{*k}$		NR	$.46^{**q}$ $.49^{**t}$	$-.17^{**s}$ $-.43^{**q}$	NR	NR	$-.19^{**r}$
I-var	$-.24^{**d}$ $-.64^{**e}$	$.19^{**e}$ $.62^{*j}$		$-.17^{**h}$ $-.29^{**k}$		NR	NR	NR	NR	NR
NA%	$-.16^{*f}$ $-.52^{**d}$	NR	$-.57^{*l}$ $.52^{**m}$	$.20^{*l}$ $.49^{*c,n}$	$.20^{**a}$ $.32^{**d}$		$-.83^{***u}$ $-.96^{*r}$	NR	$.52^{**x}$ $.73^{**p}$	$-.11^{*r}$ $-.26^{***u}$
NA(H)	$-.18^{***e}$ $-.57^{**g}$	NR	$-.15^{*n}$ $-.39^{**m}$	$-.24^{**a}$ $-.55^{***n}$	$-.14^{*j}$ $-.28^{**k}$	$-.74^{**k}$ $-.96^{***n}$		NR	$-.51^{**z}$ $-.66^{**p}$	NR
PNA	$-.08^{*f}$ $-.14^{**b}$	NR	$-.21^{**k}$	$.72^{**k}$	$-.35^{**k}$	$.12^{*f}$	$-.25^{***b}$		NR	NR
Typ	NR	NR	NR	NR	NR	NR	NR	NR		$-.27^{**x}$ $-.26^{**p}$
VC	$-.25^{*h}$ $.53^{***i}$	NR	$-.12^{*o}$ $-.48^{**c}$	$-.14^{*k}$ $-.59^{**n}$	$-.17^{*h}$ $-.24^{*j}$	$-.15^{**h}$ $-.49^{***n}$	-15^{**c} $.54^{***n}$	$-.22^{***b}$	NR	

The correlations are significant at $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$. The signal (-) is reported for negative direction of the correlations.
Note: The photographs (10) results are presented above the diagonal and line-drawings (28) results are presented below the diagonal of the table. Only the maximum and minimum correlational results for each correlation across studies are presented. AoA – Age-of-acquisition; CA - Category agreement; Fam - Familiarity; IA - Image

[2] Studies that did not present correlations between dimensions were not considered in this analysis. For Berman et al (1989), Cycowicz et al. (1997) and Pompéia, et al. (2001) only the correlations obtained with adult samples are reported. In Bonin et al (2013), Visual complexity was reported using objective measures. For studies reporting common objects as one category in contrast with other distinct type of stimuli (i.e. verb images) only results for common objects were included. See Supplemental Materials, S4, Table 2, for the entire list of extracted results across studies.

Agreement; I-var - Image variability; NA% - Name agreement percentage; NA(H) - Name agreement H-value; PNA - Picture name agreement; Typ - Typicality; VC – Visual complexity. NR: not reported across studies. Affective dimensions (i.e., arousal, aesthetic appeal and valence) were not reported in this table, once there were no studies reporting such dimensions in line-drawings studies samples.

Line-drawing references: [a]Bonin et al., 2003; [b]Johnston et al., 2010; [c]Raman et al., 2014; [d]Alario and Ferrand, 1999; [e]Liu et al., 2011; [f]Morrison et al., 1997; [g]Nishimoto et al. 2005; [h]Manoiloff et al., 2010; [i]Sirois et al., 2006; [j]Nishimoto et al., 2012; [k]Sanfeliu and Fernandez, 1996; [l]George and Mathuranath, 2007; [m]Boukadi, 2016; [n]Tsaparina et al., 2011; [o]Khwaileh et al., 2018.

Photographs references: [p]Moreno-Martinez et al., 2011; [q]Clarke and Ludington, 2018; [r]Brodeur et al., 2010; [s]Shao and Stiegert, 2016; [t]Paolieri and Marful, 2018; [u]Adlington et al., 2009; [v]Zhou and Chen, 2017; [x]Moreno-Martinez and Montoro, 2012.

Overall, the correlations scores. indicate consistency in the direction of the correlations across studies, with a few exceptions (photos: NA(H)-AoA, NA%-FAM, VC-AoA; line-drawings: VC-AoA, IA-FAM). Correlations between semantic dimensions were overrepresented. Name agreement measures were negatively correlated for both type of items. The correlation between name agreement (%) and familiarity was positive and from moderate to strong, independently of the stimuli type. Moreover, visual complexity was negatively correlated with familiarity (see Clarke and Ludington, 2018; Raman et al., 2014) and name agreement (Tsaparina et al., 2011) while picture-name agreement was positively related to image agreement (Sanfeliu and Fernandez, 1996) (see Table 3). In line with previous findings using word stimuli (see Santi et al., 2015), typicality showed a positive correlation with familiarity and with name agreement (%) for photographs. In perceptive dimensions, visual complexity was negatively correlated with typicality, familiarity and image agreement, although its association with name agreement (H) and with category agreement remained absent (Table 3). Picture-name agreement was also positively associated with name-agreement. Correlations between affective dimensions are not reported, however it is noted that valence and arousal have been positively correlated in the literature for specific categories of common objects (Foroni et al., 2013).

The examination of reliability in cross-cultural comparisons was made by extracting cross-studies correlational data from the studies sample that reported the comparison of each relevant dimension with other studies using direct analysis (i.e., with the very same images). Overall, the most reliable dimensions across studies comparisons were age-of-acquisition and image agreement. In such dimensions, the correlations found (between moderate to strong) represented a comparison between very distinct cultural and linguistic contexts (i.e., Russian and American). The high variability on Naming agreement scores indicates their sensibility to changes in cultural/linguistic variations (e.g., Tunisian Arabic vs. Spanish) and present strong correlations in similar linguistic backgrounds (i.e., American vs. British English). The results extracted from the articles reporting correlations between the original (reference) and previous studies using the same database are presented in Table 4 (extracted results by article can be found in Supplemental Materials, S4, Table 3).

Table 4. Descriptive information of cross-country comparisons of the dimensions across studies.

Dimension	Correlation range	Qualitative range	Direction	N	Strong correlation (Freq.)	Strong correlation (%)
NA(h)	.15-.69	weak to moderate	+	24	0	0%
NA(%)	.15-.74	weak to strong	+	24	2	8%
FAM	.27-.99	weak to strong	+	22	17	77%
AoA	.56-.95	moderate to strong	+	16	10	63%
IA	.42-.83	moderate to strong	+	12	4	33%
VC	.38-.92	moderate to strong	+	20	15	75%

Note: only significant results ($p < .05$) were considered for this analysis; (-) are and (+) indicate the direction of the correlations.
NA - Name-agreement; AoA- age-of-acquisition; IA – Image agreement; FAM - Familiarity; VC - Visual Complexity were considered based on their high occurrence across studies.

Availability and application potential of the normative databases

In order to evaluate the potential use of the databases, we collected information about their availability and their application.

From the 55 articles retained, the majority were available online (98%) and presented free access to the database (*n*= 43, 78%) and only eight (14%) did not refer how to access the database or presented an unavailable link (e.g., Bayram et al., 2017; Dell´Acqua et al., 2000; Kremin et al., 2003). Four studies (7.3%) allowed the conditional access to the database (Dimitropoulou et al. 2009; Janssen et al., 2011; Moreno-Martinez et al., 2011; Raman et al., 2014) controlled by the Editors/Journals website or by the first authors (see Table 1).

The number of citations of the articles in the Web of Science (range: 0 to 3947), Scopus (range: 0 to 4023), and Google Scholar (range: 0 to 5783) is relatively high. However, a closer inspection to these numbers revealed that there are very few articles with more than 100 citations (*n* = 14 in Google Scholar, 25.5%, and *n* = 11 in Scopus and WoS, 20%). The most cited articles from the overall sample refer to normalization of line-drawing images (Morrison et al., 1997; Rossion and Pourtois, 2004; Snodgrass and Vanderwart, 1980). As expected, the recency of a publication is likely to reduce its citation scores (see Table 1). Therefore, it is not surprising that the articles with fewer citations were those reporting norms for photographs of common objects that also constituted the most recent publications. However, even considering average citation per year indicators, the studies norming line-drawings are still the most cited ones (see Supplemental Material, S3). These findings are somehow surprising giving the increasing and extensive interest in ecological stimuli.

Discussion

Several normative studies in the psychological field have already established criteria to examine how specific variables are stated/evaluated in a sample of interest (Cicchetti, 1994). The assessment of any construct or variable, particularly in experimental studies, requires that the measuring tools designed for such assessment are efficient (i.e., validity) in producing reliable results. Therefore, standardization of procedures, materials and scores are essential to avoid undesirable interferences in psychological assessment (see Fischer and Milfont, 2010). To this end, several standards for building and normalizing measurement tools as well as rich statistical resources have been made available (Chichetti, 1994; Fischer and Milfont, 2010). Kyriazos and Stalikas (2018) presented relevant steps on scale development to guarantee their quality, such as the theoretical framing of the variables of interest, adequate measures of assessment (i.e., response type scale and psychometric properties) and also item quality (i.e., development and selection of good exemplars). However, specific guidelines for normative procedures of stimuli production and their selection for research/interventional purposes have been scarcely discussed. Indeed, this type of standardization reveals itself as a potential research field that remains rather unexplored.

In response to this gap, the present review evaluated the current status of normative studies using images of common objects with adults in order to systematically map and characterize the main features and practices in the field. The information extracted from the retrieved studies, was coded and summarized to answer the proposed research questions namely: a) bibliometric information and indicators (journals, journals h-index, temporal distribution); b) general characteristics and standardization practices of images of common objects (sample characteristics, language and cultural variations, procedures, stimulus characteristics); c) dimensions reported in the standardization of images of common objects (main dimensions reported, scales and task instructions, and their consistency across studies); d) assessment of images of common objects (mean ratings and correlational results, reliability of datasets); e) accessibility and application potential of the normative databases (availability and citation impact).

Overall, the results indicated 55 published normative studies using images of common objects. The bibliometric indicators examined revealed that normative studies of images of common objects have been increasing in the last 10 years and published in quality peer-review journals. These indicators document the recent efforts that have been made in the field to provide stimuli and to produce valid norms that support adequate manipulations and enhance quality and replicability in experimental research (Wilcox and Claus, 2017). However, their use should consider systematic and contextualized knowledge about the databases, their dimensions and normalization procedures.

The general characteristics and standardization practices of images of common objects, indicated that the reviewed studies were conducted with healthy young and highly-educated adults. The sampling procedure is probably one of the most important steps during normative studies. Once the samples constitute a reference to produce norms, their characteristics must be representative of the population (e.g., age, gender, language, nationality, QI, education level, etc.), and the sample size constitutes an important criterion for statistical purposes (Cohen, 1988; Mitrushina et al., 2005). Although a restricted sample may preclude generalized conclusions, the widespread use of academic samples such as those reported in most of the reviewed articles may favor the comparison across normative studies (Garrido and Prada, 2017; Pompéia et al., 2001) and be suitable for the large number of experimental studies that are often conducted with university students.

Another feature of the samples in the reviewed studies is their limited age distribution and consequent scarcity of aging and development effect analysis. In conducting norms for adult populations, it is relevant to fully consider their developmental process once with increasing age some abilities (i.e., perceptual and memory) are known to decrease (for a review see Faubert, 2002) while others may increase with life experienced knowledge (as vocabulary, see Verhaeghen, 2003 for a meta-analytic summary of findings in such topic) impacting the way norms are rated. The production of norms for images of common objects with healthy elderly participants might be important for studies using these stimuli for contrasting such population to others of the same age range but with clinical condition (see Laws et al., 2007; Semenza et al., 2003). Specifically, having standards for healthy samples of older participants may improve the quality of assessments in defining diagnostic markers and also designing interventional strategies in the clinical context. It is also worthy to note that the comparison between norms obtained with adults and norms obtained with samples from earlier stages of the life course is also scarcely presented in the reviewed studies (Berman et al., 1989; Morrison et al., 1997; Pompéia et al., 2001). The norms produced for children are crucial for understanding how development affects several dimensions and to confirm the consistency of some procedures (e.g., the adequacy of Age-of-Acquisition measures used with adults) (see Morrison et al., 1997; Pompéia et al., 2001 for an example) and, thus serve as a baseline for further research. Additionally, the production of norms with children is of great use in psycholinguistic and neurodevelopmental research, in which standardized imagens of common objects stimuli are frequently used. Nevertheless, there are normative studies across the life course which were not captured in our review simply because our search was restricted to young adults.

The language and cultural variations of the samples covered different linguistic and cultural environments, although they were predominantly constituted by speakers of English or other European languages. The prevalence of a linguistic/cultural background together with the scarcity of direct cross-cultural comparison reported reflects the need of enhancing country-based norms production. Cultural variations (i.e., as food habits, tools and technological resources, social rules, beliefs, religion and, especially, language) are known to influence the processing of meaningful stimuli, such as common objects (e.g., Brodeur et al., 2012; Duñabeitia et al., 2018; George and Mathuranath, 2007). For example, Duñabeitia et al. (2018) revealed country-based differences across correlated dimensions (e.g., h-index of naming and Visual complexity) although similarities between linguistic (i.e., English and German or Spanish and English) and also culturally-based comparisons (i.e., Dutch speakers from the Netherlands and from Belgium) were observed in mean ratings of common objects. Moreover, a cross-linguistic comparison between citizens speaking different languages but living in the same context (i.e., French and English speakers living in Canada) indicated a culturally-based convergence across mean ratings for a variety of dimensions (Brodeur et al., 2012). Consequently, the examination of the same dataset across languages and cultures may indicate specificities about their contextual variations as well as their commonalities.

The use of controlled designs and careful recruitment procedures observed (see Saryazdi et al., 2018; Zhou and Chen, 2017) reflected a continuous effort to extend and improve previously established norms production. To overcome time-consuming and resource demanding procedures (recruitment, materials, lab set preparation and availability, etc.), online studies of norms seem to constitute a valuable alternative without compromising the quality of the norms produced (i.e., King et al., 2014; Saryazdi et al., 2018). However, data collection practices are not yet fully taking advantage of those recent technologies.

The findings regarding stimuli characteristics indicated that line-drawings stand out as the most prevalent validated type of stimuli, although an increasing number of studies validating photographs of common objects has been recently observed. Real-world photographs are more realistic representations of the world (Moreno-Martinez and Montoro, 2012). They entail richer expressions of a set of object parameters that impact image processing, such as color, shade/luminance, angle, resolution and form, which together with context regularities and the semantic content inherent to images (see Brady et al. 2008; 2009; Konkle et al., 2010) comprise more complex representations of the reality. Nevertheless, their detailed representations may limit the possibility of producing prototypes which might generate more ambiguity and, consequently, more difficulty in recognizing the objects (Brodeur et al., 2010). Due to their complexity, the examination of multiple parameters of perceptive characteristics and their relations with other dimensions are desirable in normative studies using such type of stimuli.

Overall, the databases identified, showed a moderate number of items and categories, a pattern that has been changing in the last 5 years where a higher number of stimuli and categories have been observed. Regardless of their importance in object processing (Chao et al., 1999; Warrington and Shalice, 1984), the effects of semantic categories and domains across dimensions were hardly reported. While most of the reviewed studies distributed items across categories, the need to include a wider range of categories became evident considering the limited number of studies reporting more than 15 categories as well as a higher number of items within categories. Moreover, the clustering of the images into domains was even more infrequent. The semantic content inherent to common objects and their specific categories are known to influence their processing (Martin et al., 1996; Semenza, 2009; Warrington and Shalice, 1984) with distinct neural structures recruited for the different categories to be processed (for details, see Moss and Tyler, 1997). Complementary, the categorical organization also exerts influence in affective dimensions such as arousal and valence (Foroni et al., 2013) as well as in other semantic and perceptive dimensions (Brodeur et al., 2014) that varied according to the categories. The BOSS database normative studies (Brodeur et al., 2010; 2012; 2014) constitute an example of good practice, being the largest and more diversified dataset using photographs of common objects from categories from both living and non-living domains.

The dimensions reported in the standardization of images of common objects indicated that a variety of dimension were examined, mainly from semantic and perceptive domains. Overall, most normative studies report only a few dimensions with the affective dimension being the least explored. There is no systematic reporting of perceptive, semantic and affective dimensions within the same study. Interestingly, the simultaneous examination of dimensions from more than one of the semantic, affective and perceptive domains was more frequent in photographs than in line-drawings norms of common objects. According to Prada et al. (2016), the examination of various dimensions in the same image database is crucial to dissociate dimensions and avoid possible confounding effects and allows the selection of stimuli across dimensions as a function of the research interests. The unsystematic reporting of dimensions across studies, however, may limit the comparisons between studies (since studies may not present the same dimensions) and reduce their potential of application in prospective studies (e.g., when researchers need to control for specific dimensions that are not addressed).

Despite the diversity of dimensions reported across studies, some consistency was observed regarding the prevalence of naming-agreement followed by familiarity and visual complexity. Although not previously considered in the search procedures, age-of-acquisition was one of the most reported dimensions. These studies indicate the relevance of this dimension in object recognition, object naming and semantic processing for adult samples (see Johnston and Barry, 2005; 2007; Morrison et al., 1997). Furthermore, some relevant dimensions that impact this type of items, such as Typicality, Category agreement, Aesthetic appeal and Manipulability, were somehow neglected. The recent interest in the effects of manipulability was largely motivated by discoveries on the human mirror neuron system and related action imitation processes (Iacoboni, 1999) and since then have increasingly been examined (Campanella and Shallice, 2010; Kalénine and Bonthoux, 2008; Pobric et al., 2010). This effect was documented in studies showing that children show different perceptual and conceptual processing for manipulable and non-manipulable objects (Kalénine and Bonthoux, 2008). In fact, manipulability has been recognized as a dimension of the semantic system (see Campanella and Shallice, 2010). Accordingly, a recent multimodal approach suggested that semantic processing is influenced by a combination of modality-specific information comprising sensory, verbal and motor experiences, including the manipulability of objects, that are integrated at the anterior temporal lobe (Pobric et al., 2010). It seems that this dimension might be quite important for exploring common objects, and presents a considerable influence in item processing, as indicated in our study sample. Other dimensions such as Aesthetic Appeal were not explored in the elected studies. This finding is at odds with evidence showing that this dimension impacts significantly the processing of visual items (Garrido et al., 2016; Prada et al., 2016) and interacts with other dimensions such as familiarity (Prada et al., 2016) and affects visual inspection (McDougall and Reppa, 2008). Therefore, it requires further examination in norms for images of common objects.

Other dimensions often referred in the reviewed papers were naming latency, frequency, vividness, spelling agreement, beauty and word length. Although important, some of these dimensions may not be critical in normative studies of images of common objects. Specifically, some of these dimensions seem to be particularly relevant for word processing (frequency, word length) and others may present conceptual similarities with well-reported dimensions (i.e., image agreement is similar to picture-name agreement[3]).

The inclusion of innovative dimensions such as measures of color, manipulability and ambiguity in image normative studies has been increasing in recent years inspired by developments in related fields. Therefore, it is important to contextualize the emergence of such dimensions in the broader scientific context. Particularly, visual cognition and picture processing research fields have been examining surface features and cognitive processing involved in object perception. For instance, the influence of surface features, such as color, amount of details or size, in the way visual items are perceived and retrieved (Biederman and Ju, 1988; Brady et al., 2009; Konkle et al., 2010) may have motivated the inclusion of color diagnosticity, objective RGB parameters or even ambiguity in normative studies. The semantic attributes in picture norms may also derive from the approach of meaningful-based top-down processes and contextual expectancies/regularities (Bar, 2003; VanRullen and Thorpe, 2001). These developments may have influenced the emergence of semantic related dimensions (e.g., based on the meaning of the items or modality of categories) associated to visual representations, such as picture-name agreement, category agreement, image agreement, manipulability and concreteness. Others were well-explored in the word processing field but remained less explored in picture processing, namely typicality and word length. Furthermore, there were studies also reporting recent improvements in the definition of the dimensions included and related concepts. An example can be found in the familiarity dimensions that have been defined as the likelihood of being in contact or encounter an item in daily-life (see Foroni et al., 2013; George and Mathuranath, 2007 for examples). Likewise, recent findings on the difference between exposure and familiarity and the influence of exposure on perceptive processing have motivated the emergence of norms for encountered ratings (see Forsythe et al., 2017). Finally, affective dimensions have only been recently recognized as influencing the processing of non-emotional images.

The assessment of images of common objects across normative studies reviewed indicated that common objects are usually rated as moderately to highly familiar and typical and as low to moderate in complexity, with a reasonable agreement (higher than 65%) regarding their modal name and category, which vary across studies. Some of the correlations between dimensions were strong, suggesting the need for examining some potential confounds, namely between typicality and other semantic dimensions (familiarity and modal name). Moreover, unexplored dimensions, such as aesthetic appeal and arousal/valence, should be examined for their impact on the processing of images of common objects. The correlation scores provided indicators of consistency in the direction of the correlations across studies, with a few exceptions (photos: NA(H)-AoA, NA%-FAM, VC-AoA; line-drawings: VC-AoA, IA-FAM). These exceptions seem to reflect the selective influence of context on meaningfulness-based

[3] Picture-name agreement refers to the agreement between name and image, with both features presented together (see Snodgrass & Vanderwart, 1980). Image agreement refers to the degree in which the visual representation of the stimuli fits well with the participant´s previous mental image about the concept. Image agreement is considered very similar and as relevant as picture-name agreement, but the latter seems to involve less abstraction (see Snodgrass & Vanderwart, 1980 for details about both dimensions).

dimensions in each stimuli type. Of special interest and despite their consistency in direction, it was observed that the range of the strength of the reported correlations presents some variation across studies, which is expected once the geographical context and language vary across studies. The results suggest that norms are sensible to both cultural and linguistic variations and their use should be restricted to the populations in which they were produced and also that they might depend on methodological differences (i.e., number of items, task instructions, data collection environment, etc.). However, the present study only examined the ratings across studies in a qualitative manner which limits the possibility of drawing substantial conclusions and generalizations on this issue.

The availability and application potential of the normative databases showed that most studies, their materials and data, have been made increasingly accessible in the last years, which favors reproducibility and application potential in the upcoming years. However, this accessibility could be further boosted, namely by increasing open access practices that facilitate the access to the stimuli, allowing replication studies across different cultural contexts and languages. Open practices are likely to stimulate the enhancement/extension of visual normative databases and the examination of new dimensions. The past use of these norms indicates a tendency to use well-established databases (Brodeur et al., 2010; Snodgrass and Vanderwart, 1980) while overlooking other more recent and less widespread ones. Furthermore, the application potential of the normative studies is acknowledged by clinical and experimental studies exploring, for example, perceptual and linguistic variables (see Funnell and Sheridan, 1992) as well as in computational and neural approaches (see Stewart et al., 2014). These databases are, therefore, extensively applied in distinct fields.

Finally, this review was also motivated by the interest in identifying potentially relevant normative datasets of imagens of common objects that might constitute useful resources for researchers. Choosing the adequate database depends on the goals of the research, availability of images and norms, the reported dimensions and the context in which the norms were produced. Databases that provide norms for several dimensions and a diversity of cross-cultural examinations (e.g., S&V,1980; BOSS database; Multipic), present higher application potential. The reliability of the norms by dimension constitutes one of the parameters for choosing a suitable dataset (Chichetti, 1994; Fischer and Milfont, 2010). Furthermore, datasets of specific subcategories of stimuli that address very specific dimensions, although not focused on this review, constitute a valuable effort in guaranteeing the maximum control while selecting stimuli (i.e., FRIDa database). Based on our review, we encourage the production and use of available databases with a high number of categories and items, rated in several dimensions in different linguistic and cultural contexts.

The present review provides useful guidance for the production of norms, as well as for selecting datasets and items for experimental/interventional contexts. The selection of such stimuli for research purposes, should consider theoretical assumptions, multidimensional inspections and simultaneous control of variables outside the research focus as well as their suitability for the research question, population and modulations of interest (see Constantinescu et al., 2016 for an example of systematic selection of stimuli within a dataset). In advancing the field, further normative studies should contemplate a diversified group of dimensions, combining dimensions and their domains (i.e., affective, semantic and perceptive) as well as exploring them within the same image corpus and, subsequently, replicate them in other interest samples. Moreover, the influence of the semantic domain of common objects (living vs. non-living) on the ratings across dimensions requires further examination. Finally, socio-demographic variables (e.g., age, gender, education) should also be attended when producing normative studies of images of common objects.

A possible limitation of the current study was the constrain of the dimensions during the initial search, even though this specification allowed a better identification of potential studies. However, an additional hand-search enlarged the scope of the restrictions imposed by the key-words used in the Boolean search. Moreover, the choice of a qualitative approach may have circumscribed the significance of our findings to a limited context. Nevertheless, the present qualitative review may contribute as a guideline for further normative research. Finally, the use of h-index values as a journal quality measure does not exhaust all the available quality criteria and further comparisons across several existing measures might help in selecting the most representative one.

Conclusion

Common objects are frequent and recognizable items that people encounter in their daily-lives. Therefore, they are recurrently used in several research and intervention domains. The normalization of this type of stimuli is imperative since they comprise specific characteristics and dimensions. Additionally, the use of poor-quality stimuli constitutes a constraint for scientific purposes, compromising the quality of the manipulations. The current review clearly indicates the need to produce further norms for realistic images of common objects in several dimensions across diverse linguistic and cultural contexts in a more systematic way as well as the necessity of advancing the normative field, namely in stimuli selection and standardization procedures. The main theoretical contribution of the current review is the endorsement of common objects as a broad category, with specific features, that deserves careful standardization for an optimal usage. Moreover, examining images of common objects as a distinct large category of images might emphasize their own relevance in the visual processing field and stimulate the production of new, robust and contextually-relevant datasets. From a practical perspective, the present review may inform future research designs (i.e., essential dimensions, methodological issues and findings, the selection of the stimuli) as well as help preventing the impact of undesirable confounding variables. Finally, normalizing materials with the purpose of safeguarding the quality of procedures - being they experimental or interventional - is an important research field on its own. Therefore, the current review emphasizes the normalization of visual stimulus as more than a procedure related to the researchers´ everyday practices, but as a wide and rich research topic that should be acknowledged as such.

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Supplemental materials can be found in the Open Science Framework, through the link < https://osf.io/g7fe5/?view_only=87f99fd994794276aab3e159b9717d9f >.

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3.2. RealPic: Picture norms of real-world common items

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Abstract

Pictures are often used as stimuli in several fields, such as psychology and neuroscience. However, co-occurring image-related properties might impact their processing, emphasizing the importance of validating such materials to guarantee the quality of research and professional practices. This is particularly pertinent for pictures of common items both because of the high associated knowledge they prompt and their wide applicability potential. Normative studies have already been conducted to create and validate such pictures, yet most of them focused on stimulus without naturalistic elements (e.g., line-drawings). Norms for real-world pictures of common items are rare and their normative examination does not always simultaneously assess affective, semantic and perceptive dimensions, namely in the Portuguese context. Real-world pictures constitute pictorial representations of the world with realistic details (e.g., natural color or position), thus improving their ecological validity and their suitability for empirical studies or intervention purposes. Consequently, the establishment of norms for real-world pictures is mandatory for exploring their ecological richness and to uncover their impact across several relevant dimensions. In this study, we established norms for 596 real-world pictures of common items (e.g., tomato, drum) selected from existent databases and distributed into 12 categories. The pictures were evaluated on nine dimensions by a Portuguese sample. The results present the norms by item, by dimension and their correlations as well as cross-cultural analyses. RealPic is a culturally based dataset that offers systematic and flexible standards and is suitable for selecting stimuli while controlling for confounding effects in empirical tasks and interventional applications.

Keywords: Norms; Real-world pictures; Affective; Perceptive; Semantic; Cross-cultural analysis.

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Introduction

Pictures are often used as visual stimuli to access or even improve psychological processes (e.g., Brady et al., 2008; Caramazza & Konkle, 2013). However, pictures are complex stimuli, and their characteristics may influence several cognitive and affective processes (Boukadi et al., 2016; Reppa & McDougall, 2015). Therefore, their careful production and validation are essential to guarantee the quality of experimental and interventional designs and to provide comparable results across studies (see Snodgrass & Vanderwart, 1980). Specifically, the assessment of pictures and their characteristics permits the control of their impact on psychological processes, enabling the systematic manipulation of their relevant properties while reducing bias introduced by similar/correlated dimensions (Brodeur et al., 2010; Snodgrass & Vanderwart, 1980).

Critically, validation endeavors require time and precise procedures. In order to overcome this time-consuming task, several databases have been produced and made available to the scientific community. The seminal work by Snodgrass and Vanderwart (1980) constitutes one of the most cited datasets of line drawing pictures of common items (e.g., animals, fruits, tools), with more than 4.000 and 6.000 citations in SCOPUS and Google Scholar respectively (Souza et al., 2020). Subsequently, several studies replicated and extended this work to different cultures and languages (e.g., Rossion & Pourtois, 2004; Sanfeliu & Fernandez, 1996), to increased numbers and types of pictures (e.g., Cycowicz et al., 1997; Rossion & Pourtois, 2004) and to different age groups (e.g., Pompéia et al., 2001; Yoon et al., 2004). Recently, the MultiPic dataset presented an extensive open-access sample of normalized colored line drawings of common items from the same source, evaluated in name agreement and visual complexity, in six different languages (Duñabeitia et al., 2018).

Notwithstanding the relevance of the existing databases, the importance of using pictures somewhat closer to the real world in experimental studies has also been acknowledged (e.g., Felsen & Dan, 2005). This concern has motivated the production of more realistic databases (e.g., Foroni et al., 2013; Garrido et al., 2016), which include real-world pictures with vivid and realistic details (e.g., photos) that are suitable for research and intervention.

Common items refer to items of common name concepts that are easily found in our daily lives. Therefore, pictures of common items are particularly useful for research, such as in semantic memory studies with a focus on semantic properties/structure or, dissociation of categories, as well as in the evaluation of amnesic conditions (e.g., Caramazza & Sheldon, 1998; Farah et al., 1989; Rogers et al., 2015). Considering their high application potential, this type of stimuli may be improved by such ecological concern. However, normative studies that produced and validated real-world pictures of common items are still scarce (e.g., Brodeur et al., 2014; Moreno-Martinez & Montoro, 2012; Shao & Stiegert, 2016). One of the best-known databases of real-world pictures of common items is the Bank of Standardized Stimuli (BOSS) developed by Brodeur and colleagues (2010, 2012, 2014). This database includes a wide range of pictures (930 validated images) of different categories, rated on several attributes (e.g., familiarity, manipulability, visual complexity) and freely available online.

Another validated ecological database was offered by Moreno-Martinez and colleagues (2011, 2012), and includes real-world pictures of common items, evaluated, among others, for typicality and manipulability.

Despite the relevance of such databases, the systematic and simultaneous examination of measures from affective, semantic/linguistic and perceptive dimensions of the same set of pictures is not yet available. For example, the BOSS database (Brodeur et al., 2010, 2012, 2014) extensively explored semantic and perceptive dimensions but the affective ones were not investigated. Moreno and colleague's databases (2011, 2012) present picture norms by categories but do not address category agreement or any affective dimensions.

In addition, databases with improved ecological validity require careful consideration of important image properties related to their ecological richness (e.g., size, view, color parameters). An example of this concern is provided in FRIDa [Foodcast Research Image Database] (Foroni, et al., 2013), which controlled surface parameters (e.g., brightness and color) while producing norms for real-world pictures of foods and common objects in several important and little explored dimensions, such as aesthetic appeal, valence, arousal, typicality and ambiguity. Rossion and Pourtois (2004) have already shown the advantage in accuracy and reaction times for naming colored line-drawings (vs. black-and-white and gray-scale ones) on a timed vocal naming task. Overall, ignoring such properties implies overlooking additional variables that might affect picture processing.

Another important feature to consider in the validation of real-world pictures is the linguistic and/or cultural context in which the data are produced. Cross-cultural comparisons have shown that some picture attributes, particularly those related to semantic dimensions (such as familiarity, category agreement, conceptual agreement and name agreement), are culturally based (Duñabeitia et al., 2018; Kremin et al., 2003; Székely et al., 2004; Yoon et al., 2004). For example, Duñabeitia et al. (2018) provided subjective ratings of name agreement and visual complexity for colored line drawings in six different European languages across seven European countries. Their findings demonstrated that linguistic similarities are not enough to guarantee the absence of variations in naming (Duñabeitia et al., 2018), since differences were observed for the same language in different cultural contexts (e.g., Dutch-speakers from different countries did not provide the same name for all pictures). Thus, inspecting cultural-based differences is crucial for a better understanding of the way some features of picture processing depend on the cultural background.

To the best of our knowledge, the BOSS is the only real-world pictures database of common items that has been extensively examined in different cultures and languages (Brodeur et al., 2012; 2014; Clarke & Ludington, 2017). These studies provided interesting inputs regarding culturally based (i.e., English, French, Chinese and Thai) and also linguistic-based differences (i.e., French vs English speakers living in Canada). In the Portuguese context, there are some recently validated picture databases, although they mainly report affective dimensions and none of them focused on real-world pictures of common items (e.g., Garrido et al., 2016; Prada et al., 2016; 2017; Rodrigues et al., 2018).

Importantly, the referred studies did not explore cross-cultural differences, nor relevant dimensions, such as typicality, name agreement or category agreement as well as their interaction.

The current work presents a comprehensive, culturally-based, normative study of real-world pictures of common items and includes a systematic validation of several dimensions of picture processing conducted with a Portuguese sample. Specifically, RealPic establishes subjective norms for real-world pictures of 596 common items, selected from existent normalized databases, in nine measures from affective, semantic and perceptive dimensions. These dimensions were selected based on the need to extend existing norms to traditionally less studied dimensions (i.e., arousal, valence, picture-name agreement, and aesthetic appeal) in addition to the most commonly explored ones (e.g., name agreement, familiarity, visual complexity; for a review see Souza et al., 2020).

Dimensions of interest

Category agreement is a relevant indicator that provides general knowledge information about how category membership is processed (see Clarke & Ludington, 2017). The category influence has been observed across several variables, such as familiarity, lexical frequency and typicality (Brodeur et al., 2012; Foroni et al., 2013; Moreno-Martinez, et al., 2011; Rossion & Pourtois, 2004). Categorization may also depend on domain specificities, with living-things processed differently from non-living ones (Caramazza & Sheldon, 1998; Warrington & McCarthy, 1987). Domain effects reflect evolutionary aspects (Caramazza & Sheldon, 1998) that are expected to influence several variables, such as typicality (Moreno-Martinez et al., 2011) and arousal (Foroni et al., 2013) or even present cultural variance (see Na et al., 2017). Therefore, it seems critical to normalize the stimulus regarding category agreement and to explore the relation that such semantic content presents with other dimensions in a culturally-based manner.

Name agreement refers to the consensus of an individual semantic representation in capturing the most appropriate name as a label for each picture (Pompéia et al., 2001; Snodgrass & Vanderwart, 1980). Name agreement appears to be a consistent measure that is relatively independent of pure language variations as suggested in studies conducted in different languages within the same cultural environment (Brodeur et al., 2012). However, other measures of naming abilities were shown to be affected by linguistic (Kremin et al., 2003; Yoon et al., 2004) and cultural variations (Boukadi et al., 2016; Cycowicz et al., 1997; Duñabeitia et al., 2018). Given its importance to several aspects of pictures and related concept processing (e.g., naming time - Dell´Acqua et al., 2000; reading aloud - Boukadi et al., 2016), the identification of the most common name of the pictures and its variability in a given language assumes particular relevance in picture normalization studies.

Familiarity reflects the degree to which someone interacts or thinks about a specific concept or item-concept in everyday live (concept frequency; Snodgrass & Vanderwart, 1980) and seems to be influenced by characteristics of the respondents such as age, native language and social context (Pompéia et al., 2001). Previous studies suggest that familiarity influences several psycholinguistic measures of picture processing, being positively related with lexical frequency, percentage of name agreement, and typicality, although inversely correlated with visual complexity (see Brodeur et al., 2014; Moreno-Martinez et al., 2011; Snodgrass & Vanderwart, 1980). Familiarity is also a good predictor of affective ratings, showing positive correlations with valence and arousal (Garrido & Prada, 2017; Prada et al., 2016). This dimension has been largely addressed across line-drawing normative studies and may be particularly relevant for real-world pictures of common items.

Typicality refers to how well a given exemplar represents a category (Medin et al., 2007; Murphy et al., 2012). It is dependent of the number of features shared between the item and its own category (e.g., "having feathers", "having beaks", into the category "Birds"). Previous studies have shown that less typical items (i.e., items that share less features with their categories) are perceived as less familiar (Moreno-Martinez & Montoro, 2012; Moreno-Martinez et al., 2011, but see Dell´Acqua et al., 2000 for other results), more ambiguous (Foroni et al., 2013), more complex (Moreno-Martinez & Montoro, 2012) and named slower (Dell´Acqua et al., 2000). Although not well explored, typicality is a valuable dimension and examining its interaction with other dimensions may be beneficial to avoid confounding effects.

Arousal represents the emotional activation elicited by an item usually reported in a scale varying from calm to excitatory levels (Foroni et al., 2013; Russell, 1980). In previous studies evaluating symbols, arousal ratings presented a positive correlation with familiarity, aesthetic appeal, visual complexity, concreteness and valence (Prada et al., 2016). Furthermore, previous studies using pictures of food, objects and natural items showed that, overall, arousal presented a positive correlation with valence and also with typicality for natural items but a negative one with familiarity for objects (Foroni et al., 2013). However, normative studies with real-world pictures of common items from different categories have often neglected this dimension.

Aesthetical appeal refers to a preference judgment of beauty based on the capability of an item in attracting interest based on visual liking experience (Prada et al., 2016; Reber et al., 2004). It is a multi-dimensional variable that plays an important role in visual tasks since it entails several features of the aesthetic experience (Reppa & McDougall, 2015), such as surface details of the picture, meaningfulness of the concept or even self-preferences. However, aesthetical appeal is one of the least explored dimensions in picture norms studies.

Valence indicates to which extent an image elicits different degrees of pleasant-unpleasant emotionality (Prada et al., 2014; Russell, 1980). Valence is positively correlated with familiarity, typicality and arousal (Foroni et al., 2013; Prada et al., 2010; Prada et al., 2018) – independently of the item category – and also with aesthetic appeal and visual complexity (Prada et al., 2016), emphasizing the relevance of its inspection in real-world pictures.

Visual complexity is an image-based measure focused on surface features of image quality parameters (i.e., color, shape, brightness, luminosity, contrast, size, complex/simple lines). Snodgrass and Vanderwart (1980) have shown that visual complexity varies as a function of category-specificity. It is also recurrently negatively correlated with familiarity (Brodeur et al., 2012; Brodeur et al., 2014;

Pompéia et al., 2001; Prada et al., 2016; Snodgrass & Vanderwart, 1980). Highly complex items modulate category agreement and naming abilities (Brodeur et al., 2014), and are perceived as more appealing, positive and arousing (Prada et al., 2016). It is, therefore, a mandatory dimension in the validation of pictures, particularly real-world pictures due to their realistic surface parameters.

Picture-name agreement refers to the agreement between a concept and its related pictures, often indicated as a viable alternative to measure picture effectiveness in representing the intent concepts (Snodgrass & Vanderwart, 1980). Picture-name agreement is particularly relevant because it allows a direct (based on the concept) way of capturing the agreement between an image and its mental representation (Johnston et al., 2010; Sanfeliu & Fernandez, 1996; Snodgrass & Vanderwart, 1980). Picture-name agreement is positively correlated with categorization (see Sanfeliu & Fernandez, 1996), name agreement (Morrison et al., 1997), and with image agreement (Snodgrass & Vanderwart, 1980), although negatively correlated with familiarity (Sanfeliu & Fernandez, 1996). Its standardization is crucial in real-world pictures as these pictures may not be equally good in visually representing the concepts (e.g., due to different angles and details).

The inspection of such dimensions across languages and cultures may provide important cues about the consistency and generalizability of the norms produced (see Moreno-Martinez & Montoro, 2012; Prada et al., 2017). Therefore, the adaptation of the stimulus sets to different countries enables a more appropriate selection of stimuli regarding linguistic and culturally-dependent aspects, assuring an effective manipulation of stimuli for further empirical or interventional purposes.

The main goals of this research were therefore to (1) establish culturally-based norms of pictures of common items for the Portuguese context; (2) expand and increase the diversity of parameters standardized in previous studies, namely simultaneously examining affective, semantic and perceptive dimensions using systematic procedures; (3) inspect the consistency of such norms through cross-cultural comparisons.

Methods

Participants

Participants were recruited online through social networks (e.g., Facebook). Participants had to meet all the following criteria: 1) be a native speaker of European Portuguese, 2) be older than 18 years old, 3) have a minimum of four years of formal education; and 4) have their vision preserved or corrected. A sample of 759 participants volunteered to participate in the study. Fifty-nine participants who did not complete at least 50% of the survey and another 16 for not meeting the inclusion criteria were excluded. Overall, the final sample included 684 participants (472 female), with 72.1% completing the entire survey. Participants' age ranged from 18 to 65 years-old, the majority (72.95%) being young adults (age range:18-34), 20.18% mid-aged adults (age range: 35-54) and 6.9% older adults (above 55 years old). The sample reported high education levels (25.4 % post-graduation; 42.1% undergraduates; 32.5% other).

Stimuli

The stimulus set consisted of 718 pictures: 357 were selected from the BOSS database (Version 1, Brodeur et al., 2010; and Version 2, Brodeur et al., 2014), 183 from Moreno-Martinez and colleagues (2011; 2012) databases, 127 from Konklab database (Brady et al., 2008) and 51 from other free databases licensed for non-commercial usage (e.g., Flirk, Pixabay, Wikipedia). The stimuli were divided into 12 previously defined categories from living (mammal, fruit, vegetable, birds, insects) and non-living (clothing, vehicles, kitchen utensils, musical instruments, furniture, desk materials, tools) domains based on their occurrence in everyday-life, their diversity and their application potential (see Moreno-Martinez & Montoro, 2012, for a similar procedure).

Pictures were resized to 500 X 500 pixels and depicted against a white background. The pictures were previously inspected for their quality during two independent phases using subjective and objective procedures. First, in a pre-selection phase, the most culturally suitable Portuguese name for the item original name was established. Subsequently, four independent raters, native speakers of European Portuguese and completely naïve to the goals of the study, were asked to provide the most appropriate name for the pictures (i.e., two raters named half of the items and the other two the remaining half). Inter-rater agreement was high for both pairs of raters[4] (84% and 79%, respectively). Disagreements between raters were resolved by the first two authors. Overall, these evaluations established the appropriateness of the previously defined name for each item. These two judges also confirmed the suitability of the items for the target categories (see the final distribution of pictures per categories in Table 1). Additionally, the first sample of naïve judges was also asked to rate all items regarding their visual quality on a 10-point scale ranging from 1-*very poor quality* to 10- *very good quality*. These procedures lead to the exclusion of 98 pictures (13.64%) that were overall unrecognized/unnamed either due to cultural inadequacy (e.g., the fruit “pecan” or the animal “nyala” are rare or unknown in the Portuguese context), the goodness of the picture in representing the concept (e.g., an image of a “crib” that was not named by any judge) or redundancy (e.g., image of a daddy long leg spider and image of a widow spider being always named as spider). Additionally, twenty-four pictures (3.35%) from the overall sample evaluated as having low quality (i.e., rated below 6 on the quality scale) were excluded. Based on these evaluations 596 (83.01%) out of 718 photographs (119 from BOSS v.1; 175 from BOSS v.2; 158 from Moreno-Martinez & Montoro, 2012; and 144 from other sources) were selected. Each category included about 50 pictures. In a second phase, the color parameters (i.e., RGB and luminance) were also examined to ensure that the visuo-perceptual characteristics were consistent across pictures and to minimize their effect on the ratings of other dimensions. Therefore, a random sample (about 60% of the items) of 356 photographs (from 596) was examined regarding the uniform distribution of RGB

[4] The agreements were obtained by calculating the percentage of inter-rater agreement for each pair of judges in the cases when they agreed about the target name (i.e., % with which each pair of raters agreed on the name assigned to the picture).

and perceived luminance parameters[5] in order to confirm the quality of the selected pictures across domains.

Table 1. Distribution of Items by Categories and Domains

Living things (242)	Non-living things (354)
Birds (50)	Clothing (50)
Fruits (47)	Desk material (50)
Insects (47)	Furniture (48)
Mammals (49)	Kitchen utensils (57)
Vegetables (49)	Musical instruments (50)
	Tools (49)
	Vehicles (50)

Procedure

The study was conducted using the Qualtrics software. After reading the informed consent (including general information, inclusion criteria and ethical information) and agreeing to participate, participants provided sociodemographic information (i.e., age, education, gender and native language). The task instructions were presented, followed by a brief description of each of the dimensions in which pictures should be evaluated. Participants were asked to rate, in seven dimensions, a subset of 40 pictures from different categories randomly selected from a pool of 596 (see Alario & Ferrand, 1999; Brodeur et al., 2014; Cycowicz et al., 1997; Tsaparina et al., 2011 for similar procedures). Additionally, participants were asked to provide a name (name agreement task) and a category (category agreement task) to each picture.

A minimum of 30 evaluations per picture was established, in line with several normative studies using visual stimulus (Brodeur et al., 2010: N = [33, 39]; Brodeur et al, 2014: N = [32, 42]; Johnston et al., 2010: N = [25, 31]; Garrido et al., 2016: N = 30). After treating the data, the number of ratings per picture in each of the seven dimensions ranged from 27 to 34 (M = 30.61, SD = 1.783 to M = 31.20, SD = 1.890). For name agreement and picture name agreement responses per picture ranged from 29 to 57 (M = 32.35, SD = 1.890).

The task was divided into three blocks. Block A included the object-based measures: familiarity, arousal and valence ratings; Block B contained the image-based measures: Visual complexity and Aesthetical Appeal ratings; and Block C consisted of conceptually-based measures such as Name Agreement, Category Agreement, Picture-name Agreement and Typicality. Blocks A and B were randomly presented between participants as well as the order of the dimensions in each Block. Block C

[5] The surface characteristic of the photographs presented a similar pattern of color (RGB) and luminance distribution (LP) across pictures from different domains. Indeed, planed comparisons revealed that there were no significant differences between the images included in the living and non-living domains [R: $t(403) = 2.31$, $p = .210$; G: $t(403) = 1.53$, $p = .127$; B: $t(403) = .53$, $p = .593$; LP: $t(403) = 1.61$, $p = .109$]. Statistical information regarding these parameters is useful to assure the consistency of the representational quality across the images once it represents an objective measure of visual complexity (see Shao & Stiegert, 2016). For more details see Supplemental Materials.

was always presented at the end, with a fixed order of dimensions[6]. The dimensions were rated on a 7-point scale (see Table 2), except the naming and the categorization tasks that required a written response (Snodgrass & Vanderwart, 1980). The definition, the scales and the main references for each dimension are presented in Table 2.

Table 2. Instructions and their References for Each Dimension

Dimension	*English version*	Main references
	Block A (random)	
Familiarity	*Object familiarity:* you should consider how often you find the picture represented in the image in your daily life, indicating how familiar this stimulus is. Frequently encountered items are usually considered more familiar. For example, an "Apple" is a very familiar fruit, but not a "Guava". Scale: 1-*unfamiliar* to 7-*very familiar*	Brodeur et al. (2010); Foroni et al. (2013); Prada et al. (2016); Snodgrass & Vanderwart (1980);
Arousal	*Activation capacity of the object:* you should indicate to which extent you consider that this object represents something active/intense or passive/calm Scale: 1-*very passive/calm* to 7-very active/intense	Foroni et al. (2013); Garrido et al. (2016)
Valence	*Valence of the object:* you should consider to which extent this item refers to something positive/pleasant or negative/unpleasant. Scale: 1-*very negative/unpleasant* to 7-*very positive/ pleasant*	Prada et al. (2014); Prada et al. (2016)
	Block B (random)	
Visual complexity	*Visual complexity of an image:* you should evaluate the degree of picture elaboration regarding its visual details (quantity of details, lines patterns, quantity of colors), You should consider the complexity of the visual characteristics of the picture presented, but not the actual object or concept represented. The greater the amount of details/elaboration the more complex the image is. Scale: 1-*very simple* to 7-*very complex*	Brodeur et al. (2010); Cycocwcz et al. (1997); Pompéia et al. (2001); Prada et al. (2016); Snodgrass & Vanderwart (1980);
Aesthetic appeal	*Pleasantness of the image:* you should consider how visually appealing the image is, considering its visual characteristics and not the associated concept or object. Scale: 1-*visually unpleasant/unappealing* to 7- *visually pleasant/appealing*	Prada et al. (2016)
	Block C (fixed order)	
Name agreement and Category agreement	First, you will be asked to identify the item represented on the picture (write the first name that comes to your mind) and its category. Be succinct and write only one name, without ambiguity. For example, when see an image of a "sunflower", you should write "sunflower" as name response and "flower" as category response. If you do not know the object/category, you should respond "I do not know the object/category". In situations where you identify the object/category, but do not remember the name, answer "I do not know the name of the object/category". However, if you recognize the object/category and know the	Pompéia et al. (2001); Snodgrass & Vanderwart (1980)

[6] The task order in Block C (conceptually-based) was maintained considering the need to obtain a written modal name and modal category for each item before presenting the target name and target category for each image on Picture-name agreement and Typicality rating tasks, respectively.

	name but cannot remember it at the moment, say "I do not remember the object/category name".	
Picture-name agreement	*Congruence between image and name:* you should evaluate to which extent the image corresponds to a good representation of the name presented. Scale: 1-*very poor representation of the name* to 7-*excellent representation of the name*	Morrison et al. (1997)
Typicality	*Typicality:* you should evaluate to which extent the object is a good example of the indicated category. Consider the representativeness of the stimulus relative to the category, regardless of the frequency you encounter the object in your daily life or your personal preferences. For example, a "Church" can be found frequently, but it will not be a very representative item of the "Buildings" category. The objects considered the best exemplars are the most typical. Scale: 1-*very bad example of its category* to 7- *excellent example of its category*	Foroni et al. (2013); Moreno-Martinez et al. (2011; 2012)

Results

In this section we present: 1) Preliminary data analysis; 2) Item norms; 3) Descriptive results by evaluative dimension and correlations between dimensions; 4) Linguistic attributes analysis; and 5) Cross-cultural/linguistic data.

Preliminary data analysis

Preliminary analysis of all rated dimensions included the examination of biased inputs and transformations from absolute frequencies to proportional scores. Outliers' analysis followed a criterion of 2.5 standard deviations above or below the mean rating per picture in each dimension (Garrido et al., 2016). Since the occurrence of outliers in all dimensions was very low (range: 1% to 3%), and there was no overall indication of systematic or extremely biased responses, no data were excluded. Missing values were below 5% of the entire database across all rated dimensions. After data treatment, the analysis was run by-item (instead of by participants). The mean ratings (i.e., sum of ratings/N of evaluations per image) and standard deviations were obtained for each image in each dimension. Additionally, a normality test based on curves' peaks and extremities of the distributions indicated that all rated dimensions followed a normal distribution with acceptable values of Kurtosis and Skewness (between ±2; Gravetter & Wallnau, 2014).

Data pre-processing was also conducted for the two linguistic dimensions (i.e., name agreement and category agreement). These dimensions were obtained with free response which provided several linguistic attributes (i.e., modal name-agreement, modal category agreement, alternative valid names/categories, percentage of correct responses and modal responses, and h-value of agreements). Each response was analyzed regarding qualitative (written response) and quantitative (number of references to a given response) parameters. The number of different acceptable responses was quantified for each picture. This procedure included a first inspection for typing variants of the name (e.g., plural, gender, hyphen, composite names with different order, presence of determinants/adjectives/verbs) and spelling mistakes/errors (see Brodeur et al., 2014 for similar procedure). Basic level concepts (e.g., "bird" in reference to "cardinal") and regional variants ("robe", in English *robe*, or "roupão", in English *gown*) were considered as correct. Complete descriptions (e.g., "red orange") were considered different descriptions from summarized ones (e.g., "orange"). Incorrect, don't know and tip-of-the-tongue responses were not considered for further analysis[7].

Item norms

The entire RealPic dataset of norms is provided (Supplemental Materials, Table 1). Detailed information for each item is presented, including: item original database, item original name (i.e., from the original database), item Portuguese target name and item target category. For the seven rating scales, the means and standard deviations, frequencies (number of ratings for each item) and confidence intervals (CI) at 95% are also presented. Additionally, the CI's were used to classify the stimuli as low, moderate or high in each measure (Prada et al., 2016; Rodrigues et al., 2018). Whenever the CI included the scale midpoint (i.e., 4) the items were considered "moderate"; when the upper bound was lower than 4, the items were considered "low"; and when the lower bound of the CI was higher than 4, the items were considered "high" (see Supplemental Materials, Table 1). Overall, the obtained normative data is composed of items with a considerable variability in Arousal (175 high, 271 moderated, 150 low), Aesthetic appeal (219 high, 271 moderated, 106 low) and Visual complexity (108 high, 277 moderated, 211 low). The variability of the ratings for Typicality (493 highly typical items), Familiarity (406 highly familiar items) and Picture-name agreement (526 high agreement) was lower. Valence ratings (77 low) were moderate to high.

Descriptive results and correlations by evaluative dimension

Descriptive statistics (mean ratings, standard deviations, confidence intervals, skewness and kurtosis) for each of the seven rated dimensions are provided in Table 3. Overall, the means varied in all the dimensions (see Table 3). Additionally, all the dimensions presented significant differences from the scale midpoint ($p < .05$; see Prada et al., 2018 for further methodological details), with the dimensions of Picture-name agreement presenting the highest mean ratings, and visual complexity presenting the lowest mean ratings.

Overall, the mean ratings of the seven dimensions presented significant correlations ($p < .05$). Comments on moderate to very strong correlations (Evans, 1996) are provided (see Table 4 for all pearson´s *r* results). significant correlations involving less explored dimensions (i.e., typicality, arousal, valence and aesthetic appeal) in previous normative studies are also reported even if weak.

[7] The pre-processed responses together with the absolute frequencies for each type of response are available at OSF (https://osf.io/qn35s/?view_only=9c209e9236b94b2cb74f77f47e7ff390) and unfiltered data may be provided upon request to researchers interested in analysing such variations. Considering that images were evaluated in other dimensions, no picture was excluded from the dataset based on low name/category agreement scores.

Table 3. Descriptive Statistics for All Items in Each Dimension

	Familiarity	**Typicality**	**Arousal**	**Valence**	**Aesthetical Appeal**	**Visual Complexity**	**Picture-name Agreement**
Mean	5.394	5.747	4.077	4.604	4.255	3.756	6.036
SE of Mean	.045	.040	.037	.039	.037	.036	.036
SD	1.120	.971	.908	.958	.913	.890	.890
Range	2.00-7.00	2.24-7.00	2.24-6.44	1.56-6.70	1.59-6.70	1.69-6.32	2.00-7.00
Skewness	-.738	-.954	.370	-.676	-.129	-.044	-1.143
SE of Skewness	.100	.100	.100	.100	.100	.100	.100
Kurtosis	-.187	.143	-.725	.436	-.032	-.601	.665
SE of Kurtosis	.200	.200	.200	.200	.200	.200	.200
95% IC Low	5.304	5.668	4.004	4.527	4.182	3.684	5.964
95% IC Upper	5.484	5.825	4.150	4.681	4.329	3.827	6.107

Note. Means, Standard Error (SE), Standard Deviation (SD), Range interval (minimum and maximum), Normality estimation (kurtosis and skewness) and Confidence Intervals at 95% for low and upper cut-offs are provided.

Table 4. Pearson´s r Correlation Values for all Rated Dimensions

	1	**2**	**3**	**4**	**5**	**6**	**7**
1. Familiarity	--						
2. Typicality	.255**	--					
3. Arousal	-.188**	.107*	--				
4. Valence	.431**	.139**	-.288**	--			
5. Aesthetic Appeal	.342**	.190**	-.092*	**.906****	--		
6. Visual Complexity	-.459**	-.044	.519**	-.053	.097*	--	
7.Picture-name agreement	**.686****	.172**	.039	.333**	.310**	-.205**	--

*$p < .05$ (two-tailed); **$p < .01$ (two-tailed).
Note. Significant and strong correlations are presented in bold.

The results showed a positive strong correlation ($r > .60$) between familiarity and picture-name agreement. in line with previous findings for photos and line-drawings (Saryazdi et al., 2018), items rated as more familiar also presented increased picture-name agreement. Moreover, moderate correlations ($r > .40$) between familiarity and visual complexity as well as familiarity and valence were also observed. Specifically, items rated as less visually complex were considered more familiar (Brodeur et al., 2014; Moreno-Martinez & Montoro, 2012; Sanfeliu & Fernandez, 1996; Shao & Stiegert, 2016; Snodgrass & Vanderwart, 1980; but see Brodeur et al., 2010 for different results) and more positive (see Foroni et al., 2013, for a similar result). Although weak ($r < .40$), some significant correlations presented relevant indicators about the typicality dimension. For instance, typicality was positively correlated with familiarity, confirming previous findings (Moreno-Martinez et al., 2011; Moreno-Martinez & Montoro, 2012), as well as with all the other dimensions ($p < .05$), except visual complexity ($r < .20$).

Visual complexity showed a moderate and positive significant correlation with arousal ($r = .519$). Items rated as complex were also significantly rated as more exciting/arousing. Significant (but weak) correlations between picture-name agreement and valence, typicality, aesthetic appeal (all positive) and visual complexity (negative), were also observed.

The very strong correlation ($r > .80$) observed between valence and aesthetical appeal indicates that the items rated as more positive were also considered more visually appealing. Even though presenting weak correlations ($r < .40$), the significant negative correlations between arousal and aesthetic appeal, valence, and familiarity contrast with the results from previous studies using other type of stimuli in which these correlations were also weak but positive (see Garrido et al., 2016; Prada et al., 2016; Rodrigues et al., 2018). However, the negative correlation between arousal and familiarity is consistent with previous findings using real-world pictures of natural items (see Foroni et al., 2013). The observed correlation between aesthetic appeal and familiarity has also been reported in previous studies using different type of stimuli (e.g., McDougall & Reppa, 2008; Prada et al., 2016; Rodrigues et al., 2018).

Partial correlations were also obtained to control the influence of categories in the correlations between dimensions (see Table 5). Overall, the significant strong correlations reported remained when controlling for categorical effects. Importantly, the positive correlation between typicality and familiarity increased from small to medium. The weak positive correlation between arousal and typicality previously reported without category control was the only one that was not observed with this new analysis.

Table 5. Partial Correlation for all Rated Dimension Controlled by Category

	1	2	3	4	5	6	7
1. Familiarity	--						
2. Typicality	$.312^{**}$	--					
3. Arousal	$-.168^{**}$	.072	--				
4. Valence	$.421^{**}$	$.173^{**}$	$-.277^{**}$	--			
5. Aesthetic Appeal	$.340^{**}$	$.209^{**}$	$-.087^{*}$	**$.907^{**}$**	--		
6. Visual Complexity	$-.454^{**}$	-.104	$.515^{**}$	-.045	$.101^{*}$	--	
7. Picture-name agreement	**$.679^{**}$**	$.172^{**}$	.059	$.324^{**}$	$.308^{**}$	$-.197^{**}$	--

$^{*}p < .05$ (two-tailed); $^{**}p < .01$ (two-tailed).
Note. Significant and strong correlations are presented in bold.

Interestingly, the most powerful correlations were observed among dimensions that were less reported in previous norms of real-word pictures (i.e., aesthetic appeal, valence, arousal and picture-name agreement). Nevertheless, such correlations were reported in normative studies using other type of stimuli (e.g., Prada et al., 2016; Rodrigues et al., 2018), which, together with our findings, emphasize the relevance of exploring these dimensions in real-world pictures.

Linguistic attributes analysis

Name and category agreement included three quantitative measures each: 1) the percentage of correct responses; 2) the percentage of the most common (modal) name/category for the item (e.g., cat / mammal); and 3) the statistic h-value[8]. Overall results are presented in Table 6.

Table 6. Descriptive Statistics for all Items in Each Linguistic Attribute

	Correct Naming (%)	%NA	H-VALUE NA	Correct Categorization (%)	%CA	H-VALUE CA
Mean	92.16	77.94	0.78	94.32	65.17	1.40
SE	0.480	0.924	0.04	0.004	0.008	0.034
SD	10.88	20.97	0.90	0.089	20.42	0.81
Skewness	-144.34	-66.35	1.26	-184.13	-9.38	0.44
Kurtosis	104.21	-78.91	1.00	357.14	-89.77	-0.20
95% CI Low	91.22	76.13	0.70	93.59	63.49	1.33
95% CI Upper	93.11	79.76	0.85	95.05	66.84	1.47

Note. NA- Name agreement; CA – Category Agreement; Means, Standard Error (SE), Standard Deviation (SD), Normality estimation (kurtosis and skewness) and Confidence Intervals at 95% for low and upper cut-offs are provided.

Regarding name agreement, the percentage of correct responses (92%) was above chance. Participants presented high modal name-agreement (modal NA: M = 77.94%, SE = 0.92), although considerable variability was observed in valid appropriate names (h-value of NA: M = 0.78, SE = 0.04). The correspondence between the target name and the modal name was observed in 71% of the 596 pictures. From the responses referring a modal name that was different from the established target name generally, 75.88% reflected culturally accepted general names (e.g., naming different types of spoons with the general concept "spoon", in European Portuguese "colher") or similar names (i.e., naming "tweezers", in European Portuguese "pinça", as an alternative for "tongs" that is "tenaz" in European Portuguese).

The category agreement results indicated an above chance percentage of correct categorization (94%). The modal category agreement was moderate (modal CA: M = 65%, SE = 0.008), and presented

[8] The h-value measure was used to standardize the name or category agreement scores considering the variability of correct names presented for each item. The h-value is inversely related to response-averages of the modal name (Snodgrass & Vanderwart, 1980). In the case, pictures with many attributed names tend to be more complex and each name seems to evoke different mental images. This statistic is sensitive to the diversity of concepts provided, considering the number and the frequency of other possible names (see Brodeur et al., 2014; Pompéia et al., 2001; Snodgrass & Vanderwart, 1980, for more details). To calculate the h-value of name or category, the commonly accepted formula (Brodeur et al., 2014; Snodgrass & Vanderwart, 1980) was used: $H = \sum_{i=1}^{k} P_i log_2\left(\frac{1}{P_i}\right)$, with k referring to the distinct acceptable denominations as correct naming/categorization for each image (excluding the forgettable answers - don't know, don't recognize or don't remember); Pi refers to the proportion of participants that provided an acceptable name/category to the image, excluding errors and forgettable answers. The h-value increases as the number of alternatives of correct names/categories increases. Pictures with a few variations in naming response will present an h-value closer to 0 (Snodgrass & Vanderwart, 1980).

high variability in the valid appropriate categories attributed by the participants (h-value of CA: M = 1.40, SE = .03), which was expected for this task procedure (i.e., free response). Additionally, the correspondence between the established target category and modal category agreement was observed for 79% of the pictures, with about 7% presenting different but culturally-accepted categories. For example, categorizing “child scooter” as a “toy” instead of “vehicles” or using appropriate non-target categories (e.g., naming “legume” for “vegetables”), more specific categories (e.g., “dry fruits” for “fruits”) or more general categories (e.g., “animals” for “mammals” items).

Detailed information about name and category agreement for the entire database and for each image can be found in Table 2 of the Supplemental Materials.

Cross-cultural/linguistic analysis

The current RealPic norms were divided into sub-sets according to their source (original dataset). The mean ratings[9] per item in each sub-set were contrasted with the norms reported in the original datasets: the BOSS dataset (v.1 - Brodeur et al., 2010; v.2 - Brodeur et al., 2014) and the ecological database of Moreno-Martinez and Montoro (2012) obtained with English-Canadian and Spanish samples, respectively (see Table 3, Table 4 and Table 5 of the Supplemental Materials). This analysis was conducted using univariate ANOVAs with 2 Sample (original subsample vs. RealPic) X 2 Domain (living vs. non-living) as factors for each common dimension in both datasets. The variable semantic domain was included in this analysis to provide a more robust inspection of cultural-based effects. Semantic processing involves general knowledge acquired during our life experiences which is related to the environmental context. The processing of non-living items (e.g., tools, furniture, vehicles, etc.) and living ones (e.g., mammals, fruits, birds, etc.) can therefore be influenced by socio-cultural factors, such as cultural values, social needs and evolutionary pressures (see Barbarotto et al., 2002; Na et al., 2017). Domain specificities have been extensively reported in the literature (see Caramazza & Konkle, 2013; Caramazza & Sheldon, 1998; Warrington & McCarthy, 1987; Warrington & Shalice, 1984). Bonferroni adjustment contrasts were used for inspecting main effects and t-tests to explore post-hoc interaction effects.

Regarding the comparison of RealPic (Portuguese) versus BOSS v.1 (Brodeur et al., 2010; English-Canadian; item distribution - living items: 31, non-living items: 88), the inspected dimensions were name agreement measures, familiarity and visual complexity. The ANOVA results showed a significant main effect of Sample across dimensions (all p’s < .05), except for visual complexity. Specifically, the Portuguese sample presented higher name agreement (BOSS v.1: M = 56.58, SE = 3.01; RealPic: M = 70.14, SE = 3.01) and more consistency in naming (h-value: BOSSv.1: M = 32.01, SE = 2.29; RealPic: M = 21.17, SE = 2.29). The Portuguese sample also rated the items as more familiar (BOSSv.1: M = 60.55, SE = 2.31; RealPic: M = 76.40, SE = 2.31). The main effect of Domain and its interaction with

[9] The transformation of scale scores using upper and lower limits in a 0 to 100 scale (see de Vaus, 2002) was applied to compare the means of each common dimension reported in the present norms (7-point scale) and the in the norms of the original databases (5-point scales).

Sample was not significant for any of the dimensions, indicating consistency across samples by Domain. See Table 7 for detailed results.

The ANOVA results for RealPic (Portuguese) versus BOSS v.2 (Brodeur et al., 2014; English-Canadian; item distribution – living items: 72, non-living items: 103) revealed a significant main effect of Sample across all naming dimensions (all ps < .05, see Table 7 for details). Specifically, the Portuguese sample was more accurate in naming (% name agreement- BOSS v.2: *M* = 59.01, *SE* = 1.80, RealPic: *M* = 73.65, *SE* = 1.80) and more consistent in the valid names provided (h-value - BOSS v.2: *M* = 38.41, *SE* = 1.54, RealPic: *M* = 17.11, *SE* = 1.54). In contrast with the above-mentioned comparison with BOSS v.1, the main effect of Domain was observed in all dimensions (all *p*´s ≤ .03). Living-things were rated as more visually complex (Living: *M* = 59.33, *SE* = 1.70; Non-living: *M* = 47.33, *SE* = 1.42), less familiar (Living: *M* = 63.76, *SE* = 1.67; Non-living: *M* = 68.45, *SE* = 1.39), presented higher name agreement (% of name agreement - Living: *M* = 71.21, *SE* = 1.95; Non-living: *M* = 61.45, *SE* = 1.63) and less variability in naming (h-value - Living: *M* = 23.22, *SE* = 1.67; Non-living: *M* = 32.30, *SE* = 1.39) than non-living things.

The interaction effect between Sample and Domain was significant for most of the dimensions (all *ps* ≤ .03; except for Familiarity, *p* = .44), with the Portuguese sample presenting higher name agreement (% of name agreement – Boss v.2: *M* = 66.81, *SE* = 2.77; RealPic: *M* = 75.61, *SE* = 2.77, *t*(142) = -2.44, *p* = .016) and less naming variability (h-value – Boss v.2: *M* = 30.29, *SE* = 2.36; RealPic: *M* = 16.15, *SE* = 2.36, *t*(136.499) = 5.09, *p* < .001) for living things. Living items were also evaluated as less complex by the Portuguese sample (BOSS v.2: *M* = 65.31, *SE* = 2.41; RealPic: *M* = 53.34, *SE* = 2.41, *t*(142) = 4.89, *p* < .001). Regarding the non-living domain, the Portuguese sample showed more agreement in naming (% of name agreement - BOSS v.2: *M* = 51.21, *SE* = 2.31; RealPic: *M* = 71.69, *SE* = 2.32, *t*(204) = -5.94 , *p* < .001) and less naming variability in comparison with the English sample (h-value - BOSS v.2: *M* = 46.54, *SE* = 1.98; RealPic: *M* = 18.07, *SE* = 1.98, *t*(197.806)= 9.22, *p* < .001), with no significant differences by sample for the remaining dimensions (all *p* > .20).

The ANOVA results for the RealPic (Portuguese) versus the Ecological database (Moreno-Martinez & Montoro, 2012; Spanish) inspected the dimensions of familiarity, naming agreement, typicality and visual complexity. The results showed a significant main effect of Sample, for familiarity and typicality (all *p* < .005). Portuguese participants rated the items as more typical (Ecological: *M* = 63.98, *SE* = 1.87; RealPic: *M* = 76.48, *SE* = 187) and familiar (Ecological: *M* = 62.82, *SE* = 1.86; RealPic: *M* = 70.45, *SE* = 1.86). Significant main effects of Domain (living: 73 items; non-living: 84 items) for visual complexity and familiarity (p´*s* < .02) were also observed, with living things rated as significantly less familiar (Living: *M* = 63.40, *SE* = 1.92; Non-living: *M* = 69.87, *SE* = 1.79) and as visually more complex (Living: *M* = 45.03, *SE* = 1.79; Non-living: *M* = 38.04, *SE* = 1.67) than non-living things. Moreover, significant interaction effects between Sample and Domain were found for name agreement measures (h-value and percentage of NA with p´*s* ≤ .02).

Table 7. Main Effects and Interaction Effects Between Sample and Domain Across Rated Dimensions

	BOSS v.1 (Eng) X RealPic (PT)			BOSS v.2 (Eng) X RealPic (PT)			Ecological database (Sp) X RealPic (PT)		
	Sample F(1,237) 90% CI	Domain F(1,237) 90% CI	Sample X Domain F(1,237) 90% CI	Sample F(1, 349) 90% CI	Domain F(1, 349) 90% CI	Sample X Domain F(1, 349) 90% CI	Sample F(1, 313) 90% CI	Domain F(1, 313) 90% CI	Sample X Domain F(1, 313) 90% CI
NA (%)	10.168^{**} $\eta_p{}^2$=.042 [.00, .09]	n.s.	n.s.	32.889^{***} $\eta_p{}^2$=.087 [.045, .13]	14.623^{***} $\eta_p{}^2$=.041 [.01, .07]	5.229^{*} $\eta_p{}^2$=.015 [.00, .04]	n.s.	n.s.	5.449^{*} $\eta_p{}^2$=.017 [0.00, 0.05]
H-value of NA	11.237^{***} $\eta_p{}^2$= .046 [.01, .09]	n.s.	n.s.	95.419^{***} $\eta_p{}^2$=.216 [.15, .27]	17.341^{***} $\eta_p{}^2$=.048 [.02,.08]	10.797^{***} $\eta_p{}^2$=.030 [.00, .06]	n.s.	n.s.	6.453^{*} $\eta_p{}^2$=.020 [0.00, 0.05]
Visual Complexity	n.s.	n.s..	n.s.	n.s.	29.291^{***} $\eta_p{}^2$=.078 [.03, .13]	13.130^{***} $\eta_p{}^2$=.037 [.01, .07]	n.s.	8.140^{**} $\eta_p{}^2$=.026 [0.00, 0.06]	n.s.
Familiarity	23.408^{***} $\eta_p{}^2$= .091 [.04, .15]	n.s.	n.s.	n.s.	4.643^{*} $\eta_p{}^2$=.013 [.00, .03]	n.s.	8.447^{**} $\eta_p{}^2$=0.027 [0.00, 0.06]	6.080^{*} $\eta_p{}^2$=0.019 [0.00, 0.05]	n.s.
Typicality	-----	-----	----	----	----	----	23.655^{***} $\eta_p{}^2$=.071 [.03, .12]	n.s.	n.s.

$^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$.
Note. n.s. – non-significant; Eng – English language; PT – Portuguese language; Sp: Spanish language; NA – Name Agreement.
Statistical F(F), eta partial effect size ($\eta_p{}^2$) and Confidence Intervals (90%CI) in brackets [ ] are provided for significant differences.

The Portuguese sample presented less variability in naming living-things (h-value - Ecological: M = 28.45, SE = 2.82, RealPic: M = 17.02, SE = 2.82, t(132.536) = 2.93, p = .004) but no significant differences between samples were observed for non-living things (all p > .1). No differences across cultures were found in the remaining dimensions for living-things and non-living things (all p >.1). Statistical details are provided in Table 7.

Discussion

The present study systematically compiled stimuli and extended norms for real-world pictures in nine dimensions comprising the affective, semantic and perceptive domains. RealPic dataset includes a considerable range of pictures distributed across several categories (see Santi et al., 2015). To the best of our knowledge, few normative datasets normed such type of stimuli in the Portuguese context (e.g., Prada et al., 2010; Prada et al., 2014) and none of them includes standards for such a variety of dimensions.

Overall, the results indicated that the RealPic dataset comprises items that are highly familiar, typical, positive, somewhat arousing and visually appealing, medium to low in complexity and presenting high agreement between picture and name. These results are in line with previous studies using real-world pictures of common items, in which those stimuli were rated as relatively complex and presented optimal object agreement (Brodeur et al., 2010; Brodeur et al., 2014). The results also indicate that this type of pictures are less subject to negative feelings (see also Prada et al., 2010), likely because they depict well-known and easily recognizable items. Previous research has shown that the most recognizable and meaningful symbols (high valid responses) were also rated as highly arousing, positive and visually appealing (Prada et al., 2016). Furthermore, the overall high ratings obtained for typicality and familiarity do not constitute a critical issue since real-world pictures of common items are actually expected to be typical and familiar (e.g., Adlington et al., 2009; Brodeur et al., 2014; Moreno-Martinez & Montoro, 2012; Shao & Stiegert, 2016). Congruently, it seems that increasing the quality of the pictures and their proximity to the reality is likely to improve their familiarity, and consequently their typicality ratings, comparatively to line-drawings (see Saryazdi et al., 2018).

The above-chance scores for linguistic attributes (name agreement and category agreement) together with a moderate to high variation of attributed (target and non-target) names and categories, are in line with previous norms using pictures of common items (Brodeur et al., 2010; Brodeur et al., 2014; Snodgrass & Vanderwart, 1980) and also favor the applicability of those stimuli. Moreover, the high variability in category agreement contrasted to the low variation observed in typicality ratings suggests that both dimensions, although part of the categorization processing, may not be identical as considered by Clarke and Ludington (2018). For instance, a picture may be typical even if it is not consistently considered as a member of the target category (e.g., "panini grill", considered a highly typical item, although presenting high variability in categories attributed and with a CA percentage lower than 40%). In examining such findings, the RealPic dataset is likely to be an useful tool in exploring naming abilities, semantic organization and memory skills[10].

Regarding the correlation results, important insights can be used for a better understanding of the less explored dimensions in previous validation studies, namely arousal, aesthetic appeal, picture-name agreement and valence. The contrast between our correlational results, namely between arousal and aesthetic appeal, valence, and familiarity, and those reported in other normative studies might be related to the specific type of stimuli used across studies. In fact, a previous normative study has shown that the interaction between arousal and other dimensions might depend on the type of stimuli, particularly when they present novelty (see Foroni et al., 2013). In comparison to the distinctiveness of faces (Garrido et al., 2016), symbols (Prada et al., 2016) and emojis (Rodrigues et al., 2018), common items are well-known stimuli related to general knowledge and very frequent in our daily-life, that are likely to be processed in a more semantic manner. The high scores for familiarity, typicality and picture-name agreement observed in RealPic are in line with such perspective.

Original results from our study regarding aesthetic appeal and picture-name agreement showed that such dimensions are positively correlated with all the rated dimensions, except for visual complexity

[10] In order to increase RealPic usage potential in future studies, the norms per category and their domain are reported in the Supplemental Material.

and arousal respectively. Specifically, while aesthetic appeal presented positive correlations with valence (very strong), it was negatively correlated with arousal thus indicating the qualitative differences between these two affective measures as well as their predictive potential. Indeed, aesthetic appeal is a multidimensional variable that seems to capture affective but also the influence of perceptual features (see Reppa & McDougall, 2015), once it focuses on surface image characteristics. Regarding picture-name agreement, the positive correlation (strong) with familiarity (Brodeur et al., 2014; but see Sanfeliu & Fernandez, 1996) and the negative correlation with visual complexity (but see Saryazdi et al., 2018) reflect its multiple influence in both visual and conceptual-based processing (Johnston et al., 2010; Sanfeliu & Fernandez, 1996; Snodgrass & Vanderwart, 1980). Taken together, these findings indicate the relevance of exploring other visual-related attributes of pictures aside from visual complexity to further understand their impact on affective and cognitive processes. The weak/absent correlations between typicality and visual complexity as well as between arousal and typicality and valence still require further examination.

Cross-cultural comparisons indicated that the RealPic items were rated as considerably more familiar than the very same items rated by a Spanish subsample (Moreno-Martinez & Montoro, 2012). Nevertheless, familiarity seems to be the least influenced dimension by Portuguese vs. Canadian cultural differences. Accordingly, strong correlations have been observed across different cultures and languages for familiarity (Boukadi et al., 2016, Brodeur et al., 2012). Such conflicting findings may result from the influence of other variables known to influence familiarity and that were examined simultaneously in our study, such as valence and category agreement (see Foroni et al., 2013; Prada et al., 2018). Moreover, such differences in familiarity ratings could be explained by the fact that the compared items are a subsample of the original datasets used for RealPic which was selected based on their cultural occurrence in the Portuguese environment.

Cultural differences between the Portuguese and Spanish context were also found for typicality ratings. Typicality and familiarity have been presenting positive significant correlations in common items studies (Brodeur et al., 2014; Moreno-Martinez et al., 2011; Snodgrass & Vanderwart, 1980), covarying also by the frequency in which an item or its concept occur. Another possibility is that those findings might have been motivated by the differences in the original items subsamples relatively to living and non-living domains as well as categories, once familiarity and typicality are known to be influenced by category and domain effects (Brodeur et al., 2012; Foroni et al., 2013; Moreno-Martinez et al., 2011; Moreno-Martinez & Montoro, 2012).

The cross-cultural comparison also indicated that name agreement measures (i.e., percentage and h-value) presented significant differences in the Portuguese vs. Canadian samples. However, these measures showed equivalent results for the comparison between Spanish and Portuguese samples, suggesting that similarities in cultural environments associated to the consistent use of pictures may reduce the influence of linguistic differences in naming (see Brodeur et al., 2012). Likewise, linguistic consistency is expected across near-to-Mediterranean cultures and from languages sharing the same linguistic Latin background (Azevedo, 2005). In fact, a previous study reported high correlations of naming measures across languages and/or countries as well as across clustered languages from the same linguistic family (e.g., Germanic or Romance) confirming a reasonable degree of communalities across languages and cultural context (Duñabeitia et al., 2018).

Finally, the main effect of semantic domain (i.e., living and non-living), observed across samples may be also interpreted within a feature distinctiveness approach in which non-living items share less features and present higher correlations with distinctive features than living items (see Moss & Tyler, 1997; Randall et al., 2004). However, the cross-cultural differences (English-Canadian vs. Portuguese and Spanish vs. Portuguese) observed in name agreement, familiarity and visual complexity suggests that cultural background may influence semantic organization. It has been argued that the animacy of the items implies a complex neural network influencing the various stages (i.e., perceptive and semantic) of processing based on their evolutionary weight (see Caramazza & Sheldon, 1998; Nairne et al., 2013). Moreover, the survival issues are susceptible to regions and habits. For instance, it is plausible that cultural characteristics (i.e., climate, accessibility of food, availability and necessity of specific tools or even traditions) may influence the evolutionary-based value of items across the semantic domain in several dimensions which require further cultural examinations. However, the current cross-cultural findings should be interpreted with caution as the current study does not constitute a replication and any methodological differences (i.e., number of assessments, context of data collection, order of presentation of dimensions, etc.) might have influenced the results.

Despite the relevance of such normed dataset, the current study presents a few limitations, namely regarding the number of evaluations per picture, the sample characteristics and the data collection environment. First, a limited number of respondents in psychological studies has driven the production of conflicting findings across studies (Brysbaert, 2019). However, the number of evaluations per item established for the current study was based on previous normative studies that have produced reliable results (Alario & Ferrand, 1999; Brodeur et al., 2014; Cycowicz et al., 1997; Tsaparina et al., 2011). Second, the sample of our study was fairly homogenous regarding the high levels of participants' education and not equally distributed across age groups, making certain types of comparisons across these variables unfeasible. It well established in the literature that some of the dimensions (e.g., name agreement) assessed in the current study may be influenced by age and education level (Laiacona et al., 2016; Spezzano et al., 2013). For instance, Laiacona and colleagues (2016) have already shown that age and educational level are relevant predictors of naming abilities. Pompéia and colleagues' (2001), also showed differences in normative ratings between children and adults and across different education levels. On the other hand, the demographic characteristics of our sample allowed comparisons with many other normative studies that used highly-educated young adults. Future studies might adopt a developmental approach, contrasting young to older adults with different educational backgrounds in an attempt to grasp potential differences in the explored dimensions. Finally, the use of online resources for collecting data may constitute a challenge in maintaining participants engaged in the study and in establishing some control of the data collection environment. Nevertheless, online data collection procedures allow to overcome a set of constraints regarding the recruitment of participants and has been shown to be as reliable as data collected in lab settings (Saryazdi et al., 2018).

The current norms constitute a useful tool for researchers searching for well-characterized pictures in several dimensions, allowing the manipulation of specific dimensions while controlling others. This enables a better selection of stimuli while avoiding possible confounding effects and ultimately enhancing the quality of the experimental designs. Additionally, the RealPic application potential becomes particularly high if we consider all Portuguese-speaking communities (scattered or territorially distributed) around the world (Godinho & Garrido, 2016) and the rank of the Portuguese language as one of the most spoken languages around the world (see Reto et al., 2016). Future studies should consider the cultural and linguistic diversity of Portuguese speaking communities in non-European Portuguese contexts (i.e., Africa, Asia or South America) as well as expand these norms for additional dimensions (e.g., age-of-acquisition, Johnston et al., 2010; manipulability, Brodeur et al., 2014; image agreement and/or imageability, Snodgrass & Vanderwart, 1980).

In conclusion, the RealPic dataset comprises images of meaningful stimuli commonly encountered in our daily-life. As a particular general class, common items were examined in a more integrative perspective of validating stimuli across a wide range of dimensions emphasizing their independent and combined contributions for picture processing. Furthermore, this research acknowledges a valuable finding about the way we process different types of meaningful information in our "semantic brain" considering cultural diversity. The ecological concern that guided this work and its systematic procedures are likely to make RealPic a promising resource for memory, language and emotion research as well as for interventional settings (e.g., cognitive, linguistic and marketing) requiring more realistic stimuli.

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Open Practices Statement: The detailed picture norms and other results are available as supplemental materials (available at https://osf.io/qn35s/?view_only=9c209e9236b94b2cb74f77f47e7ff390) and none preregistration was done for such study.

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CHAPTER 4.

Conceptual knowledge selectively modulates memory retrieval of common items

The papers presented in this chapter explore the interaction between episodic and semantic memories by inspecting the effect of the availability of prior knowledge during encoding on subsequent recognition as well as in recollection and familiarity memories during an episodic retrieval task. The influence of prior conceptual knowledge is relevant in understanding the formation and retrieval of declarative memories since prior knowledge can facilitate learning and improve memories (e.g., Liu et al., 2016; Souza et al., 2016; Tse et al., 2011; van Kesteren et al., 2014; Yamada & Itsukushima, 2013).

The three empirical studies constitute different approaches to the interaction between memories by inspecting the influence of semantic content in episodic recognition. From a cognitive science perspective, we attempted to elucidate the existing models of consolidation memories (i.e., Dudai et al., 2015; Nadel et al., 2012; Winocur et al., 2010) in light of the transformation approach of declarative memories.

In the first article, "*Conceptual knowledge modulates memory recognition of common items: The selective role of item-typicality",* we examined the effect of two supposedly contradictory conceptual knowledge effects – the schema effect (more general) versus the item-typicality effect (more specific) – on memory operations. We took the two types of conceptual knowledge as imposing different demands on episodic and semantic systems to infer the interaction between systems and the role of the semantic system in the rapid integration of new memories.

In the paper "*Age-related differences in the interaction between memories: The selective role of prior knowledge in preventing episodic loss*", an additional developmental approach is included to reinforce the consistency of information obtained regarding the way a constrained episodic system (i.e., Hippocampus based) interacts with a preserved semantic system in older adults (e.g., Koen & Yonelinas, 2014). Moreover, because semantic knowledge is also known to improve with aging, the type of semantic knowledge (general vs. specific) influencing memory performance in aging was also explored, contrasting young and older adults. In this way, we expected to provide cues about the interaction between episodic and semantic memories and how they can interfere with or even help one another.

From a neuropsychological approach, the article "*The distinctive pattern of declarative memories in Autism Spectrum Disorder: Further evidence of episodic memory constraints*" further inspected the influence of semantic content in episodic recognition in clinical samples with episodic constraints due to alleged hippocampus dysfunction, particularly the ASD sample in comparison to healthy young controls. Based on the neuropsychological findings of episodic systems constraints in the ASD group (e.g., Gaigg et al., 2015), it makes sense to infer the role of the episodic system in memory interaction.

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4.1. Conceptual knowledge modulates memory recognition of common items: The selective role of item-typicality

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Abstract

This work examines the influence of stored conceptual knowledge (i.e., schema and item-typicality) on conscious memory processes. Specifically, we tested whether item-typicality selectively modulates recollection and familiarity-based memories as a function of the availability of a categorical schema during encoding. Experiment 1 manipulated both encoding type (categorical vs. perceptual) and item-typicality (typical vs. atypical) in a single Remember-Know paradigm. Experiment 2 replicated and extended the previous study with a complementary source-memory task. In both experiments, we observed that typical items led to more Guess responses, while atypical items led to more Remember responses. These findings support the idea that the activation of a congruent categorical schema selectively enhances familiarity-based memories, likely due to the bypassing of the activated mechanisms for novel information. In contrast, atypical items improved recollective-based memories only, suggesting that their lesser fit with the stored prototype might have triggered those novelty processing mechanisms. Moreover, atypical items enhanced memory in the categorical condition for both item recognition and recollection memories only, suggesting an episodic gain due to inconsistency/novelty. The source memory results gave further credence to the argument that "Remember" judgments were based on truly recollective experiences and presented the same interaction between encoding type and item-typicality observed in recollective-based memories. Overall, the results suggest that the supposedly opposite conceptual knowledge effects actually coexist and interact, albeit selectively, in the modulation of recollection and familiarity processes.

Keywords: Recollection, Familiarity, Schemas, Item-typicality, Declarative memories

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Introduction

Declarative memory rests on explicit long-term storage systems of meaningful representations that can be consciously retrieved. Episodic memory refers to our capability to maintain vivid representations of contextually relevant details of the events (e.g., remembering the precise details about our first visit to our best friend's home) and is associated with autonoetic (self-based) conscious awareness while re-experiencing memories (Bastin et al., 2019; Liu et al., 2020; Tulving, 2000, 2002; Yonelinas et al., 2010). Semantic memory constitutes a general knowledge that is abstracted from our experiences (e.g., the basic social rules when having dinner at someone's home) and is related to noetic (factual-based) consciousness (Tulving, 1985; 2002).

Episodic and semantic memories rest on different processes and neural substrates. Likewise, recollection and familiarity-based processes associated with memory recognition entail distinct operations supported by different brain regions (Gardiner, 1988; Tulving, 1972, 2000; Yonelinas 2002; Yonelinas et al., 2010, but see also Migo et al., 2012; Wixted & Mickes, 2010, for a single-process model perspective on how both recollection and familiarity support recognition). Recollection processes are characterized by a controlled and effortful vivid recovery. These processes are embedded of self-related conscious awareness while re-experiencing memories and are supported by hippocampus structures (Tulving, 1985; 2000; Yonelinas, 2002). Familiarity refers to an economical and less demanding process involving factual-based conscious awareness. This process is driven by holistic operations (i.e., unicity) that support the retrieval of known information (see Ozubko et al., 2017; Wang et al., 2018; Yonelinas et al., 2010), and is supposedly hippocampal-independent. Therefore, the reported dissociation between episodic and semantic memories resembles, both functionally and structurally, the contrast between recollection and familiarity-based processes (Czernochowski et al., sd; Vargha-Khadem et al., 2003; Wang et al., 2018; Tulving, 2002). The present study examines how these two processes involved in recognition memory are distinctly influenced by different types of conceptual knowledge (i.e., schema and item-typicality).

Recent studies have shown the advantage of stored schematic knowledge availability (i.e., schema) on the formation and retrieval of memories (Liu et al., 2016; Tse et al., 2007; Tse et al., 2011; van Kesteren et al., 2014; van Kesteren, Beul, et al., 2013a; van Kesteren, Rijpkema et al., 2013b; Yamada & Itsukushima, 2013). For instance, information congruent with previously learned schemata has been shown to engage cortical regions and was better retrieved than incongruent information (e.g., Dudai et al., 2015; van Kesteren et al., 2010, 2014; van Kesteren, Beul, et al., 2013a; van Kesteren, Rijpkema, et al., 2013b), suggesting the rapid integration of this type of information into the semantic system. In contrast, information that is incongruent with a prior schema engages brain regions and their connectivities, which are classically associated with the episodic system (van Kesteren et al., 2010; 2014). Critically, information that is incongruent with a schema was also shown to improve subsequent memories despite being more susceptible to forgetting with time (Bonasia et al., 2018).

Moreover, the debate on the role of prior schema becomes even more intricate depending on whether prior schema facilitation for congruent information is considered a generalized process in declarative memories or whether it is regarded as selective for specific memory processes. The facilitation effect of a prior schema for congruent items has been reported in situations where previous abstract schematic knowledge enhances familiarity-based memories compared to recollective ones (see Carr et al., 2013; Mäntylä, 1997; Rajaram, 1998). Of particular interest, Mäntylä (1997) explored the effect of distinct encoding types on different memory processes by contrasting a relational encoding task (based on similarities with the prior conceptual knowledge) with a distinctive encoding task based on item-specific information (i.e., how distinctive a face is in contrast with others). Specifically, this was tested during a face recognition memory task with the Remember-Know paradigm. In this paradigm, the phenomenological judgment regarding memory experience (Remember vs. Know responses) is obtained together with item recognition scores. Remember responses usually reflect recollection while Know responses capture a factual-based sense of familiarity (Gardiner, 1988; Gardiner et al., 1998; Tulving, 2000; Yonelinas et al., 2010). The results of Mäntylä's study showed an increase in Know responses in relational encoding and an increase in Remember responses in distinctive encoding conditions (Mäntylä, 1997). Thus, it seems that the availability of a schema during learning leads to a selective increase in familiarity-based memories only. Moreover, the advantage of distinctive encoding over schema availability in recollective memories suggests that the schema advantage is not observed in such memory process.

The schema effect is considered controversial from a cognitive perspective, namely given the mixed-effects reported in category learning literature (De Brigard et al., 2017; Harris & Rehder 2006; Sakamoto & Love, 2004; Yin et al., 2019). According to this literature, a category can be viewed as a schema, an abstract, experienced-based, flexible, and continuously updated associative knowledge structure (see Gosh & Gilboa, 2014). Following this analogy, Sakamoto and Love (2004) investigated how consistency with a new categorical schema affects memory. The authors concluded that the recognition of items that are inconsistent with the category is improved because they violate knowledge structures (rules) inherent to the schema regularities. On the other hand, recent studies on category learning demonstrated that consistency with a newly learned category improved recognition and enhanced false alarms (De Brigard et al., 2017; Yin et al., 2019). Therefore, the role of categorical stored representations in memory retrieval needs to be further scrutinized.

Categorical prototypes are understood as schematic knowledge constituting an abstraction and an average representation of the attributes of the category (Murphy & Medin, 1985; Murphy, 2002). According to classical models of concepts and semantic organization, typicality - a property underlying semantic organization, influences the categorization process and declarative memories (Keller & Kellas, 1978; Rips et al., 1973; Rosch et al., 1976). Typicality refers to how good an exemplar is in representing its own category, which is determined by the match of each of its features with the prototypical stored representation (Lin & Murphy, 1997; Medin et al., 2007; Rosch & Mervis, 1975). Typical items are good exemplars, that is, those closer to the abstract representation in memory (e.g., prototypes). In contrast, atypical items have less fit with the categorical prototype and share more attributes with other categories (Mervis et al., 1976; Murphy & Medin, 1985; Rosch & Mervis, 1975).

Like the schema effects, the activation of stored knowledge regarding the prototype (item-typicality) also shapes declarative memories, although in a different way. In fact, the conceptual distinctiveness of atypical items seems to improve recognition and recollection processes (Alves & Raposo, 2015; Graesser et al., 1980; Vakil et al., 2003, but also see Schmidt, 1996, Experiment 5 for different results). For instance, using a Remember-Know paradigm, Alves and Raposo (2015) manipulated item-typicality (i.e., typical vs. atypical) and the congruence between the item name and the category (e.g., robin/bird). The results showed that atypical items (e.g., "penguin" as a "bird") enhanced overall recognition and remember (recollection-based) responses.

Notably, this item-typicality effect on memory seems to be similar to the facilitation effect of incongruent items observed in the categorical learning literature (see Sakamoto & Love, 2004). Following this reasoning, some authors have argued that items that do not fit the schema seem to recruit the systems involved in processing new information, which would not be engaged when the information fits the schema (see Bonasia et al., 2018; Dudai et al., 2015; Nadel et al., 2012; Yonelinas et al., 2010). Consequently, these items would be better retrieved due to the involvement of the episodic system. In a recent study, Höltje et al. (2019) simultaneously examined the effects of categorical schema consistency and prototypicality on recognition memory. Participants were required to evaluate the consistency between the items and the category (e.g., consistent pair: doll-toy; inconsistent pair: mango-toy). The items also varied in their prototypicality (e.g., high typicality: doll; low typicality: marble). After a 24-hour delay, participants recognized better the items that were consistent with the available schemata and no item-typicality effects were observed. These results suggest that the effect of categorical schema congruency seems to be affecting memory recognition, independently of item typicality.

In sum, the abovementioned findings suggest the influence of different types of stored conceptual knowledge (i.e., activation of prior schemata and item-typicality) on memory in apparently conflicting ways. Schema-consistent information seems to enhance episodic memory retrieval (Höltje et al., 2019; van Kesteren et al., 2013b; van Kesteren et al., 2014, but see Mäntylä, 1997; Sakamoto & Love, 2004 for opposing results). Likewise, information that is not (or is less) consistent with the schema (e.g., atypical items which have little fit with their categorical prototype) also seems to enhance episodic memory retrieval (Alves & Raposo, 2015; Bonasia et al., 2018; Dudai et al., 2015, but see Höltje et al, 2019 for different result). In the current paper, we argue that these differences may result from the nature of the memory processes involved during recognition.

The current studies

The current studies were designed to examine how two supposedly opposite prior conceptual knowledge effects - categorical schema consistency and item-typicality – act and interact on both recollective and familiarity-based memories. Using a single paradigm, we explore how item-typicality modulates these memory processes in an encoding condition that activates the categorical schema as compared to a perceptual encoding condition. Item-typicality is expected to impact conscious retrieval because of its relevance for the semantic organization of categorical processing (Medin et al., 2007; Rosch & Mervis, 1975). Specifically, atypical items are expected to enhance Remember responses because they trigger specific mechanism involved during novelty encoding (Bonasia et al., 2018; Dudai et al., 2015). In contrast, the activation of a categorical congruent schema is expected to enhance memories based on familiarity for typical items due to the bypassing of crucial mechanisms activated for novel information (see Dudai et al., 2015). Therefore, the interaction between both types of prior conceptual knowledge will be further inspected.

Experiment 1 explored the described prior conceptual knowledge effects on both recollection and familiarity processes using a Remember-Know paradigm. Experiment 2 replicated Experiment 1 with an additional source memory task, further looking into the recollective experiences. To our knowledge, the simultaneous examination of both categorical encoding-schema activation and item-typicality, as well as their interaction, on both recollection and familiarity-based processes constitutes an innovative effort. We expect that this research might help advance our understanding of how these two opposing prior conceptual knowledge effects impact the two different memory processes and whether they interact and influence each other.

Experiment 1: Exploring the conceptual knowledge modulation of conscious memory processes

Experiment 1 examined the role of item-typicality on conscious memory processes (i.e., recollection and familiarity) as a function of the activation of the stored categorical schema using the Remember-Know paradigm (Tulving, 1985). This paradigm allows the direct comparison between recollection and familiarity-based memories within a single task (see Gardiner, 1988; Rajaram, 1993; Tulving, 1985; but see Wixted & Squire, 2010). The encoding type modulation contrasted a categorical condition (i.e., activating prior conceptual abstract knowledge) with a perceptual condition (i.e., eliciting perceptual detailed information). The item-typicality manipulation contrasted typical items (i.e., with a good fit with their prototype) with atypical ones (i.e., less fitting with the prototype).

Method

Participants

Sample size (N =38) was determined a priori (G*Power software) using as reference the effect size η_{p2} = .14 and a power of 1-β = 0.95 from a study by Carr et al. (2013), which investigated the effect of encoding type on conscious recollection. Forty-six adults, with normal or corrected vision (38 females; M_{age} = 19.57, SD_{age} = 4.94; $M_{schooling}$ = 12.36, $SD_{schooling}$ = 1.24) volunteered for this study in exchange for course credit. Four participants were excluded due to their very low accuracy (less than 30%), one participant did not finish the task, and three additional participants were discarded due to a technical problem. The final sample included 38 participants.

Stimuli

The stimulus materials for the encoding manipulation consisted of 96 images of common items, selected from a normalized database (Souza et al., 2021). The original items belonged to eight well-studied superordinate categories (from Santi et al., 2015) from living (fruits, vegetables, mammals, birds) and non-living (vehicles, clothes, kitchen utensils and musical instruments) domains rated on commonly reported dimensions in normative studies using such type of stimuli (Souza et al., 2020). Stimuli selection was based on their ratings on item-typicality on a 7-point scale (low: M = 4.65, SD = 0.93; high: M = 6.58, SD = 0.93, $t(94)$= -13.90, p < .001, d_z = 1.42, CI 90% [1.18,1.66]) and controlled for arousal, $t(94)$= -1.546, p = .125; valence, $t(94)$ = -1.783, p = .08; and visual complexity, $t(94)$ = .807, p = .422. A different sample of 48 images (from the same semantic categories) from the same database was selected for the recognition task and presented as New items. Old and new items were matched on the same variables used in the item selection for encoding (all p's > .104).

Procedure

We used a within-participants design with 2 encoding (Categorical vs. Perceptual) and 2 item-typicality (Typical vs. Atypical) as independent variables and conscious recollection judgments (Remember vs. Know vs. Guess) as the dependent variable.

The study followed an ethical protocol approved by the Ethics Board of the host institution. Participants were informed about the goals and tasks of the study and signed the informed consent. The experiment was conducted in sessions with one to five participants who completed the tasks in separate cubicles.

During the encoding phase, participants were asked to classify the 96 images presented in two counterbalanced tasks (i.e., 48 images without repetitions for each): a perceptual, episodic-like encoding task (e.g., "how complex is the object?") using a 6-point scale (from 1 - *not complex at all* to 6 - *very complex*) and a semantic-like categorical encoding task with six forced-choice response options (e.g., "is this a: vegetable/ mammal/ vehicle/ clothes/ musical instruments/ fruit"?). The order of the category options was randomized across trials. Item-typicality was manipulated in both encoding tasks, with half of the items being typical and half atypical (e.g., "dog" for typical and "dolphin" for atypical exemplars of Mammals). All images were presented in a randomized order within each encoding task. The images were also counterbalanced between encoding tasks across participants.

After a 20 min interval (plus 5min of instructions), participants were again presented with the 96 images (Old items) together with 48 new images (New items). Participants were asked to recognize each image (i.e., Yes-No forced-choice) and, if the "Yes" response was given, to provide Remember-Know phenomenological judgments (e.g., "Do I Remember/Know/Guess[11] seeing the image?") about the recognized images (see Gardiner, 1988). Detailed instructions are provided in Appendix A (but see

[11] Guess responses involve a low confidence inferential judgment and an uncertainty conscious state (Gardiner et al., 1998). This response option was used to disentangle the Remember versus Know dichotomic judgments.

Figure 1).

E-Prime 2.0 software was used to present the stimuli and to record participants' responses. To ensure that participants understood the instructions, the experiment started with a training phase (5 practice trials in each condition), where their doubts and questions were addressed.

Figure 1. Remember-Know paradigm (adapted from Mäntylä, 1997) manipulated by Encoding Type and Item-typicality (Experiment 1).

Note. The encoding phase comprises two blocks (categorical *versus* perceptual), counterbalanced between participants. In Experiment 1, the response options of the categorical condition were presented in a randomized order across trials. The recognition phase includes a conscious recollection phase in which participants were asked to provide phenomenological judgments about their memories (Remember/Know/Guess responses). When the participants respond "yes", the subsequent slide presents the R/K/G judgments question. Otherwise, the trial ends with a final blank screen.

Data analysis

All statistical analyses were conducted with R Version 4.0.2 (R Core Team, 2019).12 The effects of prior conceptual knowledge on Remember-Know-Guess (RKG) judgments were analyzed with Bayesian mixed-effects multinomial regression models with encoding type, item-typicality, and their

[12] The package *tidyverse* (Wickham et al., 2019) was used for data processing; the packages *lme4* (Bates et al., 2015), *lmerTest* (Kuznetsova et al., 2017), *brms* (Bürkner, 2017, 2018), and *bayestestR* (Makowski et al., 2019) were used for statistical analyses.

interaction as the predictors of interest. For the Bayesian analysis, all effects with a 95% credible interval that did not include zero and a probability of direction (pd) value of 97.5% or higher were considered significant. When appropriate, follow-up analyses were conducted to obtain simple effects. Additional analyses of response times (RT) during encoding and overall accuracy during the recognition phase were also conducted. Statistical details for all the analyses can be found in Appendix B.

Results and Discussion

To confirm the influence of item-typicality on recollection and familiarity-based memories and its interaction with encoding type, we fitted a model that estimated fixed effects of encoding condition, item-typicality, and their interaction; by-participants varying intercepts and by-participant varying slopes for encoding condition, typicality condition, as well as the interaction term, including the correlation of these terms. In addition, we included varying intercepts for items in the model to preclude the possibility that something unique about a particular item may influence responses to that item and, therefore, undermine the analysis's generalizability. This way, we constructed a model with a maximal random effects structure justified by the design (see Barr et al., 2013, for discussion). If the "maximal" model failed to converge or was found to be overfitted (e.g., a singular fit warning in R), we first checked whether the model successfully converged with a random-effects structure for which no slope-intercept correlation term is specified (to minimize risks of model reduction). Only when this did not help, we reduced the model by removing a random slope that was causing convergence problems. Throughout the paper, the fixed effects predictors were deviation coded (*–1* = categorical encoding or typical item; *1* = perceptual encoding and atypical item) to facilitate the interpretation of main effects in the presence of interactions. If the presence of a significant interaction was established, follow-up analyses were performed (1) by looking at the effect of encoding condition for atypical and typical items separately, and (2) by looking at the effect of item-typicality for categorical and perceptual encoding types separately. Specifically, dummy coding of the encoding condition and item-typicality factors were used to obtain simple effects.

Response Times during Encoding

The time participants took to classify images during the encoding phase was analyzed using a linear mixed-effects regression model (similar to Horchak & Garrido, 2020a, 2020b) This analysis was conducted to understand better how encoding type (categorical vs. perceptual) and item type (typical vs. atypical) tap into attentional resources required to perform the classification tasks. The results of the best converging linear mixed-effects regression model showed that RT's were faster in the perceptual condition (M = 1388, SD = 668) than in the categorical condition (M = 1416, SD = 676). Further statistical details on this analysis can be found in Appendix B.

Overall recognition

Participants' overall recognition accuracy was 73%. The mixed-effects logistic regression model showed that perceptual condition led to higher recognition accuracy. Moreover, there was a significant increase in recognition accuracy for atypical items particularly in the categorical encoding condition. This finding might reflect an advantage in cases when there is a violation of the prototype during learning (Bonasia et al., 2018; Sakamoto & Love, 2004), which might have engaged the systems involved in processing novelty (see Dudai et al., 2015), namely the episodic one. Of note, perceptual condition alone seems to have engaged the episodic system, and hence no differences or little gain was observed for atypical items in this condition. Further statistical details on this analysis can be found in Appendix B.

Phenomenological judgments of conscious memories

The package brms (Bürkner, 2017, 2018) was used, and specifically, the categorial function, to analyze the ternary response variable "Know" versus "Remember" and "Guess" with a Bayesian mixed-effects multinomial regression model[13]. The brm's default non-informative priors for fixed (i.e., encoding type and item type) and random (i.e., participants and items) effects were used. The summary of the results is provided in Figure 2.

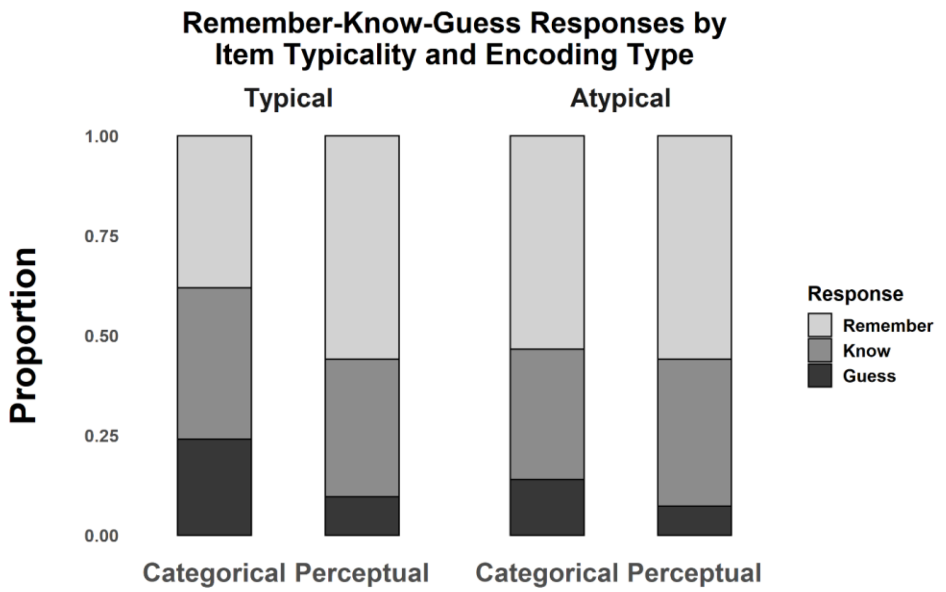

Figure 2. Proportions of "Remember", "Know" and "Guess" responses as a function of Item-typicality and Encoding type in Experiment 1.

Note. Overall, there were 1372 responses (52%) for "Remember", 943 responses (35%) for "Know" and 347 responses (13%) for "Guess".

Know versus Remember

The results revealed a significant effect for the encoding factor (*estimate* = 0.20, 95% Bayesian credible

[13] We opted for Bayesian analysis as the lme4 package (Bates et al., 2015) currently does not support the analysis that requires the estimation of mixed multinomial logistic regression models in which the outcome categorical variable has more than two levels.

interval = [0.02; 0.38], *pd* = 98.37%), indicating that the log-odds of providing a “Remember” response in the perceptual encoding condition increased relative to the categorical condition. Results for the item-typicality factor with a 95% credible interval included zero, but a probability of direction above a threshold of 97.5% (*estimate* = 0.16, 95% Bayesian credible interval = [0.00; 0.32], *pd* = 97.53%). These results suggest the advantage of “Remember” responses in the atypical item condition relative to the typical item condition.

Importantly, there was also evidence for a two-way interaction between encoding type and item-typicality (*estimate* = − 0.16, 95% Bayesian credible interval = [− 0.32; − 0.05], *pd* = 99.60%). A separate Bayesian mixed-effects logistic regression model showed that encoding type was not a significant predictor for atypical items (*estimate* = − 0.03, 95% Bayesian credible interval = [− 0.21; 0.16], *pd* = 62.80%). However, encoding type was a significant predictor for typical items (*estimate* = 0.39, 95% Bayesian credible interval = [0.18; 0.62], *pd* = 100.00%), with a log-odds increase of the “Remember” responses during the perceptual encoding, as compared to categorical encoding. When broken up by encoding factor, the results demonstrated that the effect of item-typicality for perceptual encoding was not significant (*estimate* = − 0.05, 95% Bayesian credible interval = [− 0.23; 0.13], *pd* = 68.57%). However, there was a reliable effect of item-typicality for categorical encoding (*estimate* = 0.36, 95% Bayesian credible interval = [0.14; 0.59], *pd* = 99.90%), with a log-odds increase of “Remember” responses when items were atypical rather than typical.

The effects observed for Remember responses mirror the ones found for the overall recognition accuracy and show that it was the perceptual encoding condition (but not categorical) that improved recollection. This finding is consistent with the selective role of prior schematic knowledge in memories (Mäntylä, 1997). Although apparently contradicting the previously documented advantage of schema activation in episodic retrieval (Liu et al., 2016; Tse et al., 2007; Tse et al., 2011; van Kesteren et al., 2013a; van Kesteren et al., 2013b; van Kesteren et al., 2014; Yamada & Itsukushima, 2013), such findings should be interpreted with caution since our encoding conditions did not mirror the usual schema-consistency manipulations and because the observed differences on encoding demands render the conditions not entirely comparable.

Still, the present results of item-typicality main effect replicate the advantage of the atypical items’ distinctiveness in recollection (Alves & Raposo, 2015). Finally, the advantage of atypical items in increasing the amount of remember judgments in the categorical encoding reflects the potential activation of the episodic system given the novelty of atypical items (see Bonasia et al., 2018; Dudai et al., 2015). This effect is specific for recollective-based memories.

Know versus Guess

The results indicated a significant effect for the encoding factor (*estimate* = − 0.52, 95% Bayesian credible interval = [−0.79; − 0.27], pd = 100%), in that the log-odds of providing a “Guess” response in the perceptual encoding condition decreased relative to the categorical condition. The role of the typicality factor for “Guess” responses (*estimate* = − 0.20, 95% Bayesian credible interval = [−0.41; 0.01], *pd* = 96.57%) was not significant (see Figure 2). Finally, the analysis estimated the interaction effect (encoding type by item-typicality) for “Guess” responses to be non-significant (*estimate* = 0.01, 95% Bayesian credible interval = [−0.17; 0.19], *pd* = 55.10%).

The activation of the stored schema, in the case of the categorical encoding, led to an increase of “Guess” responses, which is consistent with the selective role of the schema for familiarity-based memories (Mäntylä, 1997) likely due to the bypassing of mechanisms engaged in the processing of novelty (see Dudai et al., 2015). Such finding is also in line with previous research showing increased levels of false alarms for category-consistent memories (De Brigard et al., 2017; Yin et al., 2019), with typical items increasing guessing.

However, the influence of prior conceptual knowledge on conscious awareness of declarative memories may have derived from the different demands of the two encoding tasks. It is well-established that Remember and Know responses might be differently affected by several variables (e.g., level of processing, Gardiner, 1988; Java & Gregg, 1997; type of stimuli, Dalla Barba, 1997; Gardiner & Java, 1990; instructions, McCabe & Geraci, 2009 and aging, Koen, & Yonelinas, 2014; see McCabe et al., 2009 for a review). Of especial interest is the case of varying attentional demands (Curran, 2004; Gardiner & Parkin, 1990). For instance, divided attention during encoding is likely to decrease remembering accuracy (Dewhurst et al., 2005). In our categorical encoding task, participants had to monitor six counterbalanced response options while visually inspecting the items, thus disproportionally increasing the attentional resources required for successful task performance (compared to the perceptual encoding task). Finally, it is important to replicate Experiment 1, balancing the level of difficulty and attention demands involved in both encoding tasks. Moreover, it is crucial to further validate the Remember judgments as a truly recollective experiences. Therefore, complementary source memory information could help to discriminate between general and vivid representations (see Java & Gregg, 1997; Tulving, 1985).

Experiment 2: Contrasting the encoding type and item-typicality on conscious recollection and the quality of recollective experience

Experiment 2 replicates and extends Experiment 1 with a few modifications. First, the interaction effect of the encoding type vs. item-typicality was examined with a larger sample. Second, we tried to control the potential impact of executive processes and attentional resources on memory (Curran, 2004; Gardiner & Parkin, 1990) by balancing the demands of the categorical and perceptual encoding tasks. Additionally, we expanded the number of images presented during the encoding phase to increase the amount of collected RKG judgments. Finally, we examined whether Remember judgments actually reflect recollective experience (see Guo et al., 2006), disentangled from overconfidence effects (Guo et al., 2006; Hicks et al., 2002). To this end, we included a source forced-choice identification task (McCabe & Geraci, 2009) and a source description task for all Remember responses (Gardiner et al., 1998; Java & Gregg, 1997). As a direct recollective-based measure (Guo et al., 2006), we expected that the source memory task's results would mirror the pattern of influence of prior conceptual knowledge observed for Remember responses.

Methods

Participants

A sample of 78 participants was determined based on a power analysis (G*Power) using a medium effect size (d = 0.5; Cohen, 1988; Miles & Shevlin, 2001) and a power 1-β = 0.80[14]. Eighty-seven participants (M_{age} = 25.09, SD = 6.35; $M_{schooling}$ = 14.77, SD = 2.61; 67 female), volunteered for this study in exchange for course credit. This experiment followed the same previously approved Ethical protocol described in Experiment 1. None of the participants was excluded from the sample.

Stimuli

The stimuli (N =160) and their selection followed the same procedure as in Experiment 1. For each encoding task 80 images were used (without repetitions), with 20 images per category. Their selection was based on mean contrasts of the ratings provided in a 7-point scale on item-typicality (low: M = 4.75, SD = 0.01; high: M = 6.39, SD = 0.03, $t(158) = -16.14$, $p < .001$, d_z = -1.280, CI 90% [1.10, 1.45] while controlling for arousal, $t(158)$= -1.074, p = .284; valence, $t(158)$ = -1.472, p = .143; aesthetical appeal, $t(158)$=-1.475, p = .142; and visual complexity, $t(158)$ = 1.12, p = .264. A different sample of 106 new images was selected for both phases of the recognition task, with Old and New items matched on the same criteria as Experiment 1 (all ps > .498).

Procedure

We used the same paradigm as in Experiment 1 with a few variations. First, we presented a higher number of items during the encoding phase (N =160). Second, we narrowed the response options for both encoding tasks. Specifically, for the categorical encoding, we used a four forced response, this time with fixed categories (e.g., "is this a: vegetable/ mammal/ vehicle/ clothes"?). Accordingly, the scale for perceptual encoding ranged from 1 - *not complex* to 4 - *very complex*. The item categories were counterbalanced between encoding tasks and between participants.

The recognition task consisted of two phases. Recognition phase 1 (Rec1), with 96 old and 64 new items, and Recognition phase 2 (Rec2), with 64 old and 42 new items, different from those used in Rec1. During this phase, and following a Remember response, a source memory task required participants to 1) identify in which task the item was presented (first or second task; i.e., categorical or perceptual; counterbalanced; McCabe & Geraci, 2009); and 2) provide a detailed memory description associated with the previous experience with the item during the encoding phase (adapted from Gardiner et al.,

[14] None of the previous studies on visual memory using the Remember-Know paradigm reported an interaction between these conceptual knowledge variables (i.e., Encoding and Item-typicality) in conscious recollection. Therefore, in order to provide a reliable sample criterium for such interaction we used the standard medium effect size reported in statistical literature (Cohen, 1988; Miles & Shevlin, 2001).

1998; Java & Gregg, 1997) by writing which details they remembered (i.e., particular associations they made, the way they evaluated the images, item order, etc.) about their first contact with each image (see detailed instruction in Appendix A). Everything else was kept similar to Experiment 1.

Results and Discussion

Response Times during Encoding

The analysis followed the same procedures as Experiment 1 (see Appendix B for detailed RT's and accuracy analyses). The best converging linear mixed-effects regression model demonstrated that, in contrast to Experiment 1, RT's became faster in the categorical condition (M = 819, SD = 501) than perceptual condition (M = 908, SD = 574).

Overall accuracy of Recognition phase 1

Participants' overall recognition accuracy was 84%. The mixed-effects logistic regression model showed similar results to Experiment 1 (see Appendix B for further details). These results give further credence to the idea that the perceptual condition is a better predictor for recognition accuracy (Mäntylä, 1997). Furthermore, the item-typicality effect was robust, with atypical items enhancing recognition (as in Alves & Raposo, 2015). These results are consistent with findings showing the influence of low-fit prototypical information on the categorical condition only (see Sakamoto & Love, 2004).

Phenomenological judgments of conscious memories of Recognition phase 1

The same multilevel model was fit as in Experiment 1. The summary of results is presented in Figure 3.

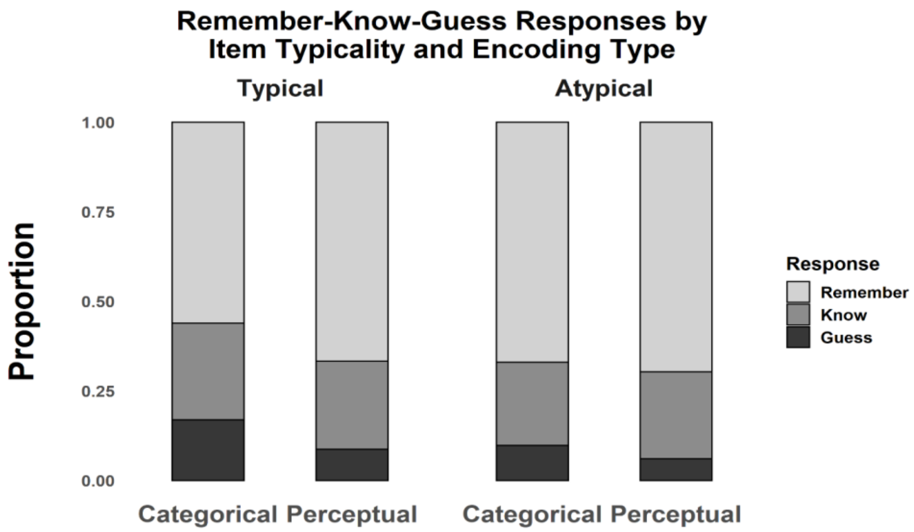

Figure 3. Proportions of "Remember", "Know" and "Guess" responses as a function Item-typicality and Encoding type in Experiment 2 (Rec1).

Note. Overall, there were 4603 responses (65%) for "Remember", 1742 responses (25%) for "Know" and 711 responses (10%) for "Guess".

Know versus Remember

The mixed-effects multinomial regression analysis revealed a significant effect for the encoding type factor (*estimate* = 0.19, 95% Bayesian credible interval = [0.06; 0.33], *pd* = 99.70%), indicating that the log-odds of providing a "Remember" response in the perceptual encoding condition increased relative to the categorical condition. This time, the results were also significant for the item-typicality factor (*estimate* = 0.17, 95% Bayesian credible interval = [0.05; 0.30], *pd* = 99.78%), in that there was an advantage in proportion of "Remember" responses for atypical items, as compared to typical. There was also a significant two-way interaction between encoding type and item-typicality (*estimate* = − 0.11, 95% Bayesian credible interval = [− 0.19; − 0.03], *pd* = 99.73%). Follow-up analyses showed that, similar to Experiment 1, the type of encoding was not a significant predictor for atypical items (*estimate* = 0.08, 95% Bayesian credible interval = [− 0.08; 0.25], *pd* = 84.47%). However, encoding type was again a significant predictor for typical items (*estimate* = 0.30, 95% Bayesian credible interval = [0.14; 0.47], *pd* = 100.00%), with a log-odds increase of the "Remember" responses during the perceptual encoding, as compared to categorical encoding. When broken up by encoding factor, the results were again in line with those obtained in Experiment 1. Specifically, the effect of item-typicality was not significant for perceptual encoding (*estimate* = 0.06, 95% Bayesian credible interval = [− 0.07; 0.21], *pd* = 81.70%). However, it was significant for categorical encoding (*estimate* = 0.27, 95% Bayesian credible interval = [0.13; 0.43], *pd* = 100.00%), with a log-odds increase of "Remember" responses for atypical items rather than typical items. Such results clearly corroborate the findings observed in Experiment 1, this time with a robust item-typicality effect.

Know versus Guess

The results showed that encoding type was a significant predictor of participants' responses (*estimate* = − 0.31, 95% Bayesian credible interval = [−0.45; − 0.17], *pd* = 100%), in that the log-odds of providing a "Guess" response in the perceptual encoding condition decreased relative to categorical condition. This time, there was also a significant main effect of item-typicality for "Guess" responses (*estimate* = − 0.21, 95% Bayesian credible interval = [−0.34; − 0.07], *pd* = 99.83%), reflecting the fact that atypical items led to less "Guess" responses than typical items. Finally, and in line with the results of Experiment 1, there was no evidence for the interaction between encoding type and item-typicality for "Guess" responses (*estimate* = 0.01, 95% Bayesian credible interval = [−0.09; 0.12], *pd* = 59.87%).

In sum, categorical encoding improved familiarity-based memories only, likely due to the economical processing related to the activation of a schema, suggesting the recruitment of the semantic system only. This result is compatible with the schema effect e.g., van Kesteren et al., 2010, van Kesteren, Beul, et al., 2013a, van Kesteren et al., 2014) that seems to be selective depending on the nature of the memory processes involved. Perceptive encoding, in contrast, enhanced recollection (e.g., Mäntylä, 1997). Furthermore, the observed item-typicality effects were also selective regarding the memory types, in that they seem to only affect recollection (Alves & Raposo, 2015; but see Höltje et al., 2019). Finally, item-typicality improved recollection only for categorically encoded items. This is arguably the case because atypical items have a small fit with their categorical prototype which might lead to an inconsistency effect that enhances episodic memories (Alves & Raposo, 2015; Bonasia et al., 2018; Dudai et al., 2015; Sakamoto & Love, 2004).

Overall accuracy of Recognition phase 2

Participants' overall recognition accuracy was 77%. The best converging logistic mixed-effects regression model followed the same steps as in Recognition Phase 1. The results are essentially the same as those observed in both previous recognition results, presenting the expected main effects and confirming the interaction effect observed before (see Appendix B for further details on this analysis).

Phenomenological judgments of conscious memories of Recognition phase 2

The modeling followed the same steps indicated in Experiment 1. The summary of results is presented in Figure 4.

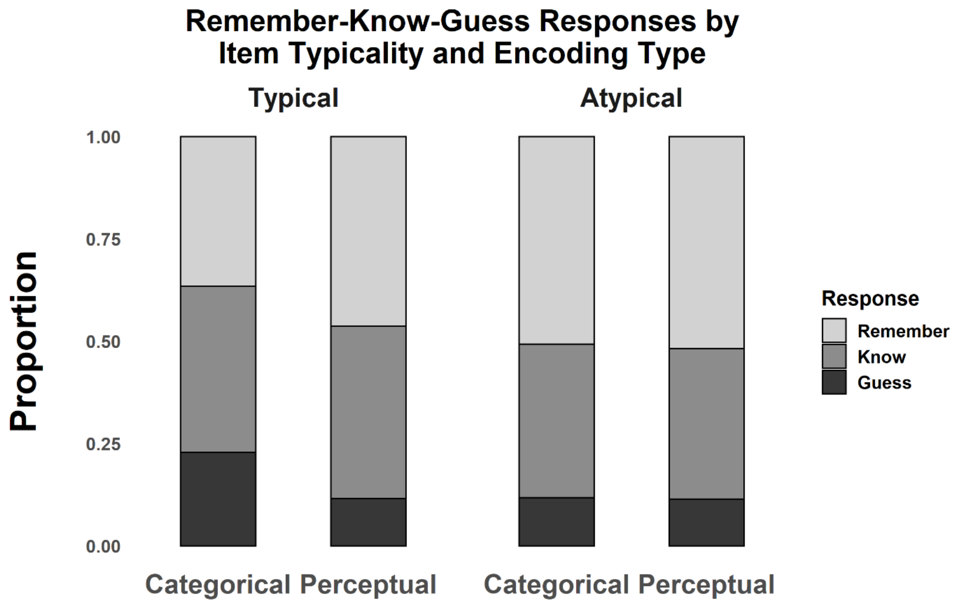

Figure 4. Proportions of "Remember", "Know" and "Guess" responses as a function Item-typicality and Encoding type in Experiment 2 (Rec2).

Note. Overall, there were 2010 responses (47%) for "Remember", 1686 responses (39%) for "Know" and 605 responses (14%) for "Guess".

The results from Rec2 replicate the item-typicality effect for Remember, with more Remember responses for atypical items (summary of results in Appendix B). For Guess responses, the expected encoding type effect was observed, with more guessing for categorical encoding, compared to perceptual encoding. At the same time, we observed a significant decrease in the amount of Remember responses (47%) as compared to 52% and 65% in Experiment 1 and Rec 1, respectively, which might have prevented us from observing the exact same pattern of results found in Experiment 1 and in Rec 1. It is possible that participants became less committed or motivated for the task in this last phase and tried to avoid the burden of giving descriptive source responses. Likewise, this second memory test might have reactivated traces from previous learning (see Antony et al., 2017; Potts & Shanks, 2012).

Source memory

The source information tasks in Rec2 inspected the source-type responses as indicators of the detailed and vivid memories regarding the item and self-related experience with the item during encoding (adapted from Gardiner et al., 1998). Below, we present the results for source accuracy in the task order identification and the source description question.

Source accuracy

Overall, 2064 source-type responses associated with Remember responses were analyzed. False recognition (i.e., New items evaluated as Old) was approximately 3% (54 responses). The responses associated with correct recognition (97%; 2010 responses) were the focus of the following analysis. Participants were highly accurate in identifying in which task the items were presented (M = .92, SD = .26). More than half (.54) of the correctly identified items in the task order question were presented in the perceptual condition and the remaining (.46) in the categorical condition. Likewise, more than half of these items (.56) were atypical, and the remaining (.44) were typical.

The analysis of the prior conceptual knowledge effects was conducted using a repeated measures ANOVA (2 Encoding and 2 Item-typicality) based on the absolute frequencies of each correct response for each condition per participant. Bonferroni's pairwise adjustment was used to contrast conditions. Post-hoc analysis was run using t-tests to inspect the direction of interaction effects. Responses from 77 participants were included in this analysis, given that a technical problem led to the loss of ten participants. The results showed a main effect of encoding, $F(1, 76) = 6.416$, $p = .013$, $\eta_{\mathrm{p}}^2 = .08$, CI 90% [.01, .18] with greater accuracy for perceptual (M = 6.01, SE = .46) than categorical encoding (M = 5.10, SE = .41), and a main effect of item-typicality, $F(1, 76) = 28.861$, $p < .001$, $\eta_p^2 = .275$, CI 90% [.14, .40] with higher accuracy for atypical items (M = 6.22, SE = .43) than for typical ones (M = 4.89, SE = .40). The interaction effect was also significant, $F(1, 76) = 10.353$, $p = .002$, $\eta_p^2 = .120$, CI 90% [.03, .24], with increased accuracy of source task for atypical items encoded in categorical conditions (Atypical: M = 6.19, SE = .47, Typical: M = 4.01, SE = .41; $t(76) = -6.642$, $p < .001$, $d_z = 1.07$, CI 90% [0.766, 1.368]). No difference was observed for perceptual encoding, $t(76) = -1.222$, $p = .226$.

Source descriptions

The 2010 source descriptions related to correct Remember responses were analyzed by two trained judges based on previously established categories (see Gardiner, 1988; Gardiner et al., 1998). The *a priori* established categories and results of source description are presented in Table 1. The high occurrence of "Item evaluation" and "Personal Associations" categories of source information reaffirms that detailed remembering was strongly related to the experience of recollection, being a marker of episodic-like processing.

Table 1. Descriptive information (category names, definition, and examples) and Percentages for each descriptive response category from the Source Description task

COD	CATEGORY	DESCRIPTION	(%)
IE	Item evaluation	when the response refers to the assessment of the item in the task, for example, “evaluated as complex”; “the item was in the animals’ category”	44
ASS	Private/personal association	when the response refers to some specific experience related to the item representation, for example, “associated with the bus that I take to go to the university”; “I found it funny”	35
AP	Item appearance	when the response refers to the appearance of the item, for example, “I found the color different”; “Size and position were unusual”	10
M	Mistake	when the response was restricted only to number 5 (key used to end response); when the text was not readable (e.g., “resdsdsds”)	5
TP	Task position	when the response refers to the position of the item in the task, for example, “I remember coming after a monkey”; “Appeared in training”	3
TE	Task event	when the response refers to an event related to the presentation of the item during encoding, for example, “I called the experimenter at the time”; “I dropped a pen when I saw the image”	1
K	Know	when the answer did not indicate details of the recall, for example, “nothing in particular”; “do not know”	1

Note. The column (%) corresponds to the percentage of responses types considering the amount of remembering.

Regarding prior conceptual knowledge modulation on source description, distinct rmANOVAs including 2 encoding type and 2 item-typicality as within-participant variables were calculated considering the proportions of source descriptions in item evaluation and personal association (the categories that were more frequent). An item-typicality main effect was observed for item evaluation, $F(1, 84) = 11.59$, $p < .001$, $\eta_p^2 = .121$, CI 90% [.03, .23] and for personal association, $F(1,84) = 10.07$, $p = .002$, $\eta_p^2 = .107$, CI 90% [.02, .21], whereby atypical items prompted higher item evaluation ($M_{Atypical} = .14$, $SE = .01$; $M_{Typical} = .01$, $SE = .01$) and personal associations ($M_{Atypical} = 0.12$, $SE = .01$; $M_{Typical} = .078$, $SE = .01$) than typical ones. Moreover, there was no encoding type effect or interaction with item-typicality. In other words, distinctive exemplars of categories seem to be directly related to the enhancement of particular details related to the recollective experience during source descriptions.

General Discussion

The present studies aimed to systematically investigate contradictory findings regarding the influence of prior conceptual knowledge (see van Kesteren et al., 2010; 2014 but see also Mäntylä, 1997; Sakamoto & Love, 2004 for opposing results) on memory, using the classic Remember-Know paradigm (Tulving, 1985). To this end, two experiments explored the idea that item-typicality effects may differentially affect recollective and familiarity-based memories, particularly as function of the availability of a stored schema. Our main prediction was that atypical items would selectively enhance recollection due to the activation of specific mechanisms supporting novelty processing (Bonasia et al., 2018; Dudai et al., 2015). Moreover, we explored how item-typicality could impact conscious memory processes as a function of encoding types by comparing recollection and familiarity-based memories for typical or less typical items depending on whether they were encoded categorically (schema activation) or perceptually (non-schematic). Experiment 2 replicated and extended Experiment 1 by including a second recognition phase with a source memory task. It was predicted that the pattern of source accuracy responses would be similar to the one observed for remember responses regarding the prior conceptual knowledge interaction effect, since both reflect the engagement in recollection processes.

Overall, the results showed enhanced recognition accuracy for atypical items in both experiments, in line with previous evidence on the facilitation effect of atypical items for episodic retrieval (Alves & Raposo, 2015; Graesser et al., 1980; although not gathering consensus in memory studies, see Schmidt, 1996).

Regarding the phenomenological judgments, we observed the selective advantage of perceptual encoding on recollection as reported by Mäntylä (1997). Notably, as expected, item-typicality differentially modulated recollection by the advantage of atypical information in selectively increasing recollection-based memories, as compared to low confidence familiarity-based memories. These results corroborate previous findings regarding the advantage of distinctiveness in promoting recollection-based memories (Alves & Raposo, 2015; Rajaram, 1998; Watier & Collin, 2012). The present findings also indicate that the improvement of recollection-based memories due to the low typicality of the materials may reflect the recruitment of the episodic system when processing information that is novel or violates the stored prototypical representation (see Bonasia et al., 2018; Dudai et al., 2015; Yonelinas et al., 2010), and is probably related to hippocampal involvement (Nadel & Moscovitch, 1997; Sekeres et al., 2018; Yonelinas et al., 2010, 2019). The ERP data reported by Höltje et al. (2019) also showed increased N400 amplitude according to the lower fit of the items with the categorical schema encoded (i.e., inconsistent > atypical > typical). This finding supports the idea that less typical information is less consistent (i.e., violating expectations) with the activated categorical schema (prototype) than highly typical one (see Bonasia et al., 2018; Dudai et al., 2015).

Furthermore, typical items increased familiarity-based judgments associated with low confidence and vagueness. The activation of typical items for familiarity-based responses is only partially in line with the schema-consistency advantage hypothesis (van Kesteren et al., 2010; 2013a), an advantage that was not observed for recollective memories. This finding suggests that the semantic system alone might be engaged bypassing the episodic system (Dudai et al., 2015). Moreover, it supports the idea that if the semanticized information is sufficient in a given situation (or in the absence of distinctive and vivid information), then the cortically-instantiated abstract version of memory will be recruited (Sekeres et al., 2017; 2018; van Kesteren & Meeter, 2020). The simultaneous observation of both schema and typicality effects helps to clarify prior conflicting findings reported in the literature (Alves & Raposo, 2015; Höltje et al., 2019; van Kesteren et al., 2013b) and suggests that these apparently contradictory effects coexist but act selectively upon either type of memory processes.

Few studies have simultaneously explored these memory conceptual knowledge effects in the context of previously stored categories, and report contradictory results (Alves & Raposo, 2015; Höltje et al., 2019). For example, our findings differ from those observed by Höltje´s et al. (2019), that report the schema advantage and the absence of typicality effects in memory recognition. However, these differences might result from relevant procedural differences, namely distinct tasks and different retention intervals. For instance, recognition tasks (as those used in Höltje´s et al., 2019) are known to involve both recollective and familiarity-based processes at the same time, which is not the case of the different conscious judgments required in the Remember-Know task (Gardiner, 1988; Yonelinas et al., 2010). Moreover, larger retention times (as those in Höltje´s et al., 2019), including sleeping, are known to improve consolidation processes (semanticization) due to reactivation of hippocampal structures and cortical regions (Dudai et al., 2015; Sekeres et al., 2017) and may enhance prior conceptual knowledge effects (as in van Kesteren et al., 2014).

Interestingly, when both types of prior conceptual knowledge interacted, atypical items boosted the probability of providing Remember responses only for the categorical condition. This finding suggests that atypical information activates episodic content, which was likely already recruited in the perceptual condition. Thus, no further gain associated with the recruitment of the episodic system was observed for perceptually encoded items. This interaction effect is noteworthy as it points to the importance of the specific stimuli used rather than the learning and encoding settings alone (see Dudai et al., 2015).

Together, these results suggest that distinct memory types might be co-activated and implicated in learning, with their available representations interacting according to materials, consolidation times, environmental demands, or behavioral requirements (see Nadel, 2020; Nadel et al., 2012; Renoult et al., 2019). Additionally, the results provided by the source-type task and source descriptions showed that recollection-based memories are influenced by distinctiveness, indicating that the overlap between the source judgments and the actual remember judgments are neither by chance nor motivated by overconfidence feelings (see Guo et al., 2006; Hicks et al., 2002).

However, there are some issues to be addressed in future work. First, the differences between categorical versus perceptual conditions might reflect different task demands involved in each encoding. Moreover, our effort to balance both encoding conditions in Experiment 2 was not entirely successful. Secondly, the inspection of response times during encoding in Experiment 1 showed that participants were overall faster in the perceptual condition, while in Experiment 2, the reverse was observed. However, this had no significant influence on the results during the recognition phase, which were consistent across experiments. Therefore, the observed differences in RTs during the encoding phase are unlikely to explain the recognition phase results since the overall recognition accuracy was always higher for perceptual encoding than for categorical encoding. Finally, previous studies on schema-congruency usually use word/sentence stimuli (e.g., Höltje et al., 2019; van Kesteren et al., 2014), while our studies examined abstract knowledge using visual materials. Since words are more abstract stimuli than images, they may present a stronger influence of semantic activation in facilitating retrieval. Therefore, our results should be replicated with different stimuli.

Conclusion

The overall role of semantic knowledge in cognitive processes has been repeatedly reported in clinical and healthy samples (Nadel et al., 2012; Souza et al., 2016; Toichi & Kamio, 2003; van Kesteren et al., 2013b). However, prior conceptual knowledge, such as schemata and prototypical information, both semantic in nature, seem to influence learning differently (e.g., Alves & Raposo, 2015; Höltje et al., 2019; Mäntylä, 1997; Sakamoto & Love, 2004; van Kesteren et al., 2013a). Our results provide important insights about the selective influence of prior conceptual knowledge in both recollective- and familiarity-based memories when a schema is available during learning and/or when it is violated. Notably, recollection was influenced by low item-typicality and by whether the categorical schema was activated or not. These findings circumscribe the general advantage of congruent schemas because this advantage was observed for familiarity-base memories only. Finally, the role of atypical information was also reiterated for vivid recollection-based memories, particularly when the categorical schema was activated during encoding.

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Open practice statement: None of the experiments were pre-registered in an open-source database. The main data are available online at the Open Science Framework, link <https://osf.io/9mfk5/?view_only=ec5ddab981f7488dbe9d248230e93170>.

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Appendix

Appendix A

Detailed instruction of RKG judgments

In this phase, you will be presented with one image at a time, and your task is to say if you HAVE SEEN these images BEFORE, during the first part of this session.

Press “S” (yes) if you have seen the image before.
Press “N” (no) if you have not seen the image.

When you claim to have seen the image before, you will then be asked to ASSESS YOUR recall experience, as:

REMEMBER: This answer implies the ability to become aware of some aspects of what happened or what was experienced when the image was presented. In other words, press REMEMBER when details related to remembering seeing the image comes to mind as a particular association (i.e., something more personal when you saw the item), the appearance of the image itself, its position in the task (i.e., what came before and after the image), or something that happened when you saw that image.

KNOW: This answer implies knowing that the image was presented previously in this task, but you cannot consciously remember anything about its specific occurrence. In other words, press KNOW when you are sure that the image was presented, but you cannot evoke any particular details about its occurrence.

GUESS: This answer implies that when you answered “yes” previously, you tried to guess that you saw the image before. In other words, just press GUESS when your answer “yes” was really guessing, with very little confidence.

For a better understanding of the task, here are some examples:

REMEMBER: If you were asked about the last film you saw, your answer would be based on a memory like “I remember”; which requires becoming aware of specific details of past experience.

KNOW: When you recognize someone on the street, but you do not remember who the person is or where you know the person from, you can only experience a feeling of familiarity without becoming aware of a particular event or experience with the person in question.

GUESS: When you say that you remember someone, but you are just trying to guess that you know him/her without much confidence.

If you have any QUESTIONS about how to classify the types of memory you have, please ask the EXPERIMENTER to EXPLAIN. A training phase will help you to understand the task better.

Appendix B

Experiment 1

Response Times (RTs) during Encoding
For this analysis, trials with RTs faster than 300 ms or slower than 3000 ms were excluded. Furthermore, trials with RTs 2.5 SDs or higher from the relevant condition means were discarded. Finally, RTs were standardized by subtracting the mean and dividing by the SD for analysis. The model was estimated using ML and BOBYQA optimizer; with encoding condition and typicality condition and their interaction considered as fixed effects, by-participant and by-item random intercepts, and a by-participant slope for encoding condition and typicality condition. The results of the best converging linear mixed-effects regression model showed that there was a main effect of encoding condition (*estimate* = − 0.05, *SE* = 0.03, *t* = − 2.04, *p* =.048, 95% CI [−0.10, 0.00]) in that response times were faster in the perceptual condition (*M* = 1388, *SD* = 668) compared to categorical condition (*M* = 1416, *SD* = 676). There was also a main effect of typicality condition (*estimate* = 0.08, *SE* = 0.02, *t* = 3.36, *p* =.001, 95% CI [0.03, 0.12]) in that response times were slower in the atypical condition (*M* = 1445, *SD* = 676) than in the typical condition (*M* = 1361, *SD* = 666). Finally, there was no evidence for an interaction between the two factors (*estimate* = − 0.01, *SE* = 0.01, *t* = − 0.68, *p* =.495, 95% CI [− 0.04, 0.02]).

Overall accuracy of Recognition
The binary response variable “Incorrect Response” versus “Correct Response” was analyzed with a mixed-effects logistic regression model, using the lme4 package (Bates et al., 2015), and specifically the binomial (link = “logit”) function. The best converging model, estimated using ML and BOBYQA optimizer, included encoding condition (categorical vs. perceptual) and typicality condition (typical item vs. atypical item) and their interaction as fixed effects; by-participant and by-item random intercepts, and by-participant slopes for encoding condition and typicality condition as random effects. The results of the mixed-effects logistic regression model showed a significant main effect of encoding condition (*estimate* = 0.54, *SE* = 0.13, z = 4.25, *p* < .001, 95% CI [0.29, 0.78]), with more correct responses in the perceptual condition (*M* = 0.80, *SD* = 0.40), compared to categorical condition (*M* = 0.66, *SD* = 0.47). There was no main effect of typicality condition (*estimate* = 0.12, *SE* = 0.11, z = − 1.04, *p* = .298, 95% CI [− 0.10, 0.33]). Furthermore, there was a significant interaction between the two factors (*estimate* = − 0.17, *SE* = 0.05, z = − 3.37, *p* = .001, 95% CI [− 0.27, − 0.07]). When broken up by the encoding type factor, follow-up comparisons showed that atypical items (*M* = 0.71, *SD* = 0.46) were recognized more accurately than typical items (*M* = 0.62, *SD* = 0.49) during the categorical encoding (*estimate* = 0.29, = 0.12, z = 2.42, *p* = .015, 95% CI [0.05, 0.52]). However, there was almost no difference in recognition rates for atypical (M = 0.79, SD = 0.40) and typical (M = 0.80, SD = 0.40) items during the perceptual encoding (*estimate* = − 0.05, *SE* = 0.12, z = − 0.43, *p* =.666, 95% CI [− 0.30, 0.19]). Finally, the segregation of the data by item-typicality revealed that participants were more accurate to recognize typical items during the perceptual (*M* = 0.80, *SD* = 0.40) encoding than during the categorical (*M* = 0.62, *SD* = 0.49) encoding (*estimate* = 0.71, *SE* = 0.14, z = 5.20, *p* < .001, 95% CI [0.44, 0.97]). Similarly, participants were also more accurate to recognize atypical items during the perceptual (*M* = 0.79, *SD* = 0.40) encoding than during the categorical (*M* = 0.71, *SD* = 0.46) encoding (*estimate* = 0.37, *SE* = 0.14, z = 2.69, *p* = .007, 95% CI [0.10, 0.63]).

Experiment 2

Response Times (RTs) during Encoding
Similar to Experiment 1, we analyzed the time participants took to classify typical and atypical images during the encoding phase using a linear mixed-effects regression model. Trimming procedures related to outlier treatment and RT standardization were the same as in Experiment 1.
This model was estimated using ML and BOBYQA optimizer; with encoding condition and typicality condition and their interaction considered as fixed effects, by-participant and by-item random intercepts, and a by-participant slope for encoding condition and typicality condition). The best converging linear mixed-effects regression model demonstrated a main effect of encoding type (*estimate* = 0.09, *SE* = 0.02, *t* = 4.48, *p* < .001, *95% CI* [0.05, 0.13]) in that response times were overall slower in the perceptual

condition (M = 908, SD = 574) compared to categorical condition (M = 819, SD = 501). There was also a main effect of item-typicality (*estimate* = 0.05, SE = 0.01, t = 4.48, p < .001, *95% CI* [0.03, 0.17]) in that response times were slower in the atypical condition (M = 886, SD = 552) compared to the typical condition (M = 841, SD = 526). However, there was a strong evidence for an interaction between the two factors (*estimate* = − 0.06, SE = 0.01, t = − 6.51, p < .001, *95% CI* [− 0.08, − 0.04]). Follow-up analyses with a dummy-coded item-typicality factor showed that participants took significantly more time to judge typical items during the perceptual (M = 914, SD = 578) encoding than during the categorical (M = 770, SD = 460) encoding (*estimate* = 0.15, SE = 0.02, t = 6.69, p < .001, *95% CI* [0.11, 0.19]). Interestingly, however, the same pattern did not hold true for atypical items, in that participants did not significantly differ in their response times during the perceptual (M = 903, SD = 569) encoding, compared to categorical (M = 870, SD = 535) encoding (*estimate* = 0.04, SE = 0.01, t = 1.56, p =.122, *95% CI* [− 0.01, 0.08]). When broken up by the encoding type factor, follow-up comparisons showed that atypical items (M = 870, SD = 535) were responded to more slowly than typical items (M = 770, SD = 460) during the categorical encoding (*estimate* = 0.11, SE = 0.12, z = 7.55, p < .001, *95% CI* [0.08, 0.14]). However, the difference in response times for atypical (M = 903, SD = 569) and typical (M = 914, SD = 578) items during the perceptual encoding was negligible (*estimate* = − 0.01, SE = 0.01, t = − 0.44, p =.658, *95% CI* [− 0.03, 0.02]).

Overall accuracy of Recognition phase 1

These analyses followed similar procedures from Experiment 1. In the present analysis, the lme4 package (Bates et al., 2015) was applied, and specifically, the binomial (link = "logit") function was used to analyze the binary response variable "Incorrect Response" versus "Correct Response" with a mixed-effects logistic regression model. The best converging model (estimated using ML and BOBYQA optimizer) included encoding condition (categorical vs. perceptual) and item-typicality condition (typical item vs. atypical item) and their interaction as fixed effects; by-participant and by-item random intercepts, and by-participant slopes for encoding condition and item-typicality condition as random effects.

The results of the mixed-effects logistic regression model showed a significant main effect of encoding type (*estimate* = 0.43, SE = 0.08, z = 5.61, p < .001, 95% *CI* [0.28, 0.57]) with more correct responses in the perceptual condition (M = 0.88, SD = 0.32) compared to categorical condition (M = 0.80, SD = 0.40). This time, there was a reliable main effect of item-typicality (*estimate* = 0.23, SE = 0.06, z = 3.66, p < .001, 95% *CI* [0.11, 0.35]), reflecting the fact that participants' accuracy was higher when they processed atypical items (M = 0.87, SD = 0.34) rather than typical items (M = 0.82, SD = 0.39). Finally, there was also a significant interaction between the two factors (*estimate* = − 0.10, SE = 0.04, z = − 2.84, p = .004, *95% CI* [− 0.17, − 0.03]). When broken up by the encoding type factor, follow-up comparisons showed that atypical items (M = 0.85, SD = 0.36) were recognized more accurately than typical items (M = 0.76, SD = 0.43) during the categorical encoding (*estimate* = 0.33, SE = 0.07, z = 4.89, p < .001, *95% CI* [0.20, 0.46]). However, and similar to Experiment 1, the differences in recognition rates were not statistically different for atypical (M = 0.89, SD = 0.31) and typical (M = 0.87, SD = 0.33) items during the perceptual encoding (*estimate* = 0.13, SE = 0.8, z = 1.65, p =.098, *95% CI* [− 0.02, 0.27]). Finally, the segregation of the data by item-typicality revealed that participants were more accurate to recognize typical items during the perceptual (M = 0.87, SD = 0.33) encoding than during the categorical (M = 0.76, SD = 0.43) encoding (*estimate* = 0.53, SE = 0.08, z = 6.44, p < .001, *95% CI* [0.37, 0.69]). In a similar way, participants were also more accurate to recognize atypical items during the perceptual (M = 0.89, SD = 0.31) encoding than during the categorical (M = 0.85, SD = 0.36) encoding (*estimate* = 0.32, SE = 0.09, z = 3.76, p <.001, *95% CI* [0.15, 0.49]).

Overall accuracy of Recognition phase 2

The same statistical procedures as in Experiment 2 were used. The best converging logistic mixed-effects regression model to analyze error rates was the same as in Recognition Phase 1. The results showed a significant main effect of encoding type (*estimate* = 0.36, SE = 0.07, z = 4.89, p < .001, *95% CI* [0.22, 0.50]) with more correct responses in the perceptual condition (M = 0.82, SD = 0.38) compared to categorical condition (M = 0.72, SD = 0.45). Similarly, there was a significant main effect of typicality condition (*estimate* = 0.23, SE = 0.06, z = 3.45, p < .001, 95% *CI* [0.10, 0.36]), with more correct responses for atypical items (M = 0.80, SD = 0.40) than typical items (M = 0.74, SD = 0.44). Finally, there was also evidence for a significant interaction between the two factors (*estimate* = − 0.15, SE =

0.04, z = − 3.98, $p < .001$, 95% *CI* [− 0.23, − 0.08]). When broken up by the encoding type factor, follow-up comparisons showed that atypical items (*M* = 0.78, *SD* = 0.42) were recognized more accurately than typical items (*M* = 0.67, *SD* = 0.47) during the categorical encoding (*estimate* = 0.38, SE = 0.07, z = 5.20, $p < .001$, 95% *CI* [0.24, 0.53]). Again, the differences in recognition rates were negligible for atypical (*M* = 0.83, *SD* = 0.38) and typical (*M* = 0.82, *SD* = 0.38) items during the perceptual encoding (*estimate* = 0.07, *SE* = 0.8, *z* = 0.93, *p* =.352, *95% CI* [− 0.08, 0.23]). Finally, and in line with previous results, the segregation of the data by item-typicality revealed that participants were more accurate to recognize typical items during the perceptual (*M* = 0.82, *SD* = 0.38) encoding than during the categorical (*M* = 0.67, *SD* = 0.47) encoding (*estimate* = 0.51, *SE* = 0.08, *z* = 6.32, $p < .001$, *95% CI* [0.36, 0.67]). Similarly, participants were also more accurate to recognize atypical items during the perceptual (*M* = 0.83, *SD* = 0.38) encoding than during the categorical (*M* = 0.78, *SD* = 0.42) encoding (*estimate* = 0.20, *SE* = 0.09, *z* = 2.40, *p* = .016, *95% CI* [0.04, 0.37]).

Phenomenological judgments of conscious memories of Recognition phase 2

Know versus Remember

The mixed-effects multinomial regression analysis demonstrated that, unlike before, there was no significant effect of encoding type factor (*estimate* = 0.11, 95% Bayesian credible interval = [−0.00; 0.23], pd = 97.20%). However, there was a significant main effect of item-typicality factor (*estimate* = 0.24, 95% Bayesian credible interval = [0.11; 0.38], pd = 99.97%), in that there again was an advantage in proportion of “Remember” responses for atypical items relative to typical ones. Unlike before, there was no evidence for an interaction between the two factors (*estimate* = − 0.06, 95% Bayesian credible interval = [− 0.15; 0.03], pd = 91.15%).

Know versus Guess

The mixed-effects multinomial regression analysis showed that encoding type was a significant predictor of participants’ responses (*estimate* = − 0.21, 95% Bayesian credible interval = [−0.34; − 0.08], pd = 99.90%), in that the log-odds of providing a “Guess” response in the perceptual encoding condition decreased relative to categorical condition. The evidence for the effect of item-typicality factor for “Guess” responses was minimal in that the probability of direction was above 97.5% but a 95% credible interval included zero (*estimate* = − 0.15, 95% Bayesian credible interval = [−0.30; − 0.00], pd = 97.87%). Most interestingly, however, the analysis showed that this time there was a reliable evidence for the interaction between encoding type and item-typicality for “Guess” responses (*estimate* = 0.19, 95% Bayesian credible interval = [0.08; 0.31], pd = 99.95%). A separate Bayesian mixed-effects logistic regression model with a dummy-coded item-typicality factor demonstrated that the type of encoding was not a significant predictor for atypical items (*estimate* = − 0.01, 95% Bayesian credible interval = [− 0.18; 0.17], pd = 84.47%). However, encoding type was a significant predictor for typical items (*estimate* = − 0.40, 95% Bayesian credible interval = [− 0.57; − 0.24], pd = 100.00%), with a log-odds decrease of the “Guess” responses during the perceptual encoding, as compared to categorical encoding. When broken up by encoding factor, the results showed that the effect of item-typicality was not significant for perceptual encoding (*estimate* = 0.04, 95% Bayesian credible interval = [− 0.15; 0.24], pd = 65.80%). However, it was significant for categorical encoding (*estimate* = − 0.35, 95% Bayesian credible interval = [− 0.53; − 0.18], pd = 100.00%), with a log-odds decrease of “Guess” responses for atypical items rather than typical items.

4.2. Age-related differences in the interaction between memories: The selective role of prior knowledge in preventing episodic loss

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Abstract

Healthy older adults present a distinctive pattern of reduced episodic memories but normal-to-improved semantic memories, which might help them overcome the challenges in retrieving episodic information. Still, the mechanisms underlying that advantage are yet to be clarified. It is unclear whether prior conceptual knowledge exerts a general influence on episodic retrieval or whether this influence selectively depends on the familiarity or recollective nature of memories. In this study, we examined age-related differences regarding the effect of categorical schema and item-typicality during encoding in selectively modulating familiarity- vs. recollection-based retrieval. Older adults (n = 53) were contrasted with younger adults (n = 52) in a Yes-No item recognition task modulated by encoding type (i.e., categorical vs. perceptive) and item-typicality (i.e., high-typical or low-typical) and in subsequent Remember-Know phenomenological judgments. Overall, the findings confirmed the selective role of encoding and item-typicality in enhancing declarative memories. Older adults presented lower episodic memory performance in overall recognition (accuracy and latency) and recollection response time. Notably, schematic knowledge prevented lower episodic recognition expected for a declining episodic system. Enhanced recollection-based memories (but not familiarity) in categorical encoding were also observed for this age group. However, while benefiting from low typicality, older adults took longer to process this information. These results support an interactive view of memory systems and encourage the development of interventional strategies using schematic knowledge to prevent age-related episodic losses.

Keywords: declarative memories; remember-know paradigm; recollection; familiarity; aging.

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Introduction

Declarative memory[15] retrieval problems are commonly reported in healthy older adults in clinical and experimental contexts and constitute a well-documented finding in the literature (e.g., Koen & Yonelinas, 2014; Spencer & Raz, 1995). Still, theories on age-related changes in declarative memories urge for further development and are far from conclusive regarding the impact of age on different types of memories (see Fraundorf et al., 2019). The current study examines how semantic knowledge modulates episodic recognition and related phenomenological recollection and familiarity judgments. The main goal is to better understand age-related strategies to overcome possible lifespan decline in retrieving contextual-based memories while clarifying the interaction between semantic and episodic systems.

Aging memory studies have shown a decreased performance of declarative memories on free-recall, associative learning, source memory, recognition, and semantically demanding tasks in older people (e.g., Danckert & Craig, 2013; Gaesser et al., 2011; Rhodes et al., 2008; see also Spencer & Raz, 1995 for a review). However, the role of aging in recognition memories is not consensual (e.g., Sekuler et al., 2005). A recent meta-analysis of 232 recognition memory studies showed that older adults present globally impaired item recognition compared to younger ones, being less competent in accurately discriminating previously learned items and also more likely to judge new items as old (see Fraundorf et al., 2019). However, declarative memories retrieval is differently affected throughout healthy life. Age-related memory decline seems to be specific to episodic memories, while semantic memories of very familiar concepts, facts, and information remain preserved or might even improve over the life span (e.g., Lövdén et al., 2004; Luo et al., 2008; Nilsson et al., 1997; Rönnlund et al., 2003; Verhaeghen, 2003). These latter findings suggest that aging may also bring some memory advantages. One possible explanation for such dissociation is supported by the different systems involved in each memory type. The structures supporting the episodic system (i.e., Medial Temporal Lobe – MTL and, more specifically, the hippocampus) seem to be associated with the expected cognitive decline in healthy aging (O´Shea et al., 2016). However, semanticized memories that surpass those structures by a more direct and cortically allocated processing (Dudai et al., 2015; Sekeres et al., 2018) seem preserved in healthy aging.

Accumulated evidence using the remember-know (R-K) paradigm to inspect memory recognition points in the same direction. In this paradigm, a recognition task is followed by phenomenological judgments of recollection (Remember responses) and familiarity (Know responses). Recollection is an episodic-like memory process of re-experiencing the context in which memories were encoded in a self-based and detailed manner, supported by hippocampal structures (Yonelinas et al., 2010). Familiarity is an economic conscious recognition process likely supported by the semantic system and hence

[15] Declarative memories are conscious memories that may be factual-based (semantic-like memories) or context-dependent (episodic-like memories) representations (see Tulving, 1972; 1985).

independent of hippocampal structures (see Tulving, 1985; Yonelinas et al., 2010). Several studies indicated that recognition based on recollection processes is impaired in healthy aging (e.g., Bastin et al., 2004; Koen & Yonelinas, 2014; Mantÿla, 1993; Parkin & Walter, 1992; Prull, 2015). In contrast, familiarity processes seem to be preserved or even improved in aging samples (see Koen & Yonelinas, 2014; Mantÿla, 1993; Parkin & Walter, 1992). These findings suggest that, as we get older, our ability to learn new things and consciously retrieve information with vividness and enriched details diminishes. However, older adults can resort to their well-preserved semantic system to support recognition by means of familiarity. Based on this reasoning, we hypothesize that older adults' memory systems are likely to depend more on episodic-semantic interactions. If this is the case, prior conceptual knowledge is expected to assume an important role in enhancing memories.

The role of prior conceptual knowledge in improving memories has been documented in studies showing that the availability of schemas during encoding may optimize learning and subsequent retrieval processes (Liu et al., 2016; Tse et al., 2007; van Kesteren et al., 2010; 2014). Prior conceptual knowledge, such as schemas (i.e., structured knowledge), endorse and strengthen links between new learnings (supported by MTL structures) and previous representations spread over cortical regions (Tse et al., 1997). The availability of schematic knowledge allows rapid integration of new traits into a transformed abstract representation, bypassing novelty-based mechanisms (Dudai et al., 2015; Sekeres et al., 2018). The influence of schematic knowledge in memories has been observed in episodic performance in older adults (e.g., Tinard & Guillaume, 2019; Toth et al., 2011).

However, the generalized role of schemas in memories has been challenged (e.g., Mantÿla, 1997; Souza et al., 2022) as they seem to be both beneficial and detrimental to learning and retrieval processes (van Kesteren & Meete, 2020). Specifically, schema availability during learning appears to play a distinct role in subsequent recognition processes, namely recollection (purely episodic) and familiarity (semantic-based) memories (Mantÿla, 1997; Souza et al., 2022). Recently, Souza et al. (2022) argued that conceptual knowledge acts in a selective manner and depends on the type of information involved. The authors inspected the influence of two types of conceptual knowledge, namely, encoding type (categorical vs. perceptual) and item-typicality (typical vs. atypical), in conscious recollection (recollection vs. familiarity). Prior conceptual knowledge was tested at two levels: the superordinate abstraction level, as measured by schemas (i.e., categorical schemas), and the fine-graded organizational level, as measured by item-typicality (i.e., the fit of the item in its own categorical schema). While schematic knowledge constitutes purely semantic-based information, item-typicality information involves both general knowledge regarding the categories but also specific knowledge about the exemplars. Their results showed that categorical schemata are not beneficial to episodic-like memories (recognition and remember responses), which were enhanced by perceptual encoding only. However, a categorical schema advantage emerged for familiarity-based memories (Mäntylä, 1997; Souza et al., 2022). The authors also showed that the specific content or organization structures of the categories (i.e., the item-typicality information) and also its co-activation together with a categorical encoding might improve episodic-like memories. Specifically, low-typical information selectively increased recollection (the opposite was observed for familiarity judgments), mainly in categorical encoding conditions (Souza et al., 2021). These results are congruent with an episodic mechanism supporting the retrieval of items violating the available prototype (see Bonasia et al., 2018; Dudai et al., 2015; Yonelinas et al., 2010), as low-typical ones do. Moreover, the increased recollection of low-typical items encoded categorically further supported the selective role of prior schematic knowledge in enhancing detailed and vivid memories, strengthening the argument of declarative memories interaction.

Concerning older adults, studies have also shown that the encoding schema selectively improves recollection in R-K paradigms (Castel, 2005; Peters & Daum, 2008; see also Mäntÿla et al., 1993) - but not familiarity-based memories (Peters & Daum, 2008); a pattern that becomes accentuated in Alzheimer disease patients (e.g., Dalla Barba, 1997). Critically, recent meta-analytic data showed that, although advantageous to recollection memories, semantic-based encoding could disturb the recognition of old items of high semantic relatedness and lead to increased false alarms in aging (Fraundorf et al., 2019).

On the one hand, a well-preserved semantic system allows the formation of conceptual knowledge representations along healthy aging, favoring the emergence of a schema advantage in memory retrieval that helps surpass the demands imposed on a declining episodic system. On the other hand, episodic memory constraints in older people might impact the processing of item-typicality information, particularly in cases of low fit with the categorical prototype due to their higher dependence on episodic-semantic interactions. Therefore, the profile of declarative memories in aging could contribute to understanding the selective role of those two types of conceptual knowledge on different retrieval processes. To our knowledge, the role of categorical schema and item-typicality has not yet been examined in older adults, particularly within the same design. From a theoretical perspective, inspecting older adults' memory profiles might be promising for exploring the interplay between episodic and semantic systems. From a practical perspective, understanding how each type of conceptual knowledge affects episodic memories in this age group might contribute to refining assessment protocols and designing more effective interventions for promotion or rehabilitation purposes.

In this study, we examined the influence of prior conceptual knowledge (i.e., categorical schema and typicality) on episodic recognition and related phenomenological experiences (i.e., Recollection vs. Familiarity). Congruently with prior studies conducted with young adults, we predicted a selective improvement of episodic-like memories (recognition and recollection) in perceptive encoding and an advantage of schema knowledge specifically for semantic-like memories (familiarity) for this age group. The benefit of low-typical information was expected for episodic-like memories only, mainly for categorically (vs. perceptively) encoded items.

Our main goal was to extend the examination of prior knowledge influence on episodic-like memories by inspecting them in an aging sample, in which the interplay between episodic and semantic systems might be incremented in compensation for emerging age-related difficulties. In line with the literature (e.g., Nilsson et al., 1997; Peters & Daum, 2008), episodic-like memories should be worse in older adults with reduced performance and longer reaction times for recognition and recollection memories than in younger adults. In contrast, familiarity-based memories (Know and Guess responses) would remain preserved or even increase.

Critically, we expected the categorical schema to help overcome older adults' difficulties in recognition and recollection (reducing the performance differences between age groups), reflecting the semantic system engagement in overcoming episodic system decline. Furthermore, the age-related episodic decline would compromise the benefit of perceptual encoding (vs. categorical encoding) in enhancing recognition and recollection memories (Souza et al., 2022; 2022b; see also Dudai et al., 2015). We also did not expect an advantage of low typicality for older adults as predicted for younger ones. Item-typicality information constitutes conceptual knowledge that captures the fit of exemplars with their own semantic category. Processing this type of information is likely to recruit the semantic system and the episodic system as well (see Bonasia et al., 2018). Therefore, because of their declining episodic system, the use of available item-typicality information might be compromised.

Methods

Transparence and openness

All deidentified data and models are available as supplemental materials (https://osf.io/98fyj/?view_only=c571794b8b954a78a18f2963f9dd1f1e). Although not pre-registered, the design, hypothesis and analysis procedure of this study were previously defined as part of a research project previously appreciated by the Ethics Committee of [Host].

Participants

The sample size was determined based on the sample size (N = 38) of a previous related study by Souza et al. (2022, Study 1), where encoding type and item-typicality were manipulated. Given the additional predictor of age, we increased the sample size of the present research to 50 participants in each group.

Fifty-three healthy older adults (36 females; M_{age} = 66.92, SD_{age} = 1.06; $M_{schooling}$ = 9.46, $SD_{schooling}$ = .64), screened for general cognitive functioning (scoring ≥ 24/27 points on the Mini-Mental State Exam – MMSE, based on educational level; Guerreiro et al., 1994, Portuguese version[16]) were recruited and compared with a control sample of fifty-two healthy younger adults (47 females; M_{age} = 20.75, SD_{age} = 0.44; $M_{schooling}$ = 13.00, $SD_{schooling}$ = .17). Participants were volunteers who agreed to participate in the study and received a 10€ retail voucher in compensation for their collaboration.

[16] We acknowledge the variability of the educational level (range from 2-17 schooling years) of the sample of older participants, which is representative of the Portuguese aging community. This group experienced generational constraints in educational policies and socioeconomic needs, reflecting the political transition from a dictatorial regime to a democratic government. Mandatory education was four schooling years from 1956 to 1964, changed to six schooling years by the Decree Nº 45.810 of July 9th, 1964. Interestingly, even participants with less formal education (2 years) obtained MMSE scores within the minimum threshold expected for samples with a high level of education (27 points).

Stimuli

One hundred twenty-eight pictures were selected from a normed picture dataset (Souza et al., 2021) comprising eight categories of living (e.g., fruits, vegetables) and non-living domains (e.g., vehicles, kitchen utensils) varying in their typicality level (i.e., low, moderate and high). Eighty target stimuli (items presented during encoding) were selected based on their scores on item-typicality (M_{lower} = 4.91, SD_{lower} = .95; M_{higher} = 6.57, SD_{higher} = .28, $t(78) = -10.541$, $p < .001$, $d_z = -2.36$, CI 95% [1.78, 2.93]) while controlled for arousal, aesthetic appeal, picture-name agreement, familiarity, valence and visual complexity (all p's > .08). At recognition, those target items (i.e., old items) were presented together with forty-eight distractors (i.e., new items) matched in item-typicality as well as in the same dimensions as for the encoding task (all p's > .120). Examples of items are provided in the supplemental materials (https://osf.io/98fyj/?view_only=c571794b8b954a78a18f2963f9dd1f1e).

Procedures

The present study was approved by the Ethics Committee of [Host]. Data were collected in individual sessions held in cubicles at the [Host] laboratory or in a quiet room at the participants' homes, in cases of limited mobility only. E-prime 2.0 software was used to present the task and record the responses. After signing the informed consent, participants provided sociodemographic information and responded to the main task. In the main task, the Remember-Know paradigm manipulated by encoding (categorical; perceptual) and item-typicality (high typical; low-typical) was applied following a similar procedure as in Souza et al. (2022; 2022b). During encoding, participants were asked to perform two classification tasks of forty pictures each: a categorical sorting task (categorical schema encoding; "what is the best category to fit the item", 4-option forced responses with randomized categories - "mammals", "vehicles", "fruits", "musical instruments") and a complexity rating task (distinctive perceptual encoding; "how complex the image is", from "1 – very simple" to "4 – very complex") presented by blocks and counterbalanced across participants. After a 20 min interval, participants answered an incidental yes-no recognition task (i.e., they had to indicate if they saw the item during the encoding or not) followed by a conscious retrieval judgment of the recognized items. Specifically, participants had to do a phenomenological appraisal of their memories, namely indicating if they Remembered (i.e., vivid detailed retrieval), Knew (i.e., familiarity-based retrieval), or Guessed (i.e., a trying, reflecting familiarity-based retrieval without certainty) they saw the items. Each task started with a training phase to ensure that participants understood the task.

Data analyses

A 2 age group (older vs. younger) x 2 encoding type (categorical vs. perceptual) x 2 item-typicality (high typical vs. low-typical) mixed design was used to analyze accuracy scores and response times (RT) for recognition and conscious recollection judgments (Recollection and Familiarity17) as

[17] Here, familiarity comprises both Know and Guess responses in order to achieve a number of responses similar to recollective-based memories.

dependent variables. Age group was the between factor, while encoding type and item-typicality were within factors. The statistics were conducted with mixed-effects regression models with R Version 4.0.2 (R Core Team, 2019) corrected for adjustment for multiple tests (Holm-Bonferroni). Therefore, separate mixed models using logistic regression were conducted with group, encoding type, and item-typicality as main factors, as well as their interactions for overall recognition (correct vs. incorrect responses) and conscious retrieval (recollection vs. familiarity responses). We also included participants and items as random effects. To analyze the RTs for recognition accuracy and conscious judgments, we applied linear regression mixed-models with prior trial-based outliers' treatment. The acceptable interval of 300 ms to 3000 ms by participants in each group and condition was used as exclusion criterion. Only RT trials within +/- 2.5 SDs from each relevant condition by group were retained.

To ensure generalizability, the best converging models with a maximal random effects structure of the design (see Barr et al., 2013 for further details) were used to report the results. When the full model failed due to convergence or was found to be overfitted, we removed random effects (e.g., random slopes) that were causing convergence and overfitting issues. Follow-up analyses further explored simple effects when necessary.

Results

Overall recognition accuracy and respective RTs

A preliminary analysis indicated that one participant from the older group and two from the younger group performed below chance in overall recognition (*ACC* < 50%), which led to their exclusion from the analyses. The overall recognition accuracy was 88%. To inspect for conceptual knowledge effects on recognition accuracy, we performed a mixed-effects logistic regression model using the binomial (link = "logit") function of the lme4 package (Bates et al., 2015). Results are illustrated in Figure 1.

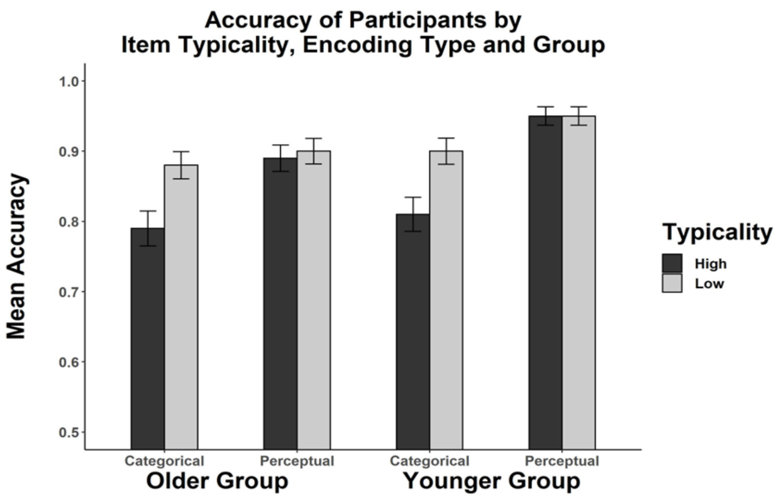

Figure 1. Participants' accuracy by encoding type (categorial vs. perceptual), item-typicality (low-typical vs. high-typical), and age group (older vs. younger).

Note. Results are shown in accuracy proportion (0-1), and error bars represent 95% confidence intervals.

The best converging model[18] showed a main effect of encoding type (*estimate* = 0.56, *SE* = 0.07, *z* = 7.58, *p* < .001, *95% CI* [0.41, 0.70]), indicating that participants were more accurate in recognizing perceptually encoded items (*M* = 0.92, *SD* = 0.27) than categorically encoded ones (*M* = 0.84, *SD* = 0.36). A main effect of item-typicality (*estimate* = 0.21, *SE* = 0.08, *z* = 2.47, *p* = .013, *95% CI* [0.04, 0.37]) was also observed, indicating that low-typical items (*M* = 0.91, *SD* = 0.29) were better recognized than high-typical items (*M* = 0.86, *SD* = 0.35). We also found a significant main effect of age group (*estimate* = −0.24, *SE* = 0.11, *z* = −2.20, *p* = .028, *95% CI* [−0.45, −0.03]), with older participants presenting lower recognition accuracy (*M* = 0.87, *SD* = 0.34) than younger ones (*M* = 0.90, *SD* = 0.30). Finally, we found a significant encoding type and item-typicality interaction (*estimate* = − 0.20, *SE* = 0.04, *z* = −4.94, *p* < .001, *95% CI* [−0.28, −0.12]) as well as an encoding type and group interaction (*estimate* = −0.20, *SE* = 0.07, z = −2.92, *p* = .004, *95% CI* [−0.33, −0.06]). No other interactions were significant (*p'*s > .15).

Follow-up analyses were run using the "emmeans" R package (Lenth, 2017), with the Hold method being selected to control for family-wise error rate. Regarding the encoding type and item-typicality interaction, we first segregated the data by encoding and observed that low-typical items (*M* = 0.89, *SD* = .31) were recognized more accurately in comparison to high-typical ones (*M* = 0.80, *SD* = .40) in the categorical encoding condition (*estimate* = 0.82, *SE* = 0.18, *z* = 4.65, *p* < .001, *95% CI* [0.42, 1.21]). However, no differences by item-typicality were observed in the perceptual encoding condition (low-typical: *M* = 0.92, *SD* = .26; high-typical: *M* = 0.92, *SD* = .27; *estimate* = 0.02, *SE* = 0.20, *z* = 0.09, *p* = .928, *95% CI* [−0.42, 0.46]). When segregated by item-typicality, both high-typical (*estimate* = 1.51, *SE* = 0.16, *z* = 9.23, *p* < .001, *95% CI* [1.15, 1.88]) and low-typical items (*estimate* = 0.72, *SE* = 0.17, *z* = 4.18, *p* <.001, *95% CI* [0.33, 1.10]) were better recognized in the perceptual encoding in comparison to categorical encoding condition.

Further inspection of the encoding type * age group interaction segregated by encoding showed that older participants presented lower accurate recognition (*M* = 0.89, *SD* = .31) than younger ones (*M* = 0.95, *SD* = .21) for perceptually encoded items (*estimate* = –0.87, *SE* = 0.29, *z* = –3.04, *p* =.005, *95% CI* [-1.51, –0.23]). However, age groups did not differ significantly in their recognition performance for categorically encoded items (older group: *M* = 0.84, *SD* = .37; younger group: *M* = 0.85, *SD* = .35; *estimate* = –0.08, *SE* = 0.22, *z* = –0.38, *p* = .703, *95% CI* [-0.58, 0.41]). When segregated by group our findings indicated an advantage of perceptual encoding over categorical in improving overall recognition accuracy for older (*estimate* = 0.72, *SE* = 0.19, *z* = 3.88, *p* < .001, *95% CI* [0.31, 1.14]) and younger adults (*estimate* = 1.51, *SE* = 0.21, *z* = 7.14, *p* < .001, *95% CI* [1.03, 1.98]).

We then performed a linear mixed-effects logistic regression model for RTs related to overall recognition accuracy. Results are illustrated in Figure 2.

[18] This accuracy (vs. error) model (without warnings) included encoding type, item-typicality, and age group as fixed effects and their interaction; participants and items as random intercepts, as well as by-participants random slope for encoding type.

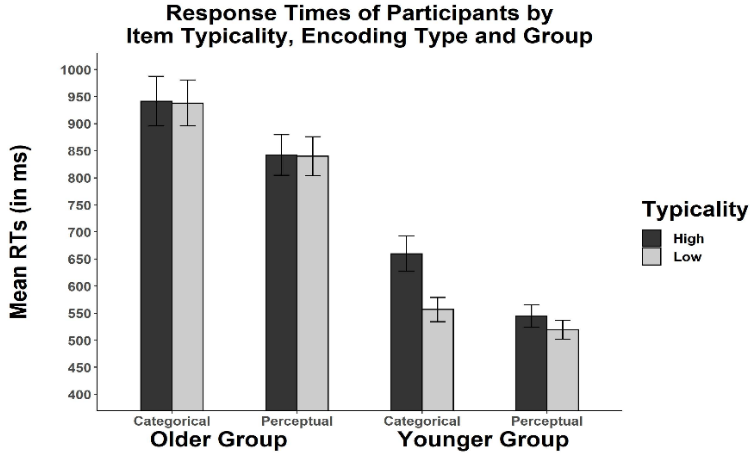

Figure 2. Participants' RTs associated with overall recognition trials by encoding type (categorial vs. perceptual), item-typicality (low-typical vs. high-typical), and age group (older vs. younger).

Note. Results are shown in mean response times (msec) and error bars represent the 95% confidence intervals.

The results of the best converging model[19] showed a significant main effect of encoding condition (*estimate* = −44.94, *SE* = 6.44, *t* = −6.97, *p* < .001, *95% CI* [−57.74, −32.13]) in that responding during perceptual condition (*M* = 682, *SD* = 426) was faster compared to the categorical one (*M* = 770, *SD* = 503). The main effect of item-typicality (*estimate* = −20.54, *SE* = 6.04, *t* = −3.40, *p* =.001, *95% CI* [−32.72, −8.36]) was also observed with low-typical items recognized faster (*M* = 710, *SD* = 455) than high-typical ones (*M* = 737, *SD* = 477). We also observed a main effect of group (*estimate* = 185.52, *SE* = 20.12, *t* = 9.22, *p* < .001, *95% CI* [145.60, 225.45]), indicating that older participants were slower in their responses (*M* = 888, *SD* = 534) than younger adults (*M* = 567, *SD* = 319). Finally, significant interactions between encoding and item-typicality (*estimate* = 12.13, *SE* = 5.35, *t* = 2.27, *p* = .023, *95% CI* [1.65, 22.61]), and between item-typicality and group (*estimate* = 12.25, *SE* = 5.43, *t* = 2.26, *p* = .027, *95% CI* [1.44, 23.06]) were also observed. No other interactions were significant.

Regarding the item-typicality and encoding type interaction, segregated data by encoding indicated that the faster recognition of low-typical items (*M* = 746, *SD* = 489) than high-typical ones (*M* = 796, *SD* = 516), was only observed in categorical encoding (*estimate* = −65.34, *SE* = 16.55, *t* = −3.95, *p* < .001, *95% CI* [−102.44, −28.24]) but not in perceptual encoding (low-typical: *M* = 677, *SD* = 418; high-typical: *M* = 687, *SD* = 434; *estimate* = −16.81, *SE* = 15.72, *t* = −1.07, *p* = .285, *95% CI* [−52.04, 18.42]). When split by item-typicality, perceptual encoding provided faster responses than categorical encoding for both low-typical (*estimate* = −65.61, *SE* = 16.50, *t* = −3.98, *p* < .001, *95% CI* [−102.60, −28.63]) and high-typical conditions (*estimate* = −152.21, *SE* = -76.07, *t* = −6.72, *p* < .001, *95% CI* [−152.21, −76.07]). Moreover, further inspection of the item-typicality and group interaction showed higher response times for older adults in both low-typical (Young: *M* =537, *SD* = 272; Older: *M* =888, *SD* =

[19] This model followed the same structure as in accuracy analysis except that that best converging model included the following random effects: intercepts for participants and items and the by-participants random slope for encoding type and item-typicality. No warnings were detected for this model.

531, *estimate* = 395.54, *SE* = 40.57, *t* = 9.75, *p* < .001, *95% CI* [304.61, 486.47]) and high-typical (Young: *M* = 597, *SD* = 358; Older: *M* = 888, *SD* = 538; *estimate* = 346.55, *SE* = 42.75, *t* = 8.11, *p* < .001, *95% CI* [250.72, 442.37]) conditions. However, when inspected by group, older adults did not take advantage of the low-typical items (*M* = 888, *SD* = 531) over high-typical ones (*M* = 888, *SD* = 538; *estimate* = −16.58, *SE* = 16.43, *t* = −1.01, *p* =.313, *95% CI* [−53.41, 20.25]) to provide faster recognition while younger adults did (low-typical: *M* = 537, *S* = 272; high-typical: *M* = 597, *SD* = 358; *estimate* = −65.57, *SE* = 16.06, *t* = −4.08, *p* < .001, *95% CI* [−101.58, - 29.57]).

Conscious retrieval judgments (proportions and RTs)

The model for conscious retrieval judgments was identical to the best model applied for overall recognition accuracy, including the same fixed and random factors. The dependent variable for conscious retrieval judgments was Recollection (vs. Familiarity). Significant effects on recollection presented the reverse pattern for familiarity. The main results are illustrated in Figure 3.

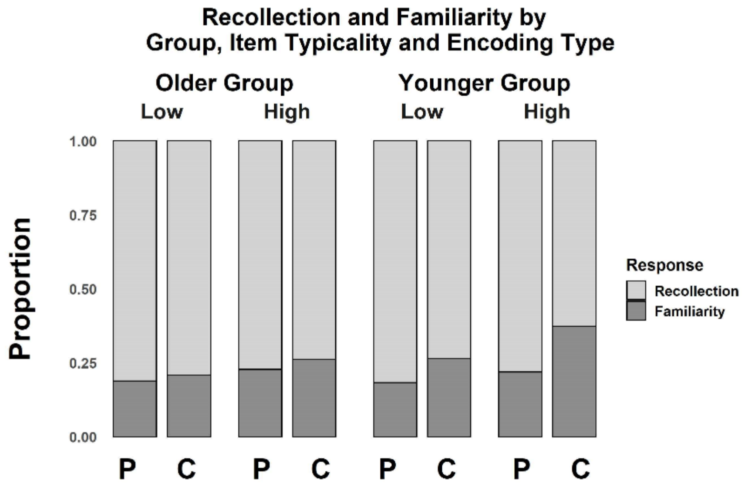

Figure 3. Conscious retrieval judgments (i.e., Recollection and Familiarity) by encoding type (C-categorial vs. P-perceptual), item-typicality (low-typical vs. high-typical), and age group (older vs. younger).

The results showed a main effect of encoding type (*estimate* = 0.34, *SE* = 0.06, *z* = 5.69, *p* < .001, 95% CI [0.22, 0.45]), in which participants provided more recollection judgments for perceptually encoded items (80%) than categorically encoded (73%) ones. The opposite pattern was observed for familiarity. A significant main effect of item-typicality (*estimate* = 0.25, *SE* = 0.07, *z* = 3.55, *p* < .001, 95% CI [0.11, 0.38]) was also observed, indicating more recollection-based memories of low-typical items (79%) than high-typical items (73%), and the reverse pattern was observed for familiarity judgements. We also found a significant interaction effect between encoding type and age group (*estimate* = − 0.12, *SE* = 0.06, *z* = − 2.17, *p* = .030, *95% CI* [− 0.24, − 0.01]). No other effects were significant.

Regarding the age group*encoding interaction, a further inspection segregated by encoding condition showed that the proportion of recollection judgments for perceptually encoded items was not significantly different between groups (older: 79%; younger: 80%; *estimate* = 0.35, *SE* = 0.42, $z = 0.83$, $p = .405$, *95% CI* [− 0.59, 1.29]). In contrast, the proportion of recollection judgments for categorically encoded items differed significantly between groups, being higher for older (77%) than younger adults (68%), *estimate* = 0.85, *SE* = 0.34, $z = 2.46$, $p = .027$, *95% CI* [0.08, 1.62]). When segregated by age group, the proportion of recollection-based memories was higher for the perceptual condition than the categorical condition for both younger (*estimate* = 0.92, *SE* = 0.16, $z = 5.93$, $p < .001$, *95% CI* [0.57, 1.27]) and older participants (*estimate* = 0.42, *SE* = 0.17, $z = 0.83$, $p = .015$, *95% CI* [0.03, 2.43]). Because of the dependency between the proportions of recollection and familiarity judgments, the opposite interaction pattern should hold for familiarity judgments.

In two separate models, we inspected the RTs for the same modeling as in accuracy for Recollection (remember responses only) and Familiarity judgments (know and guess responses collapsed). The best converging model for "Recollection"[20], showed a significant main effect of encoding type (*estimate* = -15.53, *SE* = 5.61, $t = -2.77$, $p = .006$, *95% CI* [-26.53, -4.52]), with higher RTs for recollection judgments in categorical encoding ($M = 948$, $SD = 498$) than perceptual ($M = 900$, $SD = 478$). The observed significant main effect of age group (*estimate* = 252.71, *SE* = 26.29, $t = 9.61$, $p < .001$, *95% CI* [200.53, 304.89]) indicated that older participants ($M = 1117$, $SD = 515$) were slower in providing recollection judgments than younger ones ($M = 660$, $SD = 287$). No other effects were significant. The best converging model[21] for "Familiarity" showed a main effect of age group (*estimate* = 231.08, *SE* = 28.80, $t = 8.02$, $p < .001$, *95% CI* [173.86, 288.31]) indicating that older participants ($M = 1180$, $SD = 586.39$) were slower than younger ones ($M = 810$, $SD = 346.46$) to provide familiarity judgments. A significant interaction between item-typicality and age group (*estimate* = -25.90, *SE* = 11.68, $t = -2.22$, $p = .027$, *95% CI* [-48.81, -2.98]) was also observed. A further inspection of this interaction with data segregated by item-typicality indicated that the older group was slower to provide familiarity responses than the younger one for low-typical items (older: $M = 1136$, $SD = 575.44$; younger: $M = 832$, $SD = 351.79$; *estimate* = 410.37, *SE* = 63.37, $t = 6.48$, $p < .001$, *95% CI* [268.88, 552.41]). The older group was also slower to provide familiarity responses than the younger group for high-typical items (older: $M = 1217$, $SD = 593.86$; younger: $M = 792$, $SD = 341.54$; *estimate* = 513.96, *SE* = 60.91, $t = 8.44$, $p < .001$, *95% CI* [377.44, 650.49]), although the mean difference was smaller than the one observed for low-typical items. However, when inspected by group, no significant results were observed after Holm correction. No other effects were significant.

[20] The best converging linear mixed effects model without warnings included fixed effects of encoding, item-typicality, group and their interaction, and a random intercept for participant.
[21] In this case, the best converging model without warnings included fixed effects of encoding type, item-typicality, and group and interaction between them; random intercepts for participants and items, as well as by-participants random slope for encoding type.

Discussion & Implications

The current study examined the role of the available conceptual information, namely categorical schema (categorical vs. perceptual) and item-typicality (typical vs. atypical), on conscious retrieval of declarative memories in older adults compared to younger ones to further explore the interplay between episodic and semantic systems.

We expected to confirm the selective effect of encoding type, with perceptual encoding increasing episodic-like memories (recognition and recollection) and categorical schemas improving only familiarity. The selective effect of item-typicality was also predicted, with low-typical items enhancing episodic-like memories, particularly in the categorical condition. Overall, following previous studies with young adults, our results showed that both perceptual encoding and low-typical items increased recognition and recollection (but not familiarity), particularly for categorically encoded items (see Souza et al., 2021; 2022b). In contrast, familiarity increased only in the categorical condition and for high-typical items. This pattern confirms the successful manipulation of prior knowledge within the Remember-Know paradigm.

As previously reported in the literature, older adults should present lower and slower recognition responses than younger ones. We also predicted increased familiarity-based memories (know and guess responses) and reduced recollection-based memories (fewer and slower remember responses) for older adults compared to younger ones. As expected, older adults showed lower and slower overall recognition, suggesting a globally affected episodic system (Fraundorf et al., 2019; Spencer & Raz, 1995). In contrast, recollection- and familiarity-based memories seemed to be unaffected by aging (but see Koen & Yonelinas, 2014; Mantÿla, 1993; Parkin & Walter, 1992; Prull, 2015). Notably, older participants took more time to provide recollection and familiarity judgments, likely related to overall constraints in searching, reactivating, and evaluating information. These findings suggest that processing speed might be at the core of aging-related memory deficits (see Buence & Macready, 2005; Clarys et al., 2002), possibly reflecting limited co-occurring resources for inhibitory/control mechanisms (see Kirova et al., 2015 for a review).

Regarding the conceptual knowledge manipulation, the categorical schema was expected to act selectively in preventing episodic-like memories decline by reducing the performance drop in recognition and recollection-based memories in older participants. Moreover, while the younger group would present an advantage of perceptual encoding over categorical in recognition and recollection memories, this advantage was not expected for the older group. These predictions reflect the characteristic pattern of a declined episodic system but preserved semantic system in older adults. Notably, the categorical schema was expected to help the older group overcome episodic difficulties by reducing episodic-based requirements, while in younger adults, this schema influence should not be essential to achieve successful retrieval. In contrast, item-typicality information should not benefit older adults´ memories of pure recollection-based nature (remember responses) due to a less efficient episodic memory system and, therefore, acting selectively in enhancing familiarity-based memories only (Souza et al., 2022; 2022b; see also Dudai et al., 2015).

Our findings showed different results for the categorical schema (as shown in the encoding condition contrasts) and item-typicality manipulations across age groups. Categorical schema minimized age-related episodic decline, with an equivalent performance of both age groups in recognizing categorically-encoded items. Furthermore, older participants only showed higher recollection judgments than younger ones in categorical schema encoding conditions. An opposite pattern of reduced familiarity-based memories was observed for older adults only in this condition compared to younger ones. These findings suggest the benefit of schematic conceptual knowledge in overcoming recognition and recollection-based difficulties, particularly in older adults (Peters & Daum, 2008). It is possible that, along the lifespan, recognition processes may engage compensatory semantic-based mechanisms towards optimal functioning, using the available resources (i.e., schemas) to achieve a successful retrieval (Cheryl et al., 2000; Salthouse, 2010). Therefore, it is likely that episodic and semantic systems are more intertwined in older people. Moreover, contrary to an expected widespread decline, we found that, like younger adults, older participants also took advantage of perceptive over categorical encoding in episodic-like memories (i.e., recognition and recollection). RTs did not show significant differences between groups in recognition, recollection, and familiarity when considering the encoding type. Together, these results suggest that older adults face slight (but noticeable) episodic constraints that they attempt to overcome by resorting to the semantic system and its interaction with the episodic system. Importantly we provide evidence that this interaction can potentially minimize emerging difficulties in retrieving vivid, detailed representations arising with age.

Regarding the influence of item-typicality manipulation across age groups, while presenting the same advantage of low-typical information as younger adults did in episodic-like and semantic-like memories, older adults required more time to process item-typicality information overall during recognition and familiarity judgments. This time-consuming processing of item-typicality information is likely to represent a strategy to better use this type of conceptual information in helping recognition and familiarity-based judgments, which raised their performance to younger adults' level. Processing low-fit information implies increased involvement of the semantic system in cooperation with the episodic system; this latter required to process novelty information (less congruency; see Dudai et al., 2015) of the specific exemplars. Therefore, while the schematic information may act in overcoming the episodic requirements to achieve successful episodic-like memories retrieval, item-typicality information requests the active role of the episodic memory system, regardless of how fragile this memory system is in aging. Our findings seem to mirror this pattern and support a dynamic and intertwined perspective on memory systems (see de Mendonça et al., 2021; Nadel & Moscovitch, 1997; Winocur et al., 2010).

Memories are critical in preserving adaptative and social behavior that support an autonomous life. Understanding how memories progress along life helps clarify how memory systems function, improving neurocognitive theories as well as elucidating several memory-related pathological conditions. The current findings confirmed that age-related memory decline affects episodic recognition and slows down memory performance, thus should be considered a (pre)clinical condition (Small, 2001).

However, the reported findings challenge an alleged overall age-related decline in episodic memories by showing that age differences in memory can be minimized (in accuracy and processing time) when structured schematic knowledge is available. The observed advantage of categorical schemas in reducing the episodic constraints experienced by older people on recollective memories may be helpful in future assessments and interventions. Aging assessments usually inspect memories as a single entity or, when considering different memory types, assume them to be independent. As our findings indicate, memory patterns along aging are complex and depend on the systems involved and the type of information to process.

Notably, besides cognitive systems, several other aspects may influence memories (e.g., education, resilience to distress, personality traits, intelligence, etc.), challenging any attempt to derive generalized conclusions. In the current study, we compared two groups differing in age but also in educational background. Nevertheless, due to the basic level of knowledge required to complete the task, the educational level does not seem responsible for the observed aging effects since the advantage of conceptual knowledge appeared specifically for the older, less educated sample (as in Peters & Daum, 2008).

Conclusion

Our primary question was whether conceptual knowledge could help overcome the possible age-related decline in episodic memories. Our results corroborate the age-related episodic decline, which seems to be compensated by a well-preserved semantic memory system. However, this advantage of conceptual information is not generalized since it is selective to general conceptual knowledge, such as categorical schemas, and not extensive to specific levels of conceptual information, such as item-typicality information. Overall, the demonstration that older people use their semantic system to compensate for episodic constraints makes them a good model to examine the interactions between these memory systems. Finally, although dissociative approaches are essential to understand the specificities of each memory system, further interactive approaches for the examination of associated personal and social-related characteristics are needed to enrich the big picture of the natural but selective decline in memory systems.

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4.3. The distinctive pattern of declarative memories in Autism Spectrum Disorder: Further evidence of episodic memory constraints

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Abstract

This study examines declarative memory retrieval in ASD depending on the availability and access to stored conceptual knowledge. Fifteen autistic participants and a matched control group of 18 typically-developed (TD) volunteers completed a Remember-Know paradigm manipulated by encoding-type (categorical, perceptual) and item-typicality (high-typical, low-typical). The autistic group showed worse and slower recognition and less recollection but equivalent familiarity-based memories compared to TDs. Notably, low-typical items did not improve their memories, as they did for TDs, likely due to difficulties in matching low-fit information to the stored schema. Results suggest that memory decline in ASD may derive from the episodic system and its dynamics with the semantic system. These findings may inform interventional strategies for enhancing learning abilities in ASD.

Keywords: declarative memories; recognition; recollection; familiarity; autism spectrum disorder

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Introduction

Declarative memories include clearly defined long-term memory types that reflect our capability to store and retrieve different types of conscious memories. Episodic memory entails representations directly dependent on experiences or context, allocated to the Medial Temporal Lobe, namely the hippocampus (Tulving, 1972; 1985; Yonelinas, 2002; Yonelinas et al., 2010). Semantic memory comprises abstract representations (context-free) that are cortically supported (Tulving, 2000; Yonelinas et al., 2010). Recent accounts of memory consolidation (Nadel & Moscovitch, 1997; Winocur et al., 2010; Winocur & Moscovitch, 2011; Sekeres et al., 2018) are more dynamic and argue in favor of the transformation of contextually-based traits (hippocampus-dependent) into more schematic representations that are supported by neocortical regions and become progressively independent from the hippocampal regions. In other words, semantic memories are formed from the transformation of episodic traits into context-free traits. Episodic memories, however, remain supported by the hippocampus as long as they maintain their contextual details (Harand et al., 2012; Winocur & Moscovitch, 2011). According to this approach, the episodic system seems crucial in processing information that brings novelty or unexpectedness (see Bonasia et al., 2018; Dudai et al., 2015; Yonelinas et al., 2010). The hippocampus acts in binding such novel inputs (received from other brain regions) in a complex, relational manner (Yonelinas et al., 2010; 2019). However, when the new information fits prior stored conceptual knowledge (i.e., schema), the involvement of the episodic system in processing and integrating new, unexpected incoming information is circumvented or even suppressed (see Dudai et al., 2015).

People in the Autism Spectrum (Autism Spectrum Disorder, ASD) tend to present a characteristic pattern for long-term declarative memories, namely a decline in episodic memory of self-based recollection experiences (Boucher & Bowler, 2008; Bowler et al., 2011; Joseph et al., 2005; see also Bowler et al., 2011; Cooper & Simons, 2018 for reviews). However, it has also been argued that this particular episodic memory profile can be subtle or absent in the spectrum depending on the sample characteristics, type of measures, and task modalities (see Boucher et al., 2012 and Griffin et al., 2021 for reviews; see also Bennetto et al., 1996; Justus et al., 2021; Souchay et al., 2013). In contrast, semantic memory remains preserved across several tasks and stimuli types (e.g., Bowler et al., 2000; Carmo et al., 2016; 2017; 2020; Gaigg et al., 2014; 2015; Joseph et al., 2005; Meyer et al., 2014; Souchay et al., 2013; Souza et al., 2016; Toichi & Kamio, 2003).

The Remember-Know (R-K) paradigm is a classic memory retrieval task that enables a contrast between episodic and semantic memory performance. In this paradigm, after a study phase, participants are invited to retrieve the information (overall recognition) and subsequently to evaluate whether they remember, know or tried to guess their retrieval experience with the item ("phenomenological judgments"; see Tulving, 1985). Remember responses are episodic-like memories associated with vivid recollective experiences sustained by the hippocampus (Tulving, 2000; Yonelinas, 2010), while Know and Guess responses are driven by familiarity processes related to cortical engagement (Gardiner, 1988;

Tulving, 1985; Yonelinas, 2010). In studies using the R-K paradigm, participants in the autistic spectrum have consistently shown diminished recollection together with a preserved or even enhanced, familiarity-based processing, regardless of stimulus type (e.g., Bowler et al., 2000; Gaigg et al., 2014; 2015; Meyer et al., 2014; Souchay et al., 2013). Gaigg et al. (2015) examined the selective retrieval mechanisms engaged by these two distinct memory-related processes as a function of the influence of relational encoding (i.e., associative learning of items and their semantic context) in autism. The results provided evidence of disparities in encoding episodic memories in ASD, with less engagement of the hippocampus and greater activation of Prefrontal Cortex (PFC) regions involved in relational demands for successfully encoded items. Moreover, individuals in the autism spectrum presented diminished recollection, associated with an absence of signal differentiation between recollection-based and familiarity-based trials in large PFC areas (middle and inferior frontal gyri), observed in their comparison group. This unusual PFC activity was attributed to a compensatory and more effortful memory encoding to overcome the reduced hippocampal binding strategies in autistic people.

Moreover, despite their preserved general semantic memory-related processes (Bowler et al., 2000; Carmo et al., 2016; 2017; Gaigg et al., 2014; 2015; Souza et al., 2016; Toichi & Kamio, 2003), autistic participants seem to present difficulties in semantic categorization (Carmo et al., 2016; Carmo et al., 2021 Gastgeb et al., 2006, but see Molesworth et al., 2005), namely in processing items that do not entirely fit the category-defining features (i.e., atypical items[22]). Autistic individuals also showed longer response times for processing atypical information (but not for typical) in categorization tasks than their comparison groups (Carmo et al., 2020; Gastgeb et al., 2006; Gastgeb & Strauss, 2012). These studies support the idea of semantic categorization decline in autistic participants that seems to be related to faulty encoding strategies during the relational binding of novel or atypical information with stored conceptual knowledge (such as category schemas).

The presence of complex associative conceptual knowledge, known as schemas, has been argued to assist and accelerate memory consolidation processes and improve retrieval of declarative memories for adaptative purposes (Tse et al., 2007 van Kesteren et al., 2013; 2014). However, recent studies with non-autistic participants have shown that the schema advantage seems to be selective for semantic memories (Mäntylä, 1997; Souza et al., 2022). For example, Souza et al. (2022) tested declarative memories of typically-developed (TD) participants using the R-K paradigm manipulated by encoding type (categorical vs. perceptual) and item-typicality (typical vs. atypical) in a visual recognition task. While schemas are generic representations, typicality reflects the likelihood of an item fitting its categorical prototype. Therefore, an atypical item activates the category prototype but does not entirely conform with it since it has more distinctive features. Their results showed that a categorical schematic

[22] Typicality refers to a semantic organization process reflecting how good an item is in representing its category. Typical items share the prototypical features of their categories (e.g., an apple in the Fruit category); atypical items present less fit with their categorical prototype (e.g., a dolphin is atypical in Mammals) (see Medin et al., 2007; Murphy & Medin, 1985; Rosch, 1978).

encoding did not improve overall recognition and remember responses, while perceptual encoding did. Likewise, atypical items increased recollection-based memories, particularly in categorical encoding. These results are consistent with the idea of an engagement of the episodic system in case of novelty or when the item is inconsistent with the available prototype (see also Bonasia et al., 2018; Dudai et al., 2015; Yonelinas et al., 2010).

The current work is based on the assumption that the distinctive pattern of declarative memories in ASD rests on flaws in the episodic memory system, likely due to altered hippocampal functioning (Gaigg et al., 2015) and its interaction with cortical regions. Therefore, our primary goal was to explore the characteristic profile of declarative memories in ASD, seeking evidence of reduced episodic memory and their impact on semantic processing. Using the R-K paradigm manipulated by encoding type (categorical vs. perceptual) and item-typicality (high vs. low typical), we examined the influence of different types of conceptual knowledge (i.e., categorical schema activation and prototype activation) in recognition and related memory processes (Recollection vs. Familiarity). We expected to find an overall reduction of episodic memory in ASD participants compared to typically developing participants, reflected in lower accuracy and slower responses in overall recognition and recollective experience (Remember responses) but not in familiarity-based responses. Furthermore, we expected that such alleged differences in the episodic system would also impact the processing of item-typicality in ASD, namely by impairing the normal processing of atypical information (that has less fit with the categorical prototype), which has been shown to enhance overall recognition and recollection-based memories in non-autistic participants (Souza et al., 2022; see also Dudai et al., 2015).

Methods

Participants

Fifteen male adults diagnosed with ASD (scoring > 70 points on the verbal subscale of Weschler Adult Intelligence Scale - WAIS) were matched with eighteen typically developed male participants in terms of age, education, and non-verbal general cognitive ability (see Table 1).

The sample size was based on a prior neurocognitive study using the same paradigm and a similar sample (13 autistic and 13 typically developed participants; Gaigg et al., 2015). This study reported significant group differences across phenomenological judgments, $F(2,46) = 6.10$, $p < .001$, $\eta^2_p = .21$), namely lower remember judgments in ASD.

Autistic participants were recruited with the collaboration of a specialized center for neurodevelopmental disorders. These participants had a clinical diagnosis provided by expert clinicians based on DSM-IV criteria (APA, 1994) and confirmed with a specific autism scale (ASDS-ASD; Myles et al., 2001).

Table 1. Sample characteristics

		ASD	***TD***	*Group differences*
	N	15	18	
Age (in years)	*M*	29.93	33.94	$t(31) = -1.373$
	SD	5.98	9.90	$p = .180$
Schooling (in years)	*M*	14.4	15.17	$t(31) = -.990$
	SD	2.38	2.07	$p = .330$
Non-verbal intelligence (RAVEN raw score)*	*M*	50.33	51.78	$t(31)=-.620$
	SD	8.28	4.97	$p = .540$
Verbal IQ	*M*	105.95		
(WAIS quotient)	*SD*	13.87		
Diagnostic	*M*	101.51		
(ASDS-ASD score)	*SD*	9.71		

Note: ASD – refers to the group of participants within the Autism Spectrum Disorder; TD – indicates the non-clinical typically developed participants; IQ – Intelligence Quotient; RAVEN – Raven´s Progressive matrices; WAIS - Wechsler Adult Intelligence Scale (WAIS-IV); ASDS-ASD - Asperger Syndrome Diagnostic Scale.
*Standard raw score for RAVEN range: 0-60 correct responses; standards for high education (>12 years) and age 30-39 years-old: M= 47.91; SD= +/- 8.99 (Queiroz-Garcia et al., 2021).

Materials and procedures

The study was approved by the Ethics Committee of [Host], guided by the Declaration of Helsinki and other relevant documents in European legislation. All participants and their legal representatives were carefully informed of the participation conditions and signed the informed consent. The experiment was conducted in individual sessions at the laboratory of the [Host].

The task consisted of a R-K paradigm with visual stimuli (500 X 500 pixels images depicting common objects), manipulated by encoding type (categorical vs. perceptive) and item-typicality (typical vs. atypical) (see Souza et al., 2022). The encoding phase included two different tasks, requiring more perceptive (complexity rating task) or more abstract (categorical sorting task) encoding. In the visual complexity rating task (in which perceptual details of the image are more relevant during encoding), participants were asked to rate, on a 4-point scale, how complex the image was. In the categories sorting task (in which categorical schematic knowledge is more relevant during encoding), participants had to indicate the best category to describe the item, using a 4-option forced-response corresponding to four different categories (e.g., vehicles, mammals). A brief pause (about 5min) was introduced between the rating and sorting blocks to avoid fatigue. During encoding, 160 images of common objects from eight different categories (i.e., birds, fruits, mammals, vegetables, vehicles, furniture, kitchen utensils, musical instruments, clothes) were presented. These images were selected based on previous ratings for typicality[23] (low: $M = 4.75$, $SD = 0.01$; high: $M = 6.39$, $SD = 0.03$, $t(158) = -16.14$, $p < .001$, $d_z = -1.280$,

[23] The items were selected from normative studies of concepts and their related pictures conducted with Portuguese samples (Santi et al., 2015; Souza et al, 2021). The typicality ratings were obtained for items (displayed in a picture) representing specific basic concepts (e.g., penguin as less typical and cardinal as typical) within a specific superordinate category (e.g., birds).

CI 90% [1.10, 1.45] see Figure 1 for examples) and controlled for relevant dimensions in common objects' processing such as arousal, valence, aesthetical appeal and visual complexity (all p's > .10; see Souza et al., 2020; 2021). Each encoding task comprised 80 unrepeated items equally distributed into four categories (counterbalanced across tasks). These items were equally distributed in two counterbalanced blocks across the two encoding conditions. The encoding conditions were counterbalanced across participants.

After a 20min retention interval, participants performed the retrieval phase. This phase consisted of a yes-no recognition task and subsequent phenomenological judgments. All encoded images (160 old items) were presented again together with 106 new images of common objects matched in the same criteria applied at encoding (p > .10). Participants saw an image (old or new item) and performed a recognition task ("did you see the item?" Yes/No). Whenever a "yes" response was given, participants were asked to provide a phenomenological judgment, indicating if they Remember (a recollective retrieval, based on vivid details about the experience), Know (based on a sense of familiarity), or Guess (an uncertainty feeling of having seen the item based on familiarity) the item, in a forced-choice response option (e.g., Gaigg et al., 2015; Mäntylä, 1997). At the end of the task, participants were thanked and debriefed.

Data analysis

Statistical analyses were conducted using mixed-effects regression models with R Version 4.0.2 (R Core Team, 2019), and the reported results are based on the best converging non-singular models. To favor the analysis' generalizability, a model with a maximal random effects structure based on the design (see Barr et al., 2013 for further details) was used. If the "maximal" model failed to converge or was found to be overfitted, we simplified the random effects structure by removing random effects that were causing convergence or singular fit problems. The conceptual knowledge modulation on memory was subject to separate mixed-effects logistic regression models that considered overall recognition (correct vs. incorrect responses) and conscious retrieval judgments (recollection vs. familiarity responses) as dependent variables. Group (ASD vs. TD), encoding type (categorical vs. perceptive), item-typicality (typical vs. atypical), and their interaction were the main predictors. Holm-Bonferroni corrections were used as adjustment for multiple tests. Participants and items were considered as random effects. When appropriate, follow-up analyses were conducted to obtain simple effects. Additionally, a linear mixed-effects regression model (see Horchak & Garrido, 2020a; 2020b) used the same fixed and random effects for response times (RT) during overall recognition and conscious judgments. Outliers were trimmed based on participants' responses in the relevant condition for each group separately. First, trials shorter than 300ms or longer than 3000ms were removed. Second, trials with RTs 2.5 SDs or higher from the relevant condition means were discarded.

Results

Response time during Encoding

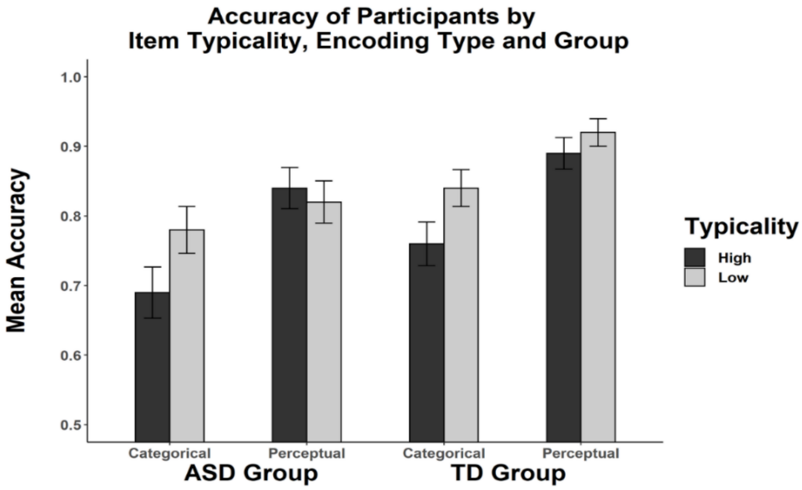
The mixed-effects model result for RTs (both perceptive and categorical conditions) and Accuracy (only in the categorical condition) during encoding showed that the only significant result was a main effect of group, ACC: *estimate* = −0.39, *SE* = 0.20, *z* = −1.97, *p* = .049, *95% CI* [−0.78, 0.00]; RT: *estimate* = 91.17, *SE* = 25.55, *t* = 3.57, *p* = .002, *95% CI* [41.08, 141.26], suggesting that autistic individuals were less accurate in their categorical appraisal (ASD: *M* = 0.90, *SD* = 0.30; TD: *M* = 0.95, *SD* = 0.21) and much slower in their overall responses (ASD: *M* = 915ms, *SD* = 529ms; TD: *M* = 729ms, *SD* = 418ms) than their controls. No other effects were significant (*p* > .600).

Overall Recognition Accuracy and Response Times

The overall recognition accuracy results of the mixed-effects logistic regression model showed a significant effect of group (*estimate* = −0.32, *SE* = 0.13, *z* = −2.40, *p* = .016, 95% CI [−0.58, −0.06]), with ASD group (*M* = 0.78, *SD* = 0.41) being less accurate than TD group (*M* = 0.85, *SD* = 0.35). As expected, the main effects of encoding type (perceptual: *M* = 0.87, *SD* = 0.33; categorical: *M* = 0.77, *SD* = 0.42, *estimate* = 0.44, *SE* = 0.07, *z* = 5.98, *p* < .001, 95% CI [0.30, 0.59]) and item-typicality (low-typical: *M* = 0.84, *SD* = 0.36; high-typical: *M* = 0.80, *SD* = 0.40; *estimate* = 0.17, *SE* = 0.07, *z* = 2.54, *p* = .011, *95% CI* [0.04, 0.31]) were significant. Finally, there was also a significant interaction between encoding type and item-typicality (*estimate* = −0.12, *SE* = 0.04, *z* = −2.98, *p* = .003, 95% CI [−0.20, −0.04]), as well as a trending interaction between item typicality and group (*estimate* = −0.07, *SE* = 0.04, *z* = −1.81, *p* = .070, *95% CI* [−0.15, 0.01]). All other effects were not significant (*p´s* > .20).

Follow-up analyses showed that the encoding type*item-typicality interaction was motivated by the higher accuracy for low-typical items (low-typical: *M* = 0.81, *SD* = 0.39; high-typical: *M* = 0.73, *SD* = 0.45; *estimate* = 0.29, *SE* = 0.07, z = 3.92, *p* < .001, *95% CI* [0.15, 0.44]) during categorical encoding. However, no statistically significant difference was observed in perceptual encoding depending on item-typicality (high-typical: *M* = 0.87, *SD* = 0.34; low-typical: *M* = 0.88, *SD* = 0.33; *estimate* = 0.04, *SE* = 0.08, *z* = 0.46, *p* = .646, *95% CI* [− 0.12, 0.20]). Follow-up analysis on the group*item-typicality interaction, showed that low-typical items (*M* = 0.88, *SD* = 0.32) were better recognized than high-typical items (*M* = 0.83, *SD* = 0.38) by TD participants (*estimate* = 0.25, SE = 0.08, z = 3.18, *p* = .003, *95% CI* [0.10, 0.41]); an advantage that was not observed in the ASD group (low-typical: *M* = 0.80, *SD* = 0.40; high-typical: *M* = 0.76, *SD* = 0.43; *estimate* = 0.13, *SE* = 0.08, *z* = 1.64, *p* = .101, *95% CI* [−0.02, 0.28]) The results of major interest are presented in Figure 1 (a).

(a)



(b)

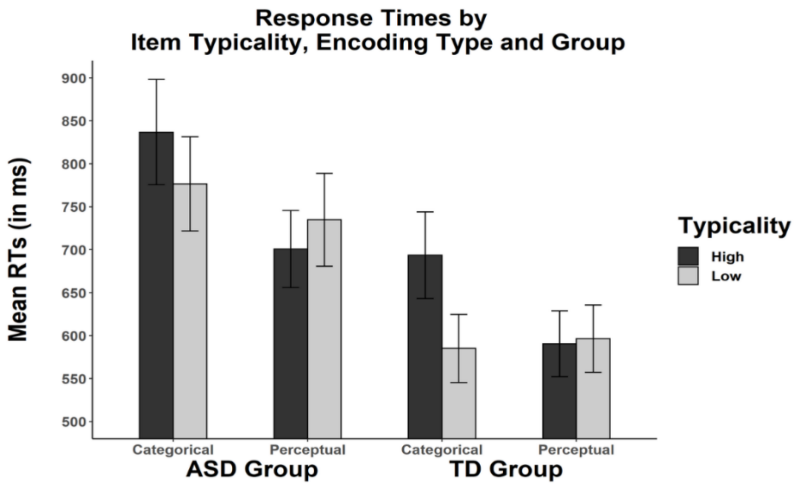


Figure 1. Participants' mean accuracy (a) and RTs (b) as a function of group, encoding type, and item-typicality

Note: Low (typicality) High (typicality); P (perceptual encoding); C (categorical encoding); Columns refer to means and error-bars to standard errors.

Because our omnibus analysis was performed considering both encoding conditions, we run a mixed-effects logistic regression model considering the categorical encoding condition only with item-typicality and group as predictors and Accuracy as a dependent variable. With this model, we look forward to disentangling the influence of item-typicality in categorical encoding from the influence of perceptual one (which would make sense since item-typicality are explicitly related to the categorical encoding) to further inspect the item-typicality effect at the group-level. Our outputs showed a significant effect of item-typicality (*estimate* = 0.29, *SE* = 0.07, z = 3.95, *p* < .001, *95% CI* [0.15, 0.44]), reflecting the fact that low-typical items were recognized more accurately than high-typical items for both groups. Furthermore, there was a trending main effect of group (*estimate* = −0.26, *SE* = 0.15, *z* = −1.82, *p* = .069, *95% CI* [−0.55, 0.02]), suggesting that autistic participants were less accurate than TD participants. Although the main effects emerged in the same direction presented in our robust model, there was no evidence for an interaction between typicality and group as well (*estimate* = −0.03, *SE* = 0.05, z = −0.55, p = .583, *95% CI* [−0.13, 0.07]). So, no group-level differences were detected for recognition performance of categorically-encoded in function of the item-typicality. Therefore, in despite of showing decreased recognition over all conditions, the advantage of low-typicality was observed in autistic individuals as well.

The RTs results of the mixed-effects linear regression model showed a significant effect of group (*estimate* = 100.55, *SE* = 27.97, t = 3.60, p < .001, *95% CI* [45.73, 155.37]), with autistic participants being much slower (*M* = 746, *SD* = 474) in their recognition responses than TD participants (*M* = 566, *SD* = 334). In addition, there was a main effect of encoding type (perceptual: *M* = 625, *SD* = 391; categorical: *M* = 673, *SD* = 436; *estimate* = − 29.53, *SE* = 10.22, t = − 2.89, p = .007, *95% CI* [−49.56, −9.50]) and a trending main effect of item-typicality (low-typical: *M* = 635, *SD* = 411; high-typical: *M* = 661, *SD* = 415; *estimate* = − 13.88, *SE* = 7.46, t = − 1.86, p = .064, *95% CI* [− 28.49, 0.73]). Finally, there was a significant interaction between encoding type and item-typicality (*estimate* = 15.41, *SE* = 7.07, t = 2.18, p = .030, *95% CI* [1.54, 29.27]), as well as between encoding type and group (*estimate* = −26.24, *SE* = 10.22, t = −2.57, p = .016, *95% CI* [−46.27, −6.22]). Other effects were not significant (*p*´s > .20).

For a better understanding of those interactions, we performed follow-up analyses. As shown in Figure 1 (b), the encoding type*item-typicality interaction was motivated by the faster processing associated to correctly recognized low-typical items (*M* = 643, *SD* = 421) comparatively to high-typical items (*M* = 706, *SD* = 448) during categorical encoding (*estimate* = − 30.49, *SE* = 10.43, t = − 2.92, p = .007, *95% CI* [−50.94, −10.05]). In contrast, no difference was observed for perceptual encoding (high-typical: *M* = 623, *SD* = 380; low-typical: *M* = 627, *SD* = 402; *estimate* = 1.21, *SE* = 10.04, t = 0.120, p = .904, *95% CI* [− 18.48, 20.90]). With regards to the group factor, autistic individuals were faster in correctly recognizing items during perceptual encoding (*M* = 700, *SD* = 436), as compared to categorical (*M* = 797, *SD* = 508; *estimate* = − 55.63, *SE* = 15.14, t = − 3.67, p = .001, 95% CI [−85.30, −25.95]). However, no significant differences were found for TD participants (perceptual: *M* = 560, *SD* = 335; categorical: *M* = 571, *SD* = 333; *estimate* = − 2.78, *SE* = 13.87, t = − 0.20, p = .841, 95% CI [−29.95, 24.40]).

Conscious Retrieval judgments (probability and RTs)

The models for conscious retrieval judgments were run with the same fixed and random factors used for overall accuracy. Results did not reveal any significant differences between groups (p > .400) for the probability of providing a Recollection-based judgment (vs. Familiarity). However, visual inspection of the data (see Figure 2) suggested relevant group differences.

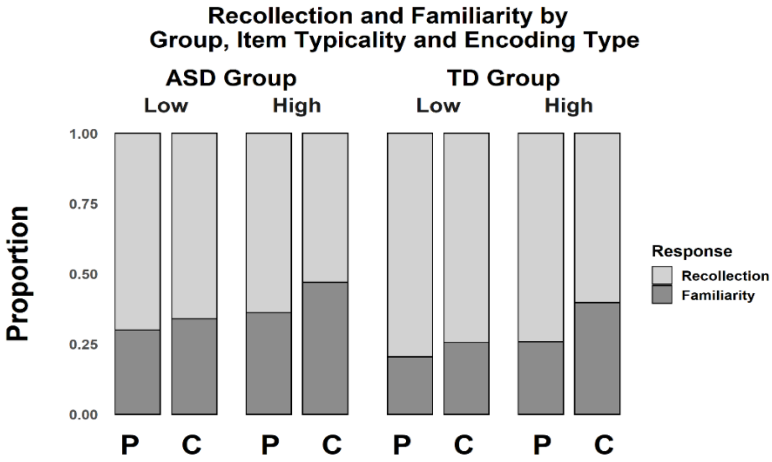


Figure 2. Proportion of judgment based on recollection and familiarity in ASD and TD groups as a function of encoding type and item-typicality

Note: Low (typicality) High (typicality); P (perceptual encoding); C (categorical encoding); Columns refer to mean proportions.

Further examination revealed that the performance of autistic individuals was variable, and thereby could have contributed to mask the effects. Using the same fixed effects and random intercept for items only, the simplified model showed a main effect of group (*estimate* = −0.22, *SE* = 0.03, *z* = −6.43, *p* < .001, *95% CI* [−0.28, −0.15]) in that the autistic participants provided significantly less Recollection-based judgments (64%) than TD participants (73%). Furthermore, there were significant main effects of encoding type (perceptual: 73%; categorical: 64%; *estimate* = 0.20, *SE* = 0.03, *z* = 5.95, *p* < .001, *95% CI* [0.13, 0.27]) and item-typicality conditions (low-typical: 73%; high-typical: 64%; *estimate* = 0.23, *SE* = 0.04, *z* = 5.35, *p* < .001, *95% CI* [0.14, 0.31]), influencing Recollection-based judgments in the same direction as reported for overall recognition. Finally, there was a significant interaction between encoding type and item typicality (*estimate* = −0.08, *SE* = 0.03, *z* = −2.23, *p* = .026, *95% CI* [−0.14, −0.01]). Follow-up analyses showed that the interaction effect was motivated by the influence of perceptual encoding in increasing the probability of “Recollection” in both low-typical (perceptual: 75%; categorical: 71%; *estimate* = 0.15, *SE* = 0.07, *z* = 2.14, *p* = .003, *95% CI* [0.01, 0.29]) and high-typical items (perceptual: 70%; categorical: 57%; *estimate* = 0.34, *SE* = 0.07, *z* = 4.93, *p* < .001, *95% CI* [0.21, 0.48]). No other interaction effects were significant (*p*´s > .200).

Two separated models were run for RTs in Recollection-based judgments (Remember responses) and Familiarity responses (Know and Guess). For these analyses, RTs faster than 150ms and RTs slower than 3 SDs from the relevant condition means in each group were discarded. The results of the best converging mixed-effects regression model for “Recollection” showed that there was a trending main effect of group, indicating that ASD group provided slower recollective-based judgments than their comparison group (ASD: *M* = 718, *SD* = 465; TD: *M* = 571, *SD* = 357; *estimate* = 93.47, *SE* = 51.61, *t* = 1.81, *p* = .080, 95% CI [−7.68, 194.61]). No other effects were significant. With regards to “Familiarity”, the only significant effect was a 3-way interaction between encoding type, item-typicality, and group (*estimate* = −28.18, *SE* = 12.71, $t = -2.22$, $p = .027$, *95% CI* [−53.09, −3.26]). To get sense of this interaction, we tested the significance of a 2-way interaction between encoding type and item typicality at each level of group factor. The results showed a marginally significant interaction between encoding type and item typicality for ASD (*estimate* = −32.89, *SE* = 17.71, $t = -1.86$, $p = .064$, *95% CI* [−67.60, −1.83]), but not for TD (*estimate* = 23.47, *SE* = 18.24, $t = 1.29$, $p = .198$, *95% CI* [−12.28, −59.21]). However, follow-up analyses did not reveal any significant results (all *p's* > .180).

False alarms rates

The analysis of the false alarms (New items considered Old) inspected their overall occurrence as well as their incidence according to recollection-based judgments by comparing ASD and TD samples. The RTs were not considered for analysis since participants´ high performance in the task limited the number of false alarms necessary for further interpretations. The results showed that the overall incidence of false alarms was small and similar in both groups (M_{ASD}= 6.58%, SE_{ASD}= .99; M_{TD}= 6.55%, SE_{TD}= 1.1; $t(31)= .021$, $p = .983$). The further inspection of incidence of false alarms in recollection-based judgments using mixed-effects models showed no main effect of group (estimate = −1.80, SE = 0.52, $z = 0.17$, $p = .869$, *95% CI* [−0.84, 0.99]). These results indicate no significant differences between the groups in false alarm responses when providing more Familiarity than Recollection judgments.

Discussion

While impaired episodic memory performance has often been observed in ASD, it remains debatable whether this decline also affects semantic memory and its processes (Carmo et al., 2016; Gastgeb et al., 2006; Souza et al., 2016; Toichi, 2008; Toichi & Kamio, 2002; 2003, but see Carmo et al., 2017; Molesworth et al., 2005). As recently demonstrated, episodic and semantic memory systems continue to interact despite becoming structurally and functionally dissociated with time and accumulated experience (de Mendonça et al., 2021; Nadel & Moscovitch, 1997; Winocur et al., 2010; Winocur & Moscovitch, 2011). Therefore, impairments in the episodic memory system in ASD are likely to affect the learning, processing, and retrieval of semantic-like memories.

The current study explored this hypothesis by inspecting performance patterns in autistic individuals and their TD comparison group with regard to both declarative memory types within a Remember-Know paradigm. We hypothesized that autistic people would present a decline in overall recognition together with a decline in recollection-based memories but not for familiarity-based memories when compared to TD participants. We also inspected the role of stored conceptual knowledge availability at encoding in predicting memory retrieval. Since the episodic memory system is likely disrupted in autism, we expected to find no gains in episodic memory performance (recollection-based “remember responses”) for perceptually encoded items in autistic individuals. Likewise, we did not expect autistic individuals to benefit from low-typical information to improve overall recognition and recollective-based memories (see Souza et al., 2022), given the potential contribution of the episodic memory system and its interaction with the semantic system for the processing of unfitted information (see Bonasia et al., 2018; Dudai et al., 2015).

Overall, the main effects of encoding type and item-typicality as well as of the encoding type*item-typicality interaction replicated previous results (Souza et al., 2022). Specifically, the observed gains in recognizing low-typical items only in categorical encoding reflect the enhancement of episodic memories in case of violation/novelty conditions (see Dudai et al., 2015; Souza et al., 2022).

Regarding group differences, our results showed, as expected, that overall recognition in ASD was less accurate and slower than that of TD controls, thus replicating previous reports of moderate episodic memory decline in ASD (e.g., Gaigg et al., 2015; Meyer et al., 2014). Moreover, we found a lower production of recollective-based memories in ASD, while familiarity-based memories were preserved. These results indicate that when memories are dissociated from the contextual traits by which they were formed (context-free or abstract memories), retrieval seems to be preserved in ASD. Previous studies had already shown that, in the autism spectrum, people do not have the distinct neural patterns for Recollection compared to Familiarity memories described in their comparison subjects (Gaigg et al., 2015). Together with the worse overall recognition observed in autistic participants, the pattern of reduced recollection memories and preserved familiarity memories suggests that the episodic memory system might be responsible for the flaws observed in declarative memory retrieval. False alarm results were also congruent with the episodic memory constraints of such a clinical group (see Bowler et al., 2011; Gaigg et al., 2015), but further studies should be designed to address specific measures of false alarms. Likewise, the preserved general semantic memory functioning is compatible with previous studies (e.g., Bowler et al., 2000; Gaigg et al., 2014; 2015; Toichi & Kamio, 2003), indicating that this clinical group has access to stored semantic information during learning (Carmo et al., 2016; Gaigg et al., 2015).

Interestingly, and contrary to our expectations, autistic participants showed an advantage of perceptual encoding during recognition and conscious recollection as observed in TDs, despite their reduced performance in episodic memory. Although not consistent with the anticipated fully compromised episodic memory system, also documented in previous studies, this finding suggests that the autistic group has at least some access to their episodic system that is required to process contextually rich perceptual details (Sekeres et al., 2018).

Regarding item-typicality processing, autistic participants were, as expected, less competent in using low-typical information to enhance recognition, as TDs did (as in Alves & Raposo, 2015; Carmo et al., 2016; Gastgeb et al., 2006; Souza et al., 2022). Low-fit information violates the stored prototypical representation activated and is likely to recruit more episodic and semantic memory systems interaction in processing novelty or inconsistencies with prior knowledge (see Bonasia et al., 2018; Dudai et al., 2015; Yonelinas et al., 2010). The improved recognition of atypical information appears to rest on an increased engagement of hippocampal structures and its connectivity with cortical regions (Nadel & Moscovitch, 1997; Sekeres et al., 2018; Yonelinas et al., 2010, 2019), a process that may be less efficient in ASD (see Gaigg et al., 2015). Nevertheless, the further inspection of item-typicality modulation in categorical encoding only raises the possibility that the atypical information (as part of semantic organization inherent to categorical learning processing; see Medin et al., 2007) exert a selective influence in the explicit coding of categorical knowledge. Or, it could be plausible that the overall deficitary episodic memory is playing a crucial role in masking item-typicality effect at the autistic sample at the whole data. Anyways, it appears that the putative disturbances in the episodic memory system in ASD are interfering in the process of binding novel incoming information that does not entirely fit the previously available stored concepts (see Sekeres et al., 2018), thus diminishing the probability of their successful recognition. According to the Schema Modification Theory (SMT), previous schemas can interact with newly acquired traits to accelerate episodic learning and facilitate future retrieval (Tse et al., 2007; Van Kesteren et al., 2013; 2014). Such relational encoding has been shown to be disturbed in ASD by Gaigg and colleagues (2015). They also found that autistic people recruit compensatory neural resources (specifically, regions in the inferior prefrontal cortex) to overcome their neurodiverse episodic memory system (as reflected in attenuated hippocampal engagement).

Contrary to what we expected, we did not find relevant group differences regarding an effect on RTs of possible interactions between item-typicality and encoding type. In contrast, prior studies observed a distinctive organization of typicality information in ASD (see also Carmo et al., 2016; Gastgeb et al., 2006), namely a more effortful encoding strategy for low-typical items (Gastgeb et al., 2006). Nonetheless, those discrepant findings may reflect differences in task demands between our and other studies using different tasks (Carmo et al., 2020; Gastgeb et al., 2006; Gastgeb & Strauss, 2012).

Overall, the current findings indicate a reduced performance in recognition and, notably, a different pattern of self-related and vivid recollective memories but not in familiarity-based (context-free) conscious memory in ASD. Such dissociation between Recollection and Familiarity memory processes suggests that the atypical pattern of overall recognition observed in autistic individuals might arise from differences in episodic memory processes. Notably, the (partial) absence of item-typicality advantage for recognition in the clinical sample is attributed to their inability to engage the episodic memory system during specific semantic processing. This finding converges with the interdependence between declarative memory systems and confirms the involvement of episodic memory systems in specific semantic memory processes (see Souza et al., 2022). These findings also suggest inefficient processing of the semantic system in ASD (at least in the perceptual encoding) for information that does not fit the available schematic knowledge (Dudai et al., 2015; Sekeres et al., 2018). Therefore, episodic memory systems in autistic persons seem to be compromised in a manner that affects the processing of conceptual information that does not fit with prior knowledge, reflecting the complex declarative memories dynamics (see also Dudai et al., 2015; Sekeres et al., 2018). This pattern is likely to rest on an anomalous interaction between a preserved semantic system and/or a fragile and dysfunctional episodic memory system.

Research focusing on episodic recollection in autism has increased recently, although the diversity of methodologies and approaches still represents an obstacle for substantial consistency across findings (see Cooper & Simons, 2018). The present work used a classic and well-explored task applied in prior relevant memory studies in autism (e.g., Bowler et al., 2000; Gaigg et al., 2015). However, the dependence between Remember and Know judgments associated with the disparate number of trials by condition characteristic of this task (higher Remember responses) might mask the expected interaction effects. To surpass this issue, we used robust statistical analyses and the combination of Know-Guess responses to compose the Familiarity condition. This combination was motivated by the familiarity-based nature of both judgments (see Gardiner et al., 1998) as well as by the similar pattern of results observed between them. Future studies who want to balance the number of remember and know judgments and reduce their dependency should try to circumvent this issue by, for example, increasing the retention interval up to 24h, since this appears to decrease recollection-based memories (Gardiner & Java, 1991; Meier et al., 2013). Another possibility is to use an adaptation of the Remember-Know task that allows disentangling familiarity and recollection judgments (e.g., requesting them alternately or in blocks) without losing its dual-process perspective (see Yonelinas 2002; Yonelinas et al., 2010). Given the potentially challenging introspective nature of this task (particularly for ASD participants), we tried to ensure the quality of these judgments (i.e., actually reflecting recollective vs. familiarity processes) by providing explanations and examples of the type of judgment required in each category during the instructions and training phases. While the percentage of correct responses provides a good indicator that participants (in both groups) were able to complete the task, a qualitative measure would be desirable to confirm the quality of these judgments (see Gardiner, 1998). However, the number of trials used in the current paradigm would render this task unfeasible (i.e., length, tiredness), particularly for the participants in the clinical sample.

Another potential concern of the current study is the reduced sample size. While small sample sizes are common in studying underrepresented clinical samples (see Bowler et al., 2000; Gaigg et al., 2015; Molesworth et al., 2005 for some examples in samples diagnosed with ASD), they might lead to underpowered studies, particularly when considering the variability expected in ASD (Geurts et al., 2008). In the current study, we tried to circumvent this issue by adopting a mixed-effects model analysis on unaggregated data in an attempt to enhance the statistical power and reduce the Type 1 error (Barr et al., 2013).

Additionally, our sample included male participants only. While the prevalence of diagnosed cases is much higher in males than females (Giarelli et al., 2010), there seems to be a male bias in diagnosis criteria and assessment measures. Consequently, the number of females within the autism spectrum may be underrepresented. Moreover, there are reasons to believe that, at least to some extent, they might differ from males in their cognitive, social, and adaptative skills (Frazier et al., 2014; Zwaigenbaum et al., 2012). These differences may also be manifested in memory abilities. Our sample composition does not uncover such potential differences that should be addressed in future studies.

Despite these limitations, the current findings confirm that the characteristic profile of declarative memory in ASD derives from episodic memory constraints, which likely motivate flaws in semantic retrieval in specific circumstances. The current findings are also relevant for better understanding the interdependency between declarative memory systems, particularly the characteristic memory profile found in Autism. Further studies are needed to better explore the neural correlates of these two memory systems and their interaction in TD and ASD group samples. In particular, it is important to confirm the fundamental role of the hippocampus-dependent system and its connectivity with other regions in the formation and retrieval of long-term memories. Finally, the present findings showed that information less compatible with stored knowledge proved to be helpful in enhancing and likely re-instantiating memories, depending on their nature, for further actualization or modification purposes (see also Nadel, 2020). These findings may usefully inform clinical interventions and the implementation of enhancing learning contexts where schematic information is currently emphasized as a strategy for better outcomes.

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CHAPTER 5.

Category differences and naming retrieval: Evidence of episodic and semantic interaction

In this chapter, we addressed the interaction between the episodic and the semantic memory systems by examining the influence of contextual information (episodic-like memories) on semantic retrieval. Therefore, we contrasted the naming performance of general semantic categories (i.e., common objects) with more specific semantic categories (i.e., people and places items), inspired by the classic dissociation of common and proper names (e.g., Martins & Farrajota, 2007; Semenza et al., 2003).

The first study, "*Norms for pictures of proper names: Contrasting famous people and well-known places in younger and older adults*", provided norms for 80 proper names items from people and places categories while also examining age differences in relevant dimensions related to proper name stimuli. Notably, the current study also compared the performance of older adults with young adults in naming retrieval of people and places, using a wide time-based range of selected stimuli suitable for both groups. As aging constitutes a relevant predictor of naming abilities related to proper names (see Kavé et al., 2018), this study attempted to uncover the influence of the natural age-related episodic constraints in semantic retrieval of proper name categories as episodic requirements increased.

The final study, "*Neural signatures of naming retrieval: Theta and Alpha oscillatory dynamics dissociate objects, people, and places*", examined the behavioral and neural oscillatory patterns of young adults in naming retrieval of those three categories, providing neurocognitive signatures for each category according to their contextual richness (see Provérbio et al., 2001). Moreover, the examination of categories with different memory requirements is likely to provide cues regarding the role of the episodic system in certain conditions of semantic representations involving the need for contextual information. Finally, the findings from this study contribute to clarifying the neural underpinnings of common and proper names dissociation (Brédart et al., 2017) by showing how differences in brain oscillatory patterns across categories reflect the involvement of different memory systems according to the degree of contextual information those categories entail.

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5.1. Norms for pictures of proper names: contrasting famous people and well-known places in younger and older adults**

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Abstract

Proper names comprise a class of labels that arbitrarily nominate specific entities, such as people and places. Compared to common nouns, retrieving proper names is more challenging. Thus, they constitute good alternative semantic categories for psycholinguistic and neurocognitive research and intervention. The ability to retrieve proper names is known to decrease with aging. Likewise, their retrieval may differ across their different categories (e.g., people and places) given their specific associated knowledge. Therefore, proper names' stimuli require careful selection due to their high dependence on prior experiences. Notably, normative datasets for pictures of proper names are scarce and hardly have considered the influence of aging and categories. The current study established culturally adapted norms for proper names' pictures ($N = 80$) from an adult sample ($N = 107$), in psycholinguistic measures (naming and categorization scores) and evaluative dimensions (fame, familiarity, distinctiveness, arousal, and representational quality). These norms were contrasted across different categories (famous people and well-known places) and age groups (younger and older adults). Additionally, the correlations between all variables were examined. Proper names' pictures were named and categorized above chance and overall rated as familiar, famous, distinctive, and of high representational quality. Age effects were observed across all variables, except familiarity. Category effects were occasionally observed. Finally, the correlations between the psycholinguistic measures and all rated dimensions suggest the relevance of controlling for these dimensions when assessing naming abilities. The current norms provide a relevant aging-adapted dataset that is publicly available for research and intervention purposes.

Keywords: picture norms; proper names; aging; famous people; well-known places; psycholinguistic measures; evaluative dimensions.

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Introduction

Proper names comprise a class of labels that arbitrarily nominate specific entities (such as people and places) without necessarily reflecting their properties (see Semenza, 2006). For example, the "Eiffel Tower" received this name not because of any particular characteristic (i.e., location, materials, shape) but in honor of Gustav Eiffel (the engineer who projected it). Proper names also make things particular or unique, assuming a relevant social function of differentiating an entity from others while communicating (Brédart, 2017). For instance, the reference to "Nelson Mandela" will be recognized as that unique man who dedicated his life to political activism against racism and later became the president of South Africa. The ability to particularize things by labeling them with a unique name constitutes a relevant adaptative step derived from language evolution and the development of a more efficient neural system (see Semenza, 2009). This individualization of entities through singular labels reflects a more complex world representation that is useful for adaptive purposes. A child may identify his mother to others; a traveler can identify a destination more effectively; a boy can refer to the name of the street he lives in case of being lost. However, proper names are also fragile mental representations susceptible to being easily forgotten (Cohen, 1990; Cohen & Burke, 1993). Classic case studies exploring anomia for proper names have also documented the special status of proper names. These studies converge in showing that proper names are more difficult to name, more easily forgotten, and processed in different (and perhaps more profound) neural structures, in comparison to common names - like apple or car (e.g., Cohen et al., 1994; Lucchelli & De Renzi, 1992; Martins & Farrajota, 2007; Semenza et al., 2003; Semenza & Zettin, 1989).

As a particular class of semantic representation, proper names' stimuli constitute an important resource in neurocognitive research and intervention, particularly in linguistic and neuropsychological examination (Adorni et al., 2014; Bélanger & Hall, 2006; Benke et al., 2013; Brédart et al., 2005; Evrard, 2002; James, 2004; Semenza et al., 2003; Semenza, 2006). For example, proper names' stimuli are helpful for inspecting grammatical and lexical structures across languages (e.g., Müller, 2010) as well as for examining and stimulating linguistic acquisition (e.g., Bélanger & Hall, 2006). Pictures of proper names are also suitable for studying cognitive decline, particularly memory (see Martins & Farrajota, 2007; Semenza et al., 2003 for examples).

Despite their widespread application, one major challenge of using proper names in psychological research and intervention is the lack of consistency in selecting proper names. Researchers often use non-normalized stimuli (e.g., Kljajevic & Erramuzpe, 2018; Wang et al., 2015). Due to cultural constraints, they produce their own standards by conducting a pilot study or collecting ratings together with the picture-naming task (Benke et al., 2013; Martins & Farrajota, 2007; Rizzo et al., 2002; Ross & Olson, 2012). In some cases, these pilots even support further examination of clinical samples (e.g., Benke et al., 2013; Martins & Farrajota, 2007). Finally, the number of stimulus items and/or variables examined is often limited (e.g., Benke et al., 2013; Ross & Olson, 2012). Consequently, normative databases of proper names and particularly of proper names' pictures are still rare and include primarily celebrities' pictures (Bizzozero et al., 2005; Bizzozero et al., 2007; Bonin et al., 2008; Lima et al., 2021; Marful et al., 2018; Rizzo et al., 2002; Smith-Spark et al., 2006; Stoney et al., 2020; but see Benke et al., 2013, for standardized famous places).

One of the first studies that normalized proper names' pictures was conducted by Rizzo et al. (2002) and presented norms for naming measures, recognition, fame, and associated semantic knowledge in the Italian cultural context. This database comprises 50 pictures of famous people, systematically distributed by national (e.g., "Luciano Pavarotti") and international (e.g., "Madonna") domains of fame across several categories (arts, politics, sports, etc.). Subsequently, Bonin et al. (2008) normed a high number of pictures of famous people from several categories (e.g., actors, athletes, singers, etc.) from an extensive period of fame (between 1920 to 2003). In this study, besides naming performance and other linguistic measures, familiarity and distinctiveness were also reported as relevant dimensions. Familiarity refers to the frequency with which people interact with or think about a given entity in everyday life. Familiarity is likely influenced by prior experiences and the linguistic and cultural context (Rendell et al., 2005; Smith-Spark et al., 2006; Snodgrass & Vanderwart, 1980). Distinctiveness is focused on the singularity of the items, reflecting the degree to which the item is easily recognized from its own features. This singularity is a central characteristic of proper names (see Semenza, 2006) that should also be relevant to their pictographic representations.

In the European Portuguese context, to our knowledge, there are only three standardizations of famous people's pictures (Lima et al., 2021; Martins et al., 2005; Rosa et al., 2012). For instance, Martins and colleagues (2005) used 74 items from old, recent, and contemporary famous faces and explored the influence of age differences in their naming. The authors did not find any relevant correlation between aging and naming performance, although a decrease in naming performance emerged in participants older than 70 years old. Rosa et al. (2012) presented a reduced version (39 items) of Martins et al.'s (2005) naming standards and obtained norms for older adults (50-65 years old and over 65 years old). Recently, Lima et al. (2021) presented norms for 160 black-and-white pictures of celebrities regarding their age of acquisition, familiarity, and distinctiveness, along with recognition and naming scores. This latter study showed that Portuguese young adults rated the presented celebrities' faces low in familiarity and high in distinctiveness, with distinctiveness being a relevant predictor for recognition and naming performance.

However, to date, normative studies of proper names have barely included relevant emotional and affective dimensions like arousal or valence (but see Marful et al., 2018; Stoney et al., 2020, for examples), particularly in the Portuguese context. Previous normative studies have shown that these affective dimensions along with semantic and perceptual variables influence the ability to name pictures of common names (e.g., Alario et al., 2004; Barbarotto et al., 2002; Bates et al., 2003; Garrido et al., 2017; Souza et al., 2021; see also Souza et al., 2020 for a review). The systematic examination of these dimensions in proper names' items thus seems critical to understand how such stimuli are processed.

Proper names are idiosyncratic designations relevant for social interaction (see Semenza, 2011) that are likely influenced by spatial, temporal, social, personal, and affective characteristics. Therefore, controlling or examining how these variables may affect picture processing for proper names' items seems crucial.

Aging, for instance, has been widely indicated as a relevant predictor of proper names' retrieval abilities (see Evrard, 2002; James, 2004; Kavé et al., 2018). Proper name categories are known to be labile and suffer the influence of aging and neurophysiological constraints/deterioration (Brédart, 2017; Semenza, 2009; 2011). Moreover, aging alone is expected to generate a natural decline in cognitive competencies relevant to naming (e.g., Nilsson et al., 1997; Rönnlund et al., 2003). Age-related differences were also documented in ratings of evaluative dimensions in norms for famous people's names (see Smith-Spark et al., 2006) in line with those previously observed in object picture processing (see Ghasisin et al., 2015; Yoon et al., 2004 for an example). Moreover, naming famous people was significantly affected by age (Bizzozero et al., 2007). Likewise, a normative Italian dataset of famous buildings' names (a type of famous places) also showed age influence in several tasks related to naming performance (Mina et al., 2010). These findings suggest that the effect of age should be examined in norms for proper names. Despite their importance, the availability of age-related norms for several relevant variables in processing famous proper names is scarce (see Bizzozero et al., 2005; 2007), particularly in the European Portuguese context (but see Martins et al., 2005; Rosa et al., 2012 for examples of Portuguese naming tests).

Furthermore, the effect of the category (i.e., people or place) in proper names' picture processing also deserves more attention, namely regarding its possible influence in name agreement and the appraisal of evaluative dimensions (e.g., Brodeur et al., 2014). Prior standards of proper names' items (although not directly comparing these categories) obtained with healthy adults (age range: 19-65) showed comparable performance in naming famous people (71.1%) and places (71.8%), despite the slight differences observed in recognition and semantic knowledge retrieval capabilities (Benke et al., 2013). However, to our knowledge, the direct comparison between famous people and place pictures across aging has not been made in any normative study to date.

Besides age and categories, socio-demographic characteristics like educational background and the engagement in socio-cultural activities (e.g., watching tv, travel, etc.) also constitute relevant variables that influence face naming and face processing (see Bizzozero et al., 2007; Bonin et al., 2008; Garrido & Prada, 2017; Garrido et al., 2017; Kavé et al., 2018). For instance, educational background influenced the naming of famous people as a function of task difficulty, while gender/sex differences did not emerge (Bizzozero et al., 2007). As pictures of well-known proper names (e.g., celebrities or monuments), aside from unique, are also embedded in experience-based knowledge, some attention should be given to those experience-based variables.

In sum, the production of proper names' picture norms remains scarce in the European Portuguese environment. Notably, the few existing Portuguese norms for proper names' pictures only explored pictures of famous people and did not include places' items such as monuments or landmarks. Moreover, as discussed above, age and other personal-related variables seem particularly relevant for proper names' retrieval because these stimuli are relatively contextual-dependent and supported by singular arbitrary associations between the name and the entities named (see Semenza, 2006). These variables have not been systematically examined. In the current study, we produced norms for pictures of proper names (N=80) by age (younger and older adults) and category (people vs. places) in the dimensions of fame, familiarity, distinctiveness, arousal, representational quality, and psycholinguistic measures such as naming and category accuracy. We also present correlational analyses to further understand the relationship between the dimensions and their co-variation, as well as to clarify how the ratings of the dimensions influence naming measures.

Method

Participants

The initial sample included 110 healthy adults between 19 and 78 years old. Each subsample was recruited to meet the minimum number of evaluations (around 30) per picture recommended in prior norms for visual stimuli (e.g., Brodeur et al., 2014; Garrido et al., 2017; Souza et al., 2021). Three participants were excluded because they did not answer the entire survey and missed the socio-demographic questions (one younger adult and two older adults). The final sample included 107 participants (age range of 19-77-year-old), 56 younger adults (age range:19-45), and 51 older adults (age range: 55-78) matched on educational level and socio-cultural profile[24] (*p's*> .200). The majority of the participants presented intermediate to high educational level (44.85% completed high school, and 47.66% held a university degree) and were students or active workers (70.9%). Aside from age, younger and older adults only significantly differed in their employability information ($p < .001$; see Table 1).

Table 1. Socio-demographic profile of the sample by age group

	Younger Adults (n=56)	**Older Adults (n=51)**	***Statistics***
Age Mean (SD)	31.71 (9.28)	62.82 (6.14)	$t(105) = -20.246$, $p < .001$
Educational level	50% Intermediate 48.22% High	56.86 % Intermediate 47.06 % High	$\chi^2(4) = 5.889$, $p = .208$
Socio-cultural profile *Mean (SD)*	.66 (.096)	.64 (.108)	$t(105) = .774$, $p = .459$
Employability profile	87.5% active	50.98 % active	$\chi^2(1) = 16.982$, $p < .001$

[24]Participants' socio-cultural profile was assessed with seven items reporting socio-cultural habits, namely (1) watching TV; (2) watching films and series; (3) reading newspapers and magazines; (4) use of social media; (5) traveling; (6) visiting museums and monuments; (7) practice sports/outdoors activities. Participants were asked to evaluate on a 5-point rating scale (1 - *never* to 5 – *daily*) how frequently they engage in these activities. The engagement in socio-cultural activities is represented by a relative score (i.e., total reported score/maximum score).

The sample was recruited online through social networks (e.g., Facebook). Two 50€ commercial vouchers were drawn to all participants who agreed to participate. The present study was approved by the Ethics Board of the host institution (ref. 01/2018). All participants provided informed consent before participation.

Stimulus materials

The initial sample of stimuli consisted of 120 proper names' pictures retrieved from online sources that allow free use for non-commercial purposes, mainly pictures from web-newspapers, wiki library, and Flickr. All the images were previously selected by three native Portuguese speakers. Overall, the pictures were equally distributed by subcategories (e.g., arts, sports, geographical places, historical monuments), time periods[25] (old and current), and international and national reputation. Well-known places' pictures were selected considering famous Portuguese and international topographical locations and comprised four categories: geographical places (e.g., Rua Augusta, a famous touristic street in Lisbon), infrastructures/services buildings (e.g., 25 de Abril Bridge, that connects the two sides of the Tagus´ river), historical or archeological monuments (e.g., Pyramids of Giza), and architectonic structures (e.g., Eiffel Tower). People's pictures were obtained based on a previous list of celebrities (Martins & Farrajota, 2007) updated through an additional search. The selection of items of famous people considered four different areas, namely culture (e.g., Frida Kahlo), entertainment and TV (e.g., Jane Fonda), sports (e.g., Cristiano Ronaldo), and leaders (e.g., Nelson Mandela). Half of the items were male, and half were female. The pictures were selected considering an extended period (1940 to currently). The referred distribution of pictures across different subcategories and time periods was made to make them suitable for both young and older adults as well as to prevent ceiling effects that are likely to occur when using well-known items (see Martins et al., 2005). At this phase, two judges also provided the correct target and category names and evaluated the appropriateness of each picture to the Portuguese cultural environment. Inter-rater agreement was 86.67% (n =104). Disagreements were further discussed with a third judge until an agreement was reached. Whenever there was no consensus, items were excluded (n =12). In this judgment phase, items with agreed naming (n =108) but considered of lower cultural relevance were also excluded (n =28). The final sample of stimuli included 80 items equally distributed into two subsamples of famous people and well-known places (40 items each) (see Figure 1). Because the selected pictures might have differed in quality, pictures were resized at 500X500pxls with a blank canvas and controlled for 25% luminosity.

[25] The variable time period was based on previous work (e.g., Martins et al., 2005) and refers to the period during which celebrities were likely more famous. In the present research, "old" items refer to those predominantly famous until 1999 and "current" items include those with recognized fame since 2000.

Figure 1. Examples of stimuli by category

Note: The figure presents examples of national and international items from people and places' categories. For the "people" category, we present "José Saramago", a Portuguese writer awarded with the Nobel Prize of Literature as a national exemplar, and "Elizabeth II", the Queen of England, as an international exemplar. For the "places" category, we present the "25 de Abril Bridge" as a famous national place and the "Pyramids of Giza" as an internationally famous place.

Procedures and measures

Data was collected with Qualtrics Experience Management online software (Qualtrics, Provo-UT, USA), and data analysis was performed using SPSS version 26. Once they accessed the link, participants were informed about the voluntary and anonymous nature of their collaboration. For control purposes, after providing their informed consent and socio-demographic information, participants were asked to complete their socio-cultural profile by indicating to which extent (on a scale from 1 - *never* to 5 - *daily*) they engage in a set of recreational and cultural activities. Subsequently, the instructions for ratings, naming, and categorization tasks appeared together with examples (for practice purposes), and then participants were forwarded to the test phase. Each participant saw the 80 pictures, one at a time, distributed in a randomized order by two between-participants counterbalanced category blocks (i.e., famous people and well-known places). For each picture, participants were asked to complete four rating tasks regarding familiarity, fame, distinctiveness, and arousal, randomly presented across pictures. Afterward, participants performed the naming and categorization tasks. In the naming task (written form), participants were asked to name the item as precisely as possible. In the categorization task, they were asked to choose the best category to classify the item within the four category options for famous people or well-known places. These options were presented in a fixed order and included an additional "I don't know" option always presented in the end. Finally, they completed a representational quality rating, assessing the potential of each picture in representing the concept/name. The detailed information for each measure is presented in Table 2.

Table 2. Description of the evaluative dimensions and psycholinguistic measures

Measures	Description	References
Familiarity	Participants should consider how often they encountered the item represented in the picture in their daily life, indicating how familiar the stimulus was on a scale ranging from (1) *unfamiliar* to (10) *very familiar*. Frequently found stimuli are usually considered more familiar.	*Bonin et al., 2008; Prada et al., 2016; Snodgrass & Vanderwart, 1980*
Arousal	Evaluates the degree of activation elicited by the item. Participants should indicate to what extent they considered the item (1) *very passive/calm* or (10) *very active/intense*.	*Prada et al., 2016; Prada et al., 2018*
Fame	Participants should evaluate to which extent the item presented was famous/well-known, from (1) *not famous* to (10) *very famous*.	*Rizzo et al., 2002*
Distinctiveness	Participants were asked to indicate how distinctive was the face/place based on its visual aspects (i.e., facial features, architectural features, colors, etc.) on a scale ranging from (1) *low distinctive* to (10) *highly distinctive*.	*Bonin et al., 2008; Marful et al., 2018*
Image representational quality	Evaluates the representational quality of the picture. Specifically, whether the picture favors the recognition of the represented entity, from (1) *very low quality* to (10) *very good quality*.	*Souza et al., 2021*
Naming task	Participants were asked to write down the name they thought best identifies the item represented in the picture (write the first name that comes to your mind).	*Marful et al., 2018; Snodgrass & Vanderwart, 1980; Souza et al., 2021*
Categorization task	Participants were asked to indicate the best option to categorize the item (in a forced-choice task).	*Brodeur et al., 2014; Souza et al., 2021*

The main psycholinguistic measures included name accuracy (%) and categorization accuracy (%). Subsequently, the psycholinguistic measures of modal name (the most referred valid name) and name agreement (percentage of agreement regarding the modal name) were computed (see Souza et al., 2021). The respective value of name variability (H-stats[26]) was also estimated to capture the conceptual variability in correctly naming the item (see Snodgrass & Vanderwart, 1980, for details of the calculation procedure).

[26] The h-statistics (h-stats) is a measure that allows obtaining a standardized agreement value for naming based on the occurrence of the target name and the variability of acceptable concepts (see Brodeur et al., 2014; Snodgrass & Vanderwart, 1980). The calculation of the h-stats considers the proportion of agreement of an item name across participants (Pi; excluding errors and missing responses) and the different accepted names for the item (k), within the formula: $H = \Sigma P_i log_2\ (1/P_i)k_i$ (Brodeur et al., 2014; Snodgrass & Vanderwart, 1980). The h-stats increases (closer to 1) with the number of alternative names and is inversely related to the modal name scores (Snodgrass & Vanderwart, 1980).

Whenever participants were not able to name a given picture, they were asked to indicate whether they were not able to do so because they "don't know" the item presented in the picture (DK) or they "know the item but were momentarily unable to name it" (TOT – "tip-of-the-tong"). In TOT responses, participants could provide semantically related information (e.g., "Portuguese football player" or "the best football player in the world"; for Cristiano Ronaldo's picture). Errors corresponded to cases in which incorrect names were provided. Incorrect responses comprised the occurrence of Errors (%) together with DK (%) and TOT (%) responses. Complementary, DK, TOT, and Error percentages were also inspected, as reflecting the causes for incorrect responses.

Data analysis

Norms are provided by item using descriptive statistics and correlations for all ratings and psycholinguistic measures. The descriptive summary of the data (i.e., means and standard deviation, confidence interval, skewness, and kurtosis) is provided for all dimensions and psycholinguistic measures for the entire sample, by category and age group. The influence of age-group (younger vs. older) and category (people vs. places) was explored using separate repeated-measures ANOVAs for each dependent variable (i.e., ratings and psycholinguistic measures), with age as between and category as within factors. The Greenhouse-Geisser adjustment was used in case of sphericity violation. Bonferroni correction was used to adjust multiple comparisons. When appropriate, t-tests were performed as follow-up analyses of significant interaction effects. Finally, the association between psycholinguistic measures and all normative dimensions was explored using partial Pearson correlational scores by age group with correction for category effects.

Results

Preliminary analysis

Regarding naming measures, participants' responses for each item were first inspected for typing errors, adjectives, order, and synonyms. Because of the experienced-based nature of the items, the naming analysis was performed using a lenient criterium and considered the target name and other valid related names attributed to the items (i.e., "CR 7" for "Cristiano Ronaldo's" picture). Likewise, names of relevant characters were considered as a variant name of the item (e.g., "Charlot" for "Charlie Chaplin"). Short versions of the correct name (e.g., "Amoreiras" referring to the "Amoreiras Shopping Center") and correct composite names presented in a different order ("Shopping Center Amoreiras") were considered valid alternatives. Afterward, responses were classified as correct or incorrect, and the naming measures were calculated.

The questionnaires were then examined for unnamed items. The naming task was inspected for "Don't Know" responses by participant and by item. The percentage of Errors and TOT responses were also determined to provide a detailed description of naming performance and disentangle their influence in naming measures. Five participants were excluded from the naming scores analysis based on their naming performance (presenting more than 51% of DK or naming errors). Missing cases of naming were rare (less than 1%) and nonexistent after excluding those participants (all younger adults). None of the items reached 80% or higher of DK responses in naming. Incorrect responses comprised 34.24 % of the overall responses. Specifically, DK responses represented 20.91% of the responses, and TOT (8.92 %) and Errors (4.41 %) were less frequent.

The categorization task was also inspected for DK responses to identify unknown items that did not activate the associated semantic category. Four items were challenging to categorize (more than 50% of DK), although none of the items reached 80% of DK category responses.

Overall, no items were excluded from the sample since they were difficult to name but not uncategorizable items. Difficult items are welcome and should intentionally be retained to avoid ceiling effects in further testing/interventional contexts (Martins et al., 2005; Stiver et al., 2021).

Rating tasks were inspected for biased responses and missing cases. Systematic/biased responses (i.e., extreme values[27], continued use of the same value across items/dimensions, or scale midpoint tendency) were rare (i.e., below 2.6% of outliers for each dimension). No data were excluded based on such criteria. No missing cases were observed for the rating tasks.

Item Norms

Normative data is summarized for each rated dimension, together with naming and categorization measures for the entire sample, by age and by category (see Table 3). All the stimuli and detailed norms per item are presented as Supplemental Materials (https://osf.io/g8w3c/?view_only=cd1a8da3c85346ffb99f66d82c5302e5). These norms include computed means, standard deviation, 95 CI% as well as the defined level of dimension expression (low, moderate, or high) based on the midpoint of the scale (see Prada et al., 2016, for similar procedures). Additionally, the modal name and target category for each picture are provided.

Firstly, we contrasted the mean results of each dimension/measure with the midpoint of their respective scales to provide an overall description of the entire dataset. The results indicated that the pictures were overall rated above the scale midpoint (i.e., 5.5) in all dimensions (see Table 3). Specifically, the items were rated as familiar, $t(79) = 12.32$, $p < .001$, $dz = 1.38$, *95% CI* [1.07; 1.68], distinctive, $t(79) = 13.77$, $p < .001$, $dz = 1.54$, 95% CI [1.21; 1.86], famous, $t(79) = 13.37$, $p < .001$, $dz = 1.49$, *95% CI* [1.17; 1.81], arousing, $t(79)= 8.34$, $p < .001$, $dz = .93$, *95% CI* [.66; 1.19], and as having good representational quality, $t(79) = 24.06$, $p < .001$, $dz = 2.69$, *95% CI* [2.21; 3.16].

The performance in all the psycholinguistic measures (see Table 3) was above 50% across age groups and categories. Specifically, the percentage of name agreement, $t(79) = 3.85$, $p < . 001$, $dz = .43$, *95% CI* [.20; .65], name accuracy, $t(79) = 5.30$, $p < .001$, $dz = .59$, *95% CI* [.35; .82], and category accuracy, $t(79) = 6.07$. $p < .001$, $dz = .68$, *95% CI* [.43; .92], were all above chance. No celling effects

[27]Outliers' inspection based on the criteria of ±2.5 standard deviation from the mean rating per item and across participants (see Garrido et al., 2017).

were observed for both naming and category accuracy, and none of the tasks proved unfeasible. Moreover, the results indicated low variability in naming proper names (H-stats: *M* = .22, *SD* = .05).

Table 3. Normative data for the entire sample, by age groups and by category

Dimension:		*NA%*	*H (NA)*	*NAcc%*	*CAcc %*	*FAM*	*FAME*	*DIST*	*AROU*	*RQ*
OVERALL (80 inputs)										
Entire Sample	*Min*	1.96	0.00	1.96	1.96	2.34	3.03	3.40	3.81	5.94
	Max	98.04	1.62	100.00	100.00	9.96	9.94	9.79	8.51	9.38
	M	**61.29**	**0.22**	**65.86**	**66.20**	**7.84**	**7.83**	**7.70**	**6.48**	**7.89**
	SD	2.93	0.05	2.99	2.67	0.19	0.17	0.16	0.12	0.10
	Skew	-0.50	2.02	-0.69	-0.62	-0.99	-0.71	-0.68	-0.39	-0.28
	Skew SD	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27
	Kurtosis	-0.71	3.18	-0.52	-0.30	0.59	-0.03	-0.07	-0.58	-0.79
	Kurt SD	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53
By Age Group (80 inputs)										
Younger adults	*Min*	0.00	0.00	0.00	2.00	2.36	3.11	3.36	3.77	5.55
	Max	98.04	1.35	100.00	100.00	9.95	9.93	9.71	8.43	9.25
	M	**58.26**	**0.20**	**62.25**	**64.17**	**7.76**	**7.67**	**7.56**	**6.17**	**7.60**
	SD	3.08	0.04	3.18	2.77	0.21	0.18	0.17	0.13	0.11
	Skew	-0.29	1.88	-0.44	-0.51	-0.84	-0.49	-0.50	-0.03	-0.23
	Skew SD	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27
	Kurtosis	-0.98	2.41	-0.94	-0.55	0.12	-0.48	-0.50	-0.95	-0.92
	Kurt SD	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53
Older adults	*Min*	3.92	0.00	3.92	1.96	2.31	2.94	3.45	3.86	5.71
	Max	100.00	1.75	100.00	100.00	9.98	9.98	9.86	8.61	9.45
	M	**64.73**	**0.22**	**69.46**	**68.16**	**7.94**	**7.99**	**7.85**	**6.83**	**7.95**
	SD	3.03	0.05	3.07	2.72	0.19	0.18	0.16	0.12	0.10
	Skew	-0.67	2.10	-0.90	-0.67	-1.11	-0.92	-0.84	-0.74	-0.53
	Skew SD	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27
	Kurtosis	-0.60	3.85	-0.29	-0.30	0.64	0.22	0.05	-0.01	-0.43
	Kurt SD	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53
By Category (40 inputs)										
People	*Min*	1.96	0.00	0.00	1.96	2.31	2.94	3.36	3.77	5.55
	Max	97.06	0.99	100.00	100.00	9.98	9.98	9.76	8.45	9.45
	M	**59.98**	**0.06**	**61.47**	**71.25**	**7.46**	**7.64**	**7.41**	**6.31**	**7.55**
	SD	4.40	0.02	3.40	3.03	0.23	0.20	0.17	0.13	0.11
	Skew	-0.54	3.95	-0.51	-0.94	-0.73	-0.68	-0.56	-0.24	-0.10
	Skew SD	0.37	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27
	Kurtosis	-0.65	16.53	-0.99	-0.04	-0.32	-0.31	-0.38	-0.68	-0.73
	Kurt SD	0.73	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53

Places	*Min*	9.80	0.00	9.80	13.73	4.18	4.53	4.39	4.18	5.66
	Max	98.04	1.75	100.00	94.12	9.84	9.94	9.86	8.61	9.25
	M	**62.60**	**0.36**	**70.25**	**61.08**	**8.24**	**8.03**	**7.99**	**6.69**	**8.00**
	SD	3.91	0.05	2.79	2.32	0.16	0.16	0.15	0.13	0.10
	Skew	-0.41	1.17	-0.70	-0.40	-0.90	-0.54	-0.69	-0.54	-0.69
	Skew SD	0.37	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27
	Kurtosis	-0.89	0.26	-0.67	-0.72	-0.04	-0.79	-0.51	-0.76	-0.39
	Kurt SD	0.73	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53

Note: NA%: percentage of modal name agreement; H (NA): H-statistic of name agreement; NAcc%: percentage of name accuracy; CAcc%: percentage of categorization accuracy; FAM: familiarity; FAME: fame; DIST: distinctiveness; AROU: arousal; RQ: representational quality.

Norms by Age and Category

Age group and category effects were examined using separate repeated-measures ANOVAS for each evaluative dimension and psycholinguistic measure.

Evaluative dimensions

Age differences were observed in all evaluative dimensions, except in familiarity, $F(1,78) = 2.817$, $p = .326$. Specifically, aging was relevant for ratings of arousal, $F(1,78)= 80.356$, $p < .001$, $\eta^2_p = .507$, distinctiveness, $F(1,78) = 11.001$, $p = .001$, $\eta^2_p = .124$, fame, $F(1,78) = 11.025$, $p =.001$, $\eta^2_p = .124$, and representational quality, $F(1,78) = 37.800$, $p < .001$, $\eta^2_p = .124$. Bonferroni pairwise comparison showed that older participants evaluated proper names pictures as more arousing, distinctive, famous and with higher representational quality than younger participants (all p´s ≤ .001).

The main effect of category influenced the ratings of representational quality, $F(1,78) = 4.815$, $p =.031$, $\eta^2_p = .058$, and familiarity $F(1,78) = 4.433$, $p =.038$, $\eta^2_p = .054$. Specifically, places were rated higher on familiarity and representational quality than people (p´s < .05). The ratings of fame, $F(1,78) = 1.251$, $p = .267$, distinctiveness, $F(1,78) = 3.422$, $p =.068$, and arousal, $F(1,78) = 2.733$, $p =.102$, were not significantly different between the two categories.

All evaluative dimensions examined showed a marginal to significant age*category effect (representational quality, $F(1,78) = 3.802$, $p =.055$, $\eta^2_p = .046$; familiarity, $F(1,78) = 21.478$, $p < .001$, $\eta^2_p = .216$; fame, $F(1,78) = 6.401$, $p = .013$, $\eta^2_p = .076$, distinctiveness, $F(1,78) = 12.790$, $p =.001$, $\eta^2_p = .141$; and arousal, $F(1,78) = 31.205$, $p < .001$, $\eta^2_p = .286$). Subsequent analysis using t-tests, and their detailed statistics are presented in Table 4. These analyses indicated that people's pictures were rated as more familiar, famous, distinctive, arousing and considered of better quality in representing their entities by older adults compared to younger ones (all p´s ≤ .001). Ratings of places' pictures were influenced by age for familiarity, arousal, and image representational quality (p's ≤ .001). Places were considered more familiar by younger adults, while arousal and representational quality ratings were higher in older ones.

Table 4. T-tests between age groups for each category across all evaluative dimensions.

	PEOPLE						***PLACES***					
	Younger		Older		comparison statistics		Younger		Older		comparison statistics	
	M	*SD*	*M*	*SD*	*t(39)*	*Cohens' d 95% CI [Min-Max]*	*M*	*SD*	*M*	*SD*	*t(39)*	*Cohens' d 95% CI [Min-Max]*
FAM	7.11	2.01	7.80	1.99	-3.622***	-.701[.30; 1.10]	8.40	1.39	8.07	1.43	3.014**	.58[.17; .98]
FAME	7.36	1.75	7.92	1.75	-3.474***	-.67[.27; 1.07]	7.99	1.48	8.06	1.43	-.732	-.14[.00; .50]
DIST	7.11	1.53	7.71	1.55	-4.083***	-.79[.38;1.20]	8.00	1.36	7.98	1.38	.242	.05[-.33; .43]
AROU	5.77	.99	6.84	1.06	-8.737***	-1.69[1.14; 2.21]	6.57	1.22	6.82	1.07	-3.050**	-.59[.21; .98]
RQ	7.33	1.01	7.78	.92	-4.853***	-.93[.50; 1.36]	7.88	.90	8.12	.91	-3.807***	-.74[.33; 1.14]

Note. The statistics (t-test) are significant at $^{*}p \leq .05$; $^{**}p \leq .01$; $^{***}p \leq .001$.
FAM: familiarity; FAME: fame; DIST: distinctiveness; AROU: arousal; RQ: representational quality.

Psycholinguistic measures

The results for psycholinguistic measures indicated a main effect of age group (younger vs. older adults) for modal name agreement, $F(1, 78) = 12.479$, $p = .001$, $\eta^2_p = .138$; name accuracy, $F(1, 78) = 16.678$, $p < .001$, $\eta^2_p = .176$; and category accuracy, $F(1, 78) = 9.712$, $p = .003$, $\eta^2_p = .111$, but not for H-statistic of naming, $F(1, 78) = .818$, $p = .369$. Bonferroni pairwise comparison indicated that older adults named and categorized this sample of proper names' pictures more accurately than younger adults (all *p*´s < .005), and presented higher agreement regarding the modal name ($p = .001$).

The main effect of category (people vs. places) on the psycholinguistic measures, of name agreement, $F(1,78) = .269$, $p = .605$, and name accuracy $F(1,78) = 2.180$, $p =.144$, was not significant. However, differences according to category types were significant in H-statistic, $F(1,78) = 13.929$, $p < .001$, $\eta^2_p = .152$, and marginal in category accuracy $F(1,78) = 3.756$, $p = .056$, $\eta^2_p = 046$. Places presented lower variability in naming than people although people were better categorized (*p*´s < .05). The interaction effect between age and category was not significant for the psycholinguistic measures (all *p*´s > .140).

Correlational analysis

The correlational results were obtained by Partial Pearson's correlations for the entire sample scores and controlled for the category factor influence. Considering the nature of most of the measures (i.e., semantic-sensitive) and to avoid interpretations of spurious correlations derived from the influence of other common co-variates (i.e., semantic knowledge), we only provide comments on strong correlations ($r \geq .70$; Hinkle et al., 2003). The detailed correlational results are presented in Table 5.

Table 5. Partial Correlations (Pearson correlational scores) between variables independently of age groups and controlled for category effects.

	NA%	H(NA)	NAcc%	CAcc%	FAM	FAME	DIST	AROU	RQ
NA%									
H(NA)	-0.279								
NAcc%	0.925	0.066							
CAcc%	0.586***	0.047	0.631***						
FAM	**0.857*****	0.054	**0.927*****	**0.725*****					
FAME	**0.844*****	0.042	**0.912*****	0.673***	**0.962*****				
DIST	**0.844*****	0.040	**0.919*****	0.644***	**0.953*****	**0.984*****			
AROU	**0.744*****	0.014	**0.809*****	0.567***	**0.855*****	**0.885*****	**0.884*****		
RQ	**0.803*****	0.035	**0.880*****	0.601***	**0.884*****	**0.911*****	**0.937*****	**0.791*****	

Note: The correlations are significant at $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$. The signal (-) is reported for negative correlations. Results in **bold** refer to strong correlations at $r \geq .70$. NA%: percentage of modal name agreement; H (NA): H-statistic of name agreement; NAcc%: percentage of name accuracy; CAcc%: percentage of categorization accuracy; FAM: familiarity; FAME: fame; DIST: distinctiveness; AROU: arousal; RQ: representational quality.

Overall, name agreement and name accuracy were positively and strongly correlated with all rated dimensions (all *p's* < .001). Name agreement and the H-stats measures were negatively correlated (Bonin et al., 2008; Marful et al., 2018), but contrary to the expectations, the observed correlation was not significant. Category accuracy correlated significantly with familiarity in a strong and positive manner. Finally, the rated dimensions presented strong and positive correlations among themselves (all *p's* < .001).

Discussion

The current study presents systematic norms for 80 pictures of proper names culturally adapted for European Portuguese for the evaluative dimensions of arousal, fame, distinctiveness, familiarity, and representational quality. The psycholinguistic measures of name agreement, name accuracy, name variability, and category accuracy were also considered. Importantly, these norms also report the effects of age and category on the normed variables examined.

Item norms

Overall, the obtained results for the evaluative dimensions showed that pictures of well-known proper names' entities were rated as highly familiar, distinctive, and arousing. These results converge with previous norms for famous people's names (from pictures or written names) in which items were also considered familiar, highly distinctive, and arousing (photos - Bonin et al., 2008; Marful et al., 2018; generated names - Smith-Spark et al., 2006). The current findings are also consistent with previous norms obtained in the European Portuguese context in which pictures of famous faces were rated as highly distinctive, although the previously reported mean ratings of familiarity were below the scale midpoint (Lima et al., 2021). The difference between familiarity ratings observed in the current study and those reported by Lima et al. (2021) is likely due to our prior selection of items based on their relevance to the context. This procedure was also used by Bonin et al. (2008) and Smith-Spark et al. (2006), who also identified the significance of the personalities to the context (i.e., they used a prior naming generation task) before conducting the normative study. Likewise, they also reported high familiarity scores. Moreover, Lima et al. (2021) only presented famous people's pictures in black-and-white versions and in a higher number than in our study. Notably, our study indicates that familiarity ratings were lower for famous people than for famous places. Arousal ratings have not previously been obtained for pictures of famous people and places simultaneously. The current results indicate that these categories are equally arousing, confirming that arousal is a relevant dimension in stimuli that carry some uniqueness in their identity (see Garrido & Prada, 2017; Garrido et al., 2017; Marful et al., 2018; Prada et al., 2018). The current sample of pictures also presented good representational quality regarding the famous entities they intend to represent. Finally, because the pictures were from well-known entities, they were, as expected, rated highly in fame (see Rizzo et a., 2002).

The examination of psycholinguistic measures indicated that naming the pictures of proper names was a challenging but feasible task (around 65% of accuracy). Participants showed greater naming accuracy and good agreement regarding the modal name compared to previous normative studies using face stimuli only (Marful et al., 2018; Smith-Spark et al., 2006), likely motivated by differences in the analysis procedure and item diversity. Additionally, participants presented low variability in attributing a name (H-stats), a finding that is congruent with previously published celebrities' norms (Bonin et al., 2008). Prior European Portuguese norms of common objects (receiving a common noun) reported higher scores of name accuracy (92%) and name agreement (above 75%), and also more variability in naming (H-stats of 0.78) comparatively to our findings (Souza et al., 2021). Such comparison confirms that it is more challenging to name proper names than common names' items (see Brédart, 2017 for a review). Moreover, their identity nature seems to restrict the number of acceptable labels as reflected by their lower naming variability when compared to common objects. The performance in identifying the correct category was higher than 60%. However, the ability to categorize these items was also lower than what was observed for common objects (94% of accuracy) in previous norms obtained in the Portuguese context (Souza et al., 2021). This comparison further suggests that proper names refer to identity labels less susceptible of being associated with a class of items and confirms proper names as a specific lexical category (Brédart, 2017; Semenza, 2006; 2011).

Aging effect in evaluative dimensions

The effect of age on the rated dimensions indicated that familiarity was relatively immune to aging. This is a surprising finding since familiarity is likely to improve with aging, considering the significant influence of life experiences on this dimension (e.g., Yoon et al., 2004). However, age differences were observed in all the other evaluative dimensions. Specifically, older participants rated the pictures as more arousing, famous, distinctive, and with higher representational quality than younger ones. Overall, these findings might be related to the fact that older participants were better at recognizing the pictures (as shown in higher name accuracy, category accuracy, and TOT states and in less DK and Errors). Prior studies already provided age-related norms for relevant dimensions, such as fame, familiarity, and distinctiveness (Rizzo et al., 2002; Smith-Spark et al., 2006). However, while these norms were obtained from samples with large age ranges, the authors did not report aging effects statistics. Our findings suggest that ratings in dimensions such as distinctiveness, fame, and arousal vary with aging and might be sensible to life experiences. Therefore, age seems relevant for processing proper names' items and should be examined in the production of proper names' norms.

Category effects in evaluative dimensions

The current norms showed category effects only for familiarity and representational quality, with places rated higher in these dimensions than people's pictures. Famous people and famous places are known to engage different specific brain structures (Gorno-Tempini & Price, 2001; Ross & Olson, 2012). These differences are probably motivated by the unicity and richness of their associated semantic knowledge (see Ross & Olson, 2012). Therefore, category effects observed in familiarity and representational quality are expected because these dimensions are highly influenced by a semantic component.

The interaction between category and age might provide further insights into these results. For instance, familiarity ratings presented an opposite age influence across categories. Older adults rated people's pictures as more familiar, while younger adults rated places as more familiar. The different exposure to knowledge about proper names along life might be important in explaining such differences. Previous studies showed that our prior experiences and interests, as well as how familiar the items are, influence our knowledge about proper names (Martins et al., 2005; Rosa et al., 2012; Semenza et al., 1998). Specifically, the familiarity dimension captures the likelihood of occurrence in daily-life experiences (see Snodgrass & Vanderwart, 1980). For instance, the difficulty younger participants presented comparatively to older adults in recognizing peoples' items is likely related to their familiarity ratings. Because peoples' items included both recent and old characters, it is reasonable to assume that younger participants are less likely to have encountered such old items during their life. Places were better recognized by younger adults. In contrast with people items, places are less dependent on time period, thus being less susceptible to generational factors. Therefore, the increased recognition of people items seems to contribute to the appraisal of familiarity and also impact all the remaining dimensions (since they are correlated), particularly for older adults.

Together, these results suggest that the category effect plays a moderate role in assessing relevant dimensions that are influenced by age and likely by life experiences. Therefore, the influence of categories of proper names should be accounted for in future norms, at least when familiarity and representational image quality are examined.

Aging effect in psycholinguistic measures

The results observed for the psycholinguistic measures of proper names' pictures varied between age groups, as shown by significant differences for name agreement, name accuracy, and category accuracy measures. Although a decline in naming retrieval of proper names' items is expected with healthy aging (e.g., Evrard, 2002; Kavé & Yafé, 2014; Semenza, 2006), the current study showed that younger adults presented a worse performance than older ones. This interesting finding might have several explanations. First, aging effects in naming remain a controversial finding in the literature (e.g., Mina et al., 2010; Kavé & Yafé, 2014; Kavé et al., 2018; Rendell et al., 2005) that seems to be influenced by the methodology used (e.g., stimuli, instructions, response type, presentation time) as well as by the sample characteristics (see Gouler et al., 1994). For instance, a prior normative study conducted in the Italian context using famous proper name items (i.e., famous buildings) did not report significant aging effects in naming (Mina et al., 2010). Second, in the current study, the expected aging effect may have been masked by the specific characteristics of our older participants, who voluntarily applied to participate in an online study. This self-selection bias is likely to reflect an older sample with preserved capabilities (i.e., attentional resources, motor skills, executive functions, and learning facilities) as well as with an educational background and cultural profile comparable to the younger sample. The referred profile of our aging sample might have contributed to attenuating the natural (neuro)cognitive decline expected with aging, given their likely enhanced level of cognitive reserve, that is, the product of life experiences such as education, occupation, and leisure in maintaining a healthy neurocognitive functioning (see Stern, 2012 for details). Although naming people has not been associated with cognitive reserve likely due to their arbitrary content (Mondine & Semenza, 2016; Montemurro et al., 2018), there are other proper names' categories somewhat semantically sustained, like Logo names, that seem to be better retrieved when participants have a high cognitive reserve (Montemurro et al., 2019). This might be, for example, the case of the names in our category of "monuments places". Therefore, since naming proper names stimuli might be sensitive to cognitive reserve, this variable should be addressed in future studies.

Moreover, the lower scores in naming and categorization observed in the younger group could have been tight with pictures of people, which included old and recent characters. Some of these characters presented a challenge to younger participants who are less likely to have been previously exposed to semantic knowledge about them. However, the advantage of older participants was not restricted to famous people items, suggesting that overall, cumulative knowledge across life might be favoring their performance. The ability to retrieve picture names seems to be influenced by crystallized abilities (i.e., dependent on acquired world knowledge, life experiences, and educational background) and fluid cognition (e.g., executive functions, motor abilities, attentional resources; see Catell, 1963; Carpenter et al., 1990; Elias & Saucier, 2006; Lezak, 2004 for further explanation). Crystalized competencies are expected to be preserved or even enhanced throughout the lifespan and might improve naming, while fluid abilities appear to decrease with aging impairing naming retrieval and other cognitive competencies (e.g., Hunt, 2010, p.367; Verhaeghen, 2003). Therefore, the advantage for older people in naming measures observed in the present study suggests the preservation of both crystallized but also fluid abilities. While the assumption of preserved crystallized abilities and a decline in fluid cognition with healthy aging seems to be the rule, future studies might directly examine these abilities, particularly in samples of older people. Alternatively, studies might also include more heterogeneous samples in their educational background and cognitive competencies to examine further the impact of such variables in naming performance and picture appraisal. Finally, significant changes in naming performance are progressive and might only become more evident in healthy aging when participants reach older ages (likely above 70 years old; Martins et al., 2005) and memory decline is expected (see Nilsson et al., 1997; Rönnlund et al., 2003). In the earlier stages of aging (which comprises most of our older group), it is more difficult to observe such differences because they seem to be only visible in more sensitive measures, as latency times (see Verhaeghen & Poncelet, 2012). Moreover, it is even argued whether the expected age-related decline is restricted to specific types of accuracy measures (see James, 2006). Further studies including different measures are still required for inspecting aging effects in naming pictures of proper names.

Category effects in psycholinguistic measures

The category factor influenced the variability of naming (H-stats) and categorization accuracy that were both higher for people's pictures. Previous work has already shown that people items are faster to categorize and that it is easier to identify prior knowledge associated with people than with places (Fairhall et al., 2014). This availability of associations between famous people items and previous semantic information may also explain the increased variability in the number of valid attributed names for this category. Naming variability (H-stats) is influenced by both semantic attributes of conceptual diversity and frequency (see Brodeur et al., 2014; Snodgrass & Vanderwart, 1980). In contrast, the processing of places' items seems to be more contextual-dependent and requires less semantic activation than the processing of famous people's items (see Engst et al., 2006; Gorno-Tempini & Price, 2001).

Our findings also indicate that naming accuracy and modal name were not affected by the category of proper names, with well-known places being named as easily as famous people. Previous studies present conflicting findings regarding naming across categories of proper names (e.g., Benke et al., 2013; Engst et al., 2006) that seem to be tied to the specific stimuli used in each category. It could be expected that naming people would be easier than naming places (see Engst et al., 2006). However, these results suggest that our sample of people and places items is balanced in the naming challenges they pose to the participants.

Overall, albeit sharing identity-based features, our stimuli still present some relevant differences across categories that likely derive from their respective associated semantic knowledge. The results of the interaction between category and age did not indicate any statistically significant differences in naming abilities or categorization. Category effects in psycholinguistic measures presented a similar trend for younger and older participants, probably due to the similarities in socio-cultural profiles and educational background across age groups. This pattern seems to suggest the dependence of these measures on prior accumulated knowledge (see also Kavé & Yafé, 2014; Rizzo et al., 2002).

Correlational analysis

The correlational results showed that name agreement and name accuracy were positive and strongly correlated with all rated dimensions (see Bonin et al., 2008; Lima et al., 2021; Marful et al., 2018 for similar results, except for arousal). As more distinctive and familiar a picture of a proper name is, the more accurately it will be named (Bonin et al., 2008). Distinctiveness is a relevant dimension in naming proper names, influencing name accuracy and familiarity in previous normative datasets of famous people (Bonin et al., 2008; Lima et al., 2021; Marful et al., 2018). Previous studies exploring the relationship between arousal and fame and naming measures are practically absent, particularly in the Portuguese context. The positive correlations observed between fame and naming and arousal and naming suggest the need to use culturally adapted items to avoid insensitive measures that might be particularly critical for clinical purposes. Notably, all rated dimensions were correlated. Of greater interest for famous items, the dimension of fame was positively and strongly correlated with arousal, familiarity, and distinctiveness. Although circumscribed to the cultural experiences and time period, the fame dimension is relevant for confirming the actual status of the widespread knowledge regarding each item (Rizzo et al., 2002; Smith-Spark et al., 2006). Contrary to previous findings reporting negative and weak correlations between arousal and distinctiveness in a sample of Spanish speakers (Marful et al., 2018), the present study indicated a positive and strong relationship between those dimensions. Such conflicting findings may reflect differences in the variety of categories and subcategories of proper names since Marful et al. (2018) explored a higher range of subcategories of personalities and did not examine places' items.

Conclusion

Proper names are distinguishable categories based on their identity content that are also influenced by their associated semantic knowledge (Brédart, 2017; Kavé & Yafé, 2014; Marful et al., 2013), and constitute a relevant class of stimuli for psycholinguistic and neurocognitive research and intervention. The present study presents norms for proper names in five relevant dimensions and naming measures by age group and category. Overall, the results showed that age influenced almost all variables, emphasizing its importance in proper names' normalization. Moreover, while the performance in naming was similar across people and places, differences across categories were found in categorization, naming variability, and two evaluative dimensions.

One of the advantages of the current work rests on the inclusion of places items and the systematic examination of category differences in proper names. The use of places pictures may enhance the temporal suitability of this dataset and expand the types of pictures available for researchers and practitioners. Moreover, our results might help reconcile disparate findings in the literature examining the differences in person and topographical identity items. One important drawback of such a stimuli database is its limited generalization potential since the stimuli should be culturally and temporally relevant (Lima et al., 2021; Marful et al., 2018). However, including items from both categories distributed in international and national contexts and different time periods may allow some cultural comparisons. Overall, the current norms constitute a useful manipulable database of well-characterized pictures of proper names from various subcategories and degrees of difficulty normed in several relevant variables that allows a controlled and systematic selection of stimuli in future research and intervention endeavors with different age groups.

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Open practice statements: The present study was not pre-registered in an open-source database.
The stimuli and main data are available online at the Open Science Framework, link <https://osf.io/g8w3c/?view_only=cd1a8da3c85346ffb99f66d82c5302e5 >.
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5.2. Neural signatures of naming retrieval: Theta and Alpha oscillatory dynamics dissociate objects, people, and places

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Abstract

This study inspected Alpha and Theta oscillatory patterns in picture-naming retrieval of common objects, famous people, and well-known places to uncover the different memory processes engaged in retrieving these semantic categories. Prior studies showed dissociated Theta and Alpha power functionally related to episodic or semantic memory demands. Theta synchronizes with episodic content, while Alpha desynchronizes for semantic processing. However, the neural underpinnings of naming different semantic categories remain unexplored. Thirty-two adults participated in a picture-naming task manipulating three semantic categories (objects x people x places). EEG recordings were obtained during the entire task. Morlet wavelets were extracted for each band and condition in different time-bins.We observed a functional dissociation of Theta and Alpha power across categories. Places (long-lasting increase) differed symmetrically from objects (long-lasting decrease) in Theta and Alpha, respectively. Places also partially differed from people, which elicited earlier and transient Theta synchronization and later desynchronization in Alpha. Neural signatures of naming retrieval across categories presented dissociated oscillatory patterns derived from their different contextual requirements. These findings may inform interaction models of declarative memories by clarifying how different categories engage different memory systems and their concurrence while encouraging innovative assessments and interventions.

Keywords: naming retrieval; objects; people; places; Theta-band; Alpha-band.

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Introduction

Naming studies with brain-injured and healthy participants, comprising behavioral and imaging data, have suggested the temporal polar cortex within the Anterior Temporal Lobe (ATL) as the main region implicated in naming unique proper name entities such as people and places (e.g., Damasio et al., 1996; Grabowski et al., 2001; Papagno & Capitani, 1998; Provérbio et al., 2001; Tranel, 2009). However, the ATL structures also seem relevant in processing common names that nominate a class of objects since they reflect general semantic content (see Lambon Ralph, 2014). Moreover, a specific network likely involving the Medial Temporal Lobe (MTL), mainly the hippocampus regions (HP), is also argued to be engaged in proper names retrieval (e.g., Gorno-Tempini et al., 1998; Kljajevic & Erramuzpe, 2018; Martins & Farrajota, 2007). The alleged involvement of the hippocampus in proper names retrieval suggests that this category is supported by episodic processing. Accordingly, prior ERPs findings of increased positivity amplitudes (P3 component; a novelty/unexpectancy marker) were observed for proper names in centro-parietal sites, particularly in later times (350-430 ms) (Provérbio et al., 2001). Additionally, greater negativity (N1-N2; visuo-perception and attentional components) in left temporal recording sites (around 250ms) differentiated proper from common names (Dehaene, 1995; Provérbio et al., 2001). These findings indicate an increased perceptive-based and episodic processing for proper names. Nevertheless, the examination of oscillatory dynamics related to naming retrieval of different semantic categories has not been addressed yet. The present study aims to clarify how naming retrieval is supported by the semantic system, the episodic system, and their interaction by comparing the oscillatory neural dynamics related to naming objects, people, and places.

The brain structures supporting the retrieval of objects, people, and places' names do not overlap, as previously shown in localization case studies. For instance, a double dissociation reported in two case studies showed that in patient ACB, impaired retrieval of common names (e.g., “cat”) was associated with frontal sites, left temporo-parietal cortex lesions, including the ATL, and particularly the Left Temporal Pole, but not extensive to relevant MTL regions. However, ACB’s people's name retrieval was preserved (see Martins & Farrajota, 2007). In contrast, the anomia for people’s names (e.g., “Brigitte Bardot”) observed in patient JFJ was not associated with left temporal pole obstruction but with other left hemisphere lesions comprising the occipital and inferior MTL (i.e., including part of the left Hippocampal regions). Notably, despite the anomia for people's names, JFJ demonstrated a remarkable capability in retrieving names of familiar people used in a topographical context and showed no impairment in naming famous places, like street names and landmarks, or naming common objects (Martins & Farrajota, 2007). The double dissociation between the ability to retrieve proper names (in ACB) and the spared naming abilities for common names (in JFJ) suggests that those categories are supported by distinct brain structures and challenges the special role of the temporal pole for proper names retrieval while outlining the possible relevance of the MTL (i.e., hippocampus structures; HP). Furthermore, the different performance in people and places categories reported in ACB and JFJ study cases also suggests that previously learned names of people and places might constitute distinct lexical-semantic classes supported by different brain structures.

Other case studies also illustrate that retrieving names of people and places may involve distinct mechanisms (e.g., Lyons et al., 2002; McCarthy et al., 1996; Miceli et al., 2000). McCarthy and colleagues (1996) compared two cases of (partial) dissociative performance in naming familiar people vs. places. Patient SE demonstrated considerable difficulty in naming places and their descriptions, associated with lesions mainly over the right temporal pole and the hippocampus. However, SE's ability to name people was only slightly disturbed (although below the range of the controls). Notably, SE's capability to learn episodic and new topographical information and retrieve schematic spatial maps was preserved. In contrast, patient PHD (with a severe brain injury over the cortex) showed preserved topographical naming and description abilities but severe difficulties in retrieving people's names. The reported difficulties in naming places were associated, at least partially, with the necessary involvement of HP structures, while cortical damage was more detrimental for naming people. These findings suggest different neural pathways related to the distinct cognitive operations supporting people and places lexical retrieval, likely due to the different role of the HP structures. Nevertheless, SE's places naming impairment (McCarthy et al., 1996) and JFJ's places naming preservation (but not people's) (Martins & Farrajota, 2007) are not entirely and consistently dissociated and implicate the HP structures in processing both categories of proper names.

To our knowledge, only the experimental study of Milders (2020) systematically compared the ability to name people and places. Milders' study examined naming abilities across known objects, people, and buildings in a brain-injured post-traumatic amnesic sample matched in age and education with healthy controls. The results showed that clinical patients presented preserved memory for objects but impaired retrieval for people and places names compared to controls. Notably, differences between people and places emerged specifically for error measures with more incorrect naming for places, while naming accuracy was slightly higher (but not significant) for people than for places. Nevertheless, the low number of items used and the lack of examination of the damaged brain structures leaves the question of whether there are different memory-related systems involved in naming places compared to people and even objects.

Since the discovery of location-based place cells, the HP has been related to spatial memory (see Burgess, 2008; Burgess et al., 2002; Nadel et al., 2013; O'Keefe & Nadel, 1978), engaged in forming and retrieving spatial information, supporting topographical map layout, navigating in space and identifying previously learned locations (e.g., Maguire et al., 2006; 2022; Moser et al., 1998). Nonetheless, memory theories are not congruent regarding the HP involvement in topographical knowledge. The classic consolidation theory posits that the HP involvement is restricted to recent memories and that with time, memories become consolidated and transferred outside the HP structures (Squire,1992). According to this approach, the HP activation in spatial memories is not specific to the spatial content of memories (Squire, 1993). However, the Multiple Traces Theory and its reformulation

- Memory Transformation Account - argued that the HP is selectively recruited for episodic-dependent memories for as long as they keep their contextual or episodic nature (independently of time or experience) and for forming semantic memories from the transformation of the episodic traces into schematic representations (Nadel & Moscovitch, 1997; Tse et al., 2007; Winocur et al., 2010). Moreover, it is claimed that the HP is activated for spatial memories of vivid, contextual-based, and personal content that depend on one's experiences and also participates in forming schematic maps of topographies (Moscovitch et al., 2005; 2006). However, well-established topographical knowledge is argued to be non-HP-dependent. Once consolidated, prior learned content is transformed into abstract representations (schematic maps and learned routes/locations) that seem to rely upon extra-HP regions to be retrieved (see Nadel & Moscovitch, 1997).

The role of the HP and its connection with the cortical network in memories has been addressed through electroencephalographic (EEG) techniques[28] using source location, ERPs, and also oscillation power and coherence patterns (e.g., Gruber et al., 2002; Klimesch et al., 1994; Köster et a., 2008). Brain oscillations[29], in particular, are promising measures for inspecting neurocognitive processes, being primarily used to examine and dissociate memory systems (Basar, 2013; Doppelmayr et al., 2000; Gruber et al., 2018; Klimesch et al., 1994; 1997; 2001).

The oscillatory activity of Alpha and Theta is known to dissociate episodic and semantic memory processes (Klimesch et al., 1994; 2001). Moreover, the temporal dynamics (onset and duration) of Theta and Alpha also differs according to memory retrieval requirements (Klimesch et al., 2005; 2006). In particular, a prolonged and larger event-related[30] upper Alpha (10-13Hz) power decrease (desynchronization) (i.e., around 350 to 650 ms post-stimulus[31]; Klimesch et al., 2006) is expected for semantic-based processing, over-represented in left central, parietal, and temporal regions (Doppelmayr et al., 2005; Klimesch et al., 1994; 2006). Moreover, upper Alpha desynchronizes for semantic but not for episodic retrieval (Klimesch et al., 1997). In contrast, event-related Theta activity (around 4-8Hz) differs across episodic-like and semantic-like memories both in power (squared amplitude) and in time course (Klimesch et al., 1994; 1997; 2001). Specifically, event-related Theta power changes increase during encoding and retrieval of contextual-based episodes up to 400ms (Klimesch et al., 1994; 1997),

[28] EEG techniques are limited in spatial but improved in temporal resolution (see Luck, 2014). When inspecting dynamic activity, temporal resolution is prioritized over spatial resolution. Therefore, since our interest remains in dynamic activity, we elected the time-frequency oscillation activity as our interest variable.

[29] Brain oscillations correspond to the natural electrical rhythmic activity produced by individual or group of neurons, spontaneously or in response to stimulation, essential to achieve inter and intra regions communication (Basar, 1999; Basar et al., 2001). This synchronic neuronal activity comprises lower (delta and theta) to higher frequencies (alpha, beta and gamma) in voltage (Hz) that may be captured over the scalp using Eletroencephalography (Buzsáki, 2002; Lopes da Silva, 2013).

[30] The event-related measure is obtained considering the task-related (time and phase-locked) power changes in post-stimulus interval compared to the reference (i.e., pre-stimuli) interval (see Klimesch et al., 2001 for details).

[31] The referred output is based on a review summarizing data from different designs using several time-bins (e.g., of 125 or 200 ms) after stimulus presentation to analyze alpha dynamic along time, considering that Alpha rhythms vary in function of the task demands and frequency band interval used.

being maximum at ~300ms, when episodic traces are likely to be accessed (Klimesch et al., 2005). When those traces are not strong enough to ensure retrieval, a late Theta synchronization (around 500ms) emerges, reflecting demands in evaluating the accessed traces (Klimesch et al., 2005). Moreover, an earlier Theta synchronization (around ~250-400 ms after stimulus) during encoding is associated with later familiarity-based episodic recognition, while a late and prolonged Theta band power increase (around ~450-600 ms post-stimulus) predicts recollective memories (Klimesch et al., 2001). Previous studies have also shown that performance in spatial memory is associated with oscillatory Theta activity (and phase) in both animal (i.e., intra-scalp hippocampal-theta) and human healthy and clinical samples (Chauvière et al., 2009; Cornwell et al., 2008; O´Keefe & Recce, 1993; see also Herweg et al., 2020 for a review). Together, these results emphasize the relevance of the dissociated pattern of Theta and Alpha frequencies as a parameter to better scrutinize the recruitment of episodic and semantic memory systems, especially when manipulating spatial content. Therefore, inspecting oscillatory differences in naming retrieval across categories of common objects, famous people, and well-known places may unveil differences in their related memory processing. However, to our knowledge, there are no studies comparing the differences in oscillation patterns between these categories during naming.

Assuming the relevance of the HP-dependent network for proper names (see Martins & Farrajota, 2007; McCarthy et al., 1996), this study examined the dissociative pattern of Theta and Alpha in time and magnitude (power) across the retrieval of objects, people and places names. It was expected that naming retrieval of people and places would lead to an increased Theta activity (compared to common objects) since they are embedded in contextual-based information (Klimesch et al., 1997). This enhancement in Theta synchronicity might be larger for places than people due to the topographical and spatial nature of the former (Martins & Farrajota, 2007; Moscovitch et al., 2006). In contrast, a dissociated Alpha power activity was expected, with prolonged and large power suppression for objects compared to people and places (Klimesch et al., 1997). This dissociated pattern would reflect their different semantic-related processes, with objects assumed as essentially semantic while different degrees of semantic processing were expected for the other categories (Klimesch et al., 1994; 1997; 2001). As the time course of (de)synchronization power effects depend on task demands, time-dependent dynamic changes in oscillatory power during different memory processing stages involved in the retrieval of a name were also examined (see Klimesch et al., 2005).

Method

Participants

Thirty-two neurotypical adults, Portuguese native-speakers with corrected-to-normal vision and no neuropathological diagnosis (27 females; 28 right-handed; $M_{\text{age}} = 25$, $SD_{\text{age}} = 8.70$, Age range [18-48]; $M_{\text{schooling}} = 14.67$, $SD_{\text{schooling}} = 3.78$, Schooling Range [12-25]), volunteered to participate in the current study in exchange for a 10€ retail voucher. The sample size was defined based on a prior study inspecting oscillatory patterns of categorical items in two conditions in a sample of 20 participants (Zion-Golumbic et al., 2010). We slightly increased the sample size to accommodate a third condition. All participants provided written consent for their participation.

Stimuli

The set of pictorial stimuli (N = 120) included real-world images of common objects, famous people, and well-known places selected from prior normalized databases (Souza et al., 2022; Souza et al., 2021). Common objects (n = 40) comprised basic categories from living (e.g., fruits and birds) and non-living domains (e.g., vehicles and musical instruments). Items from the people category (n = 40) included male and female personalities covering a large period of national and international fame in four domains, namely culture (e.g., Frida Kahlo), entertainment and TV (e.g., Jane Fonda), sports (e.g., Cristiano Ronaldo), and leaders (e.g., Queen Elizabeth II). Places' items (n = 40) were selected considering national and international well-known locations distributed in four domains varying in topographical knowledge: highly topographic-based geographical places (e.g., Rua Augusta, a famous Lisbon Street) and geographic infrastructures (e.g., 25 de Abril bridge), and less topographic-based items such as historical or archaeological places (e.g., Pyramids of Giza), and architectural monuments (e.g., Eiffel Tower). Pictures were matched in arousal and familiarity (p > .08) across the three categories. Examples of items per condition are presented as supplementary materials (https://osf.io/vej2x/?view_only=741fef639855498b89f772b9fc39addc).

Procedure

The research was approved by the Ethical Board of the [Host] institution (REF.01/2018). First, participants were submitted to a screening phase in which they were informed about the study and the techniques involved. The eligibility criteria (i.e., age between 18 and 55 years old, health condition, and no use of controlled medication) were confirmed. After agreeing to participate, participants were prepared with the Electroencephalography (EEG) equipment and its subsequent calibration. The task was performed in a soundproof cabin using a computer equipped with E-Prime 2.0 software, loudspeakers, and a microphone. The task included three blocks of objects, people, and places items randomly presented among participants. Participants were asked to orally name each stimulus presented on the screen after they heard a beep. They were also encouraged to make short 5-minute breaks between blocks. Each block provided examples and three training trials before testing. Detailed information regarding the trial presentation and an example of the pictures are presented in Figure 1. Brain electrical activity was recorded during the entire task.

Behavioral analysis

Naming accuracy estimates considered the correct alternatives for naming responses per item in each condition. Latency times (from the zero time in which response was allowed to the onset of articulatory response) were also obtained for each category using the Check Vocal software (Protopapas, 2007). Statistical analysis included repeated measures ANOVA with 3 Semantic Category (Objects vs. People vs. Places) as independent within-subjects variables and considered Bonferroni-Holm corrections. The behavioral dependent measures were Naming accuracy and Latency times. The descriptive statistics, *p*-values, and effect sizes (η^2_p) are provided. When appropriate, t-tests were performed to further inspect interactions.

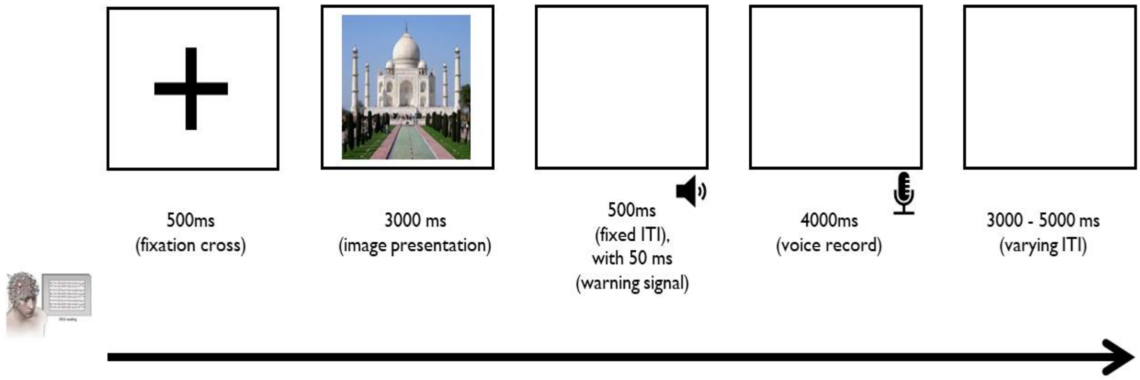

Figure 1. Trial-based design across block conditions.

Note. Each trial started with the presentation of a fixation cross (500ms), followed by a picture (500x500pxls) with a blank canvas centralized on the screen (3000ms) and an inter-stimulus blank screen (500ms) including a warning signal (50ms) informing the time to reply. Subsequently, oral naming was expected until 4000ms (response duration). Finally, another interstimulus interval varying in duration (3000-5000 ms) was presented. The two intervals before and after oral response were included to facilitate disentangling motor activity during naming and memory-related brain activity throughout stimuli processing.

EEG Data acquisition and analysis

Data collection. The EEG-based neural oscillatory data was obtained using 64-channels (Ag/Aglm actiCAP) distributed over the scalp into a 10-20 standard system in a Brain Vision Active recording system (Brain Products GmbH, Gilching, Germany). Additionally, five ocular channels were used to control electrooculogram activity (i.e., vertical and horizontal sources). The data were recorded and amplified at a 2500 Hz sampling rate within Brain Vision Recorder, version 1.21.0201 (actiCHamp Plus amplifier, Brain Products GmbH, Gilching, Germany), with the impedance of the channel kept up to 15kΩ. The online reference was FCz, which was re-established after re-referencing.

Data treatment. Data were downsampled to 500 Hz using spline interpolation and re-referenced offline to the common average over all channels (Hanslmayr et al., 2009; Köster et al., 2017). Raw data were inspected visually for intervals and artifacts (i.e., eye movements and speech muscle artifacts) per participant in each channel and segment. Persistent noisy channels were interpolated (up to five per subject) using the spherical splines method (Srinivasan et al., 1996). An offline low-high [0.5 – 40 Hz] band-pass filter and a notched 50 Hz filter were used. Eye blink detection and removal were implemented in an automatic and interval-based[32] manner with the standard Infomax Restricted Ocular

[32] The use of intervals instead of the whole data was motivated by the need to use only task-related periods and avoid residual artefacts from the rest period between blocks. Therefore, relatively short periods with effective good data were considered for performing ICA.

ICA (Independent Component Analysis) algorithm (30% of variance deleted), available in the Brain Vision Analyzer 2.2. Because only correctly named trials were considered for inspecting the neural oscillation data in each condition, data was segmented in correct trials from -500 to 2000 ms (2500ms in length) relative to the stimuli onset for each condition. The time duration was defined to include relevant memory processing and to avoid the influence of the warning alert and speech production in the neural data, thus cutting the final 1s of the image presentation. The average number of correct trials (from the 40 items presented in each category) per participants varied across objects (M = 31.29, SD = 3.60), people (M = 13.26, SD = 7.62) and places (M = 19.29, SD = 7.48). Additionally, epochs contaminated with remaining artifacts (i.e., body movements, speech interference, technical) were rejected based on a 200ms cut-off and 200 µV amplitude limit. Artefact rejection led to the exclusion of M_{obj} = 2.25 (SD = 4.03), M_{peo} = 1.06 (SD = 2.42), M_{pla}= 1.58 (SD = 3.84) of trials across participants. The final number of artifact-free correct trials included was 1605 (people - 331; places - 475; objects - 799). For analysis purposes, the Theta [3.5-7.5 Hz] and Alpha [9.5-13.5 Hz] bandwidths were defined[33], and only relevant channels were considered within Regions-of-Interest (ROI) and hemispheric location (see Figure 2).

Obtaining Spectro-temporal power. Event-related spectral power changes (in real values; μV^2) in the time-series EEG data were obtained for each Theta and Alpha bands for each condition considering all clustered channels/ROIs at each sampling time point per trial for each participant. We performed Morlet´s continuous wavelet transformation in seven cycles sampled in 0.5 Hz steps over 30 logarithmic frequency steps. Spectral power was normalized to the pre-stimulus interval of -400ms to -100 ms (avoiding overlapping effects) by trial, allowing for observing increased (synchronization) or decreased (desynchronization) activity relative to the baseline interval. Subsequently, the power changes (baseline corrected) were averaged across trials and frequencies in time per category for each clustered electrode/ROI and per time-bins of 200-400 ms and 400-600 ms in each participant. Similar time windows have already been associated with memory-related processes in recognition and naming tasks (see Klimesch et al., 1994; 2001; Provérbio et al., 2001). The mean power changes were then grand averaged (across participants) by condition and clustered electrode/ROIs for illustrative plotting purposes. Participants with a minimal of 5 trials per condition were included in the averaged data per category.

Statistical analysis. For statistical purposes, the mean power changes (μV^2) were obtained for each frequency layer within defined bandwidths across each ROI for each condition by participant as dependent measures. Afterward, data were collapsed for the follow-up analysis (e.g., obtaining the mean

[33] Bandwidth definition considered 4Hz length in each band and 2Hz transition between bands. We also confirmed if the most pronounced activity was included in the Alpha bandwidth to ensure the best fit of the band intervals. The prominent activity (in the averaged data) for the Alpha band at the parietal regions (i.e., PO3 site) was inspected using Fast-Fourier Transformation (FFT) of the maximal resolution baseline-corrected power of all corrected trials (adapted from Klimesch et al., 2001; 2005).

of all conditions and ROIs together in the first and second time-bin to contrast time-bin differences). Statistical analysis used repeated-measures ANOVAs with Bonferroni adjustments in a 3 Semantic Category (Objects, People, Places) X 2 Time-bins (200-400 ms, 400-600 ms) X 3 ROI (Frontal, Central, Temporo-parietal) within-subject design for each frequency band (Theta or Alpha). Subsequent t-tests were performed to interpret significant interactions.

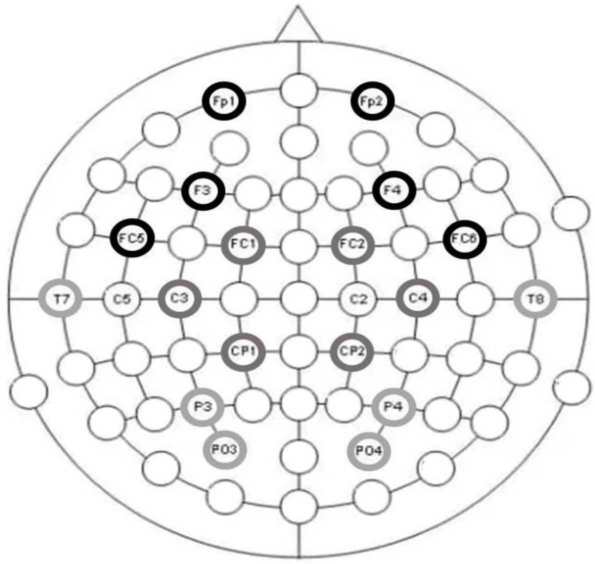

Figure 2. Mapping of ROI configuration for statistical analysis.

Note. The frontal, central and temporo-parietal sites were elected as the main Regions-of-Interest (ROI) based on previous research in memory-related oscillatory power activity (see Klimesch et al., 1994; 2006; Köster et al., 2017). The channels were distributed using a 10-20 standard system in the scalp and clustered over ROIs of frontal (in black), central (in dark grey) and temporoparietal (in light grey) sites considering a contralateral hemispheric distribution (left and right), namely in left-Frontal (F3+Fp1+FC5), right-frontal (F4+Fp2+FC6), left-central (C3+FC1+CP1), right-central (C4+FC2+CP2), left-temporoparietal (P3+PO3+T7), and right-temporoparietal (P4+PO4+T8) (see also Klimesch et al., 1997; 2005).
Figure adapted from Brain Products template, available at <https://brainvision.com/>

Results

Behavioural results: accuracy (ACC) and Latency times (Lat) across categories

The repeated measures ANOVA showed a main effect of semantic category ($F(2,62)= 119.015$, $p < .001$, $\eta^2_p = .793$). Naming accuracy (%) for people items ($M = 33.28$, $SE = 3.50$) was lower than places ($M = 48.05$, $SE = 3.24$, $t(31) = -5.368$, $p < .001$) and objects ($M = 77.42$, $SE = 1.66$, $t(31) = -14.092$, $p < .001$), showing that people was the most challenging category. Places were also more challenging than common objects ($t(31) = -10.336$, $p < .001$). The effect of semantic category in Latency times was not significant ($F(2,43.305) = 2.287$, $p = .130$, $\eta^2_p = .069$). Supplemental materials containing the raw data may be found at <https://osf.io/vej2x/?view_only=741fef639855498b89f772b9fc39addc>.

Electrophysiological results

We inspected the event-related spectral power changes in Theta (3.5-7.5 Hz) and Alpha (9.5-13.5Hz) bands across objects, people, and places categories from frontal, central, and temporo-parietal sites (i.e., collapsing data of selected electrodes from the right and left hemisphere) in the time-bins of 200-400 ms and 400-600 ms using repeated measures ANOVA. Because we were interested in power dynamics across frequencies, we inspected the power changes relative to the baseline (i.e., if synchronized/increased or desynchronized/suppressed) in each band and each time-bin. Summary of power dynamics and statistical analysis are provided in Tables 1 and 2, respectively. An illustration of oscillatory pattern across band, categories, and time-bin is provided in Figure 3.

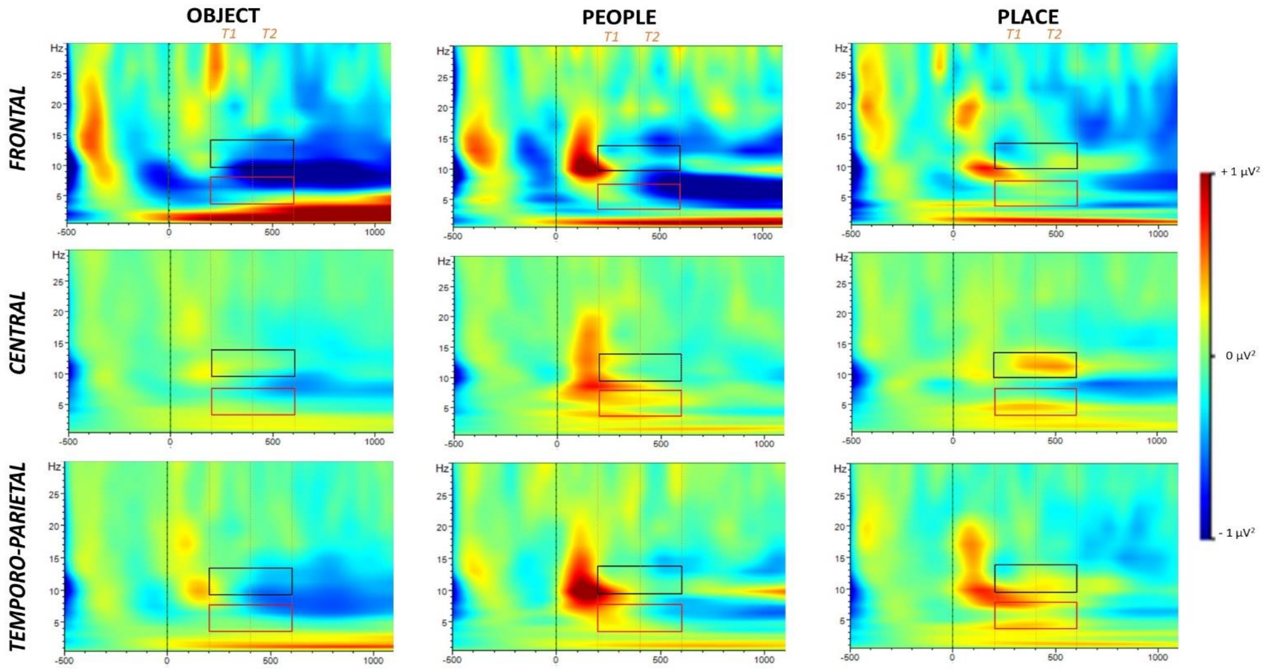

Figure 3. Spectral changes in Theta and Alpha power activity during naming retrieval (µV^2).

Note. Alpha and Theta event-related mean power changes (relatively to baseline -400ms to -100ms) are presented per condition over time, using spectral perturbation maps. The image illustrates the grand averaged data of the clustering ROI (frontal, central, and temporoparietal) across categories in the time-bins 1 (200-400 ms) and 2 (400-600 ms); Alpha is in black, and Theta is in red rectangles. Significant differences are presented in Table 2.

Theta power changes

To inspect the episodic-related memory processing underlying each semantic category, the event-related spectral power of Theta was examined. The spectral perturbation pattern across categories is shown in Figure 3. According to the statistical examination of the data, the results for time-series Theta activity showed no main effect of semantic category, $F(2,62) = 1.852$, $p = .165$. Objects ($M = -.174$, $SE = .075$), people ($M = -.069$, $SE = .190$), and places ($M = .155$, $SE = .098$) presented similar number of mean power changes. However, the power dynamic indicated that, overall, only places showed an increase in Theta related to the baseline power. The synchronized Theta power for places suggests episodic memory requirements during topographical-based retrieval (see Klimesch et al., 1997; 2001).

Table 1. Summary table of power dynamics by category across time-bins.

Category	Theta (θ)	Alpha (α)
Objects	long-lasting DESYNC in T1 to T2	long-lasting DESYNC in T1 to T2
People	shift from SYNC (T1) to DESYNC (T2)	shift from SYNC (T1) to DESYNC (T2)
Places	long-lasting SYNC from T1 to T2	long-lasting SYNC from T1 to T2

Moreover, the spectral power distribution presented no statistically significant results according to the topographical distribution (ROIs), $F(2,62) = 2.933$, $p = .061$, $\eta^2_p = .086$.

The main effect of time-bin was significant, $F(1,31) = 7.518$, $p = .010$, $\eta^2_p = .195$. Follow-up analysis indicated that overall, mean Theta power changes were more prominent in the 200-400 ms ($M = .0482$, $SE = .098$) than in the 400-600 ms interval ($M = -.107$, $SE = .077$, $t(31) = 2.742$, $p = .010$). Theta power in the 200-400 ms time-bin increased relative to the baseline and became suppressed along 400-600 ms.

Importantly, the spectral power changes in Theta were modulated by their different activity across categories in the two time-bins, $F(2,62) = 4.399$, $p = .016$, $\eta^2_p = .124$. When broken down by category, follow-up analysis indicated significant time-bin differences in mean Theta power changes across categories. Specifically, objects and places items did not show any relevant change in Theta power between the 200-400 ms time-bin and the 400-600 ms (OBJ: $M_{200\text{-}400\ ms} = -.138$, $SE_{200\text{-}400\ ms} = .077$; $M_{400\text{-}600\ ms} = -.209$, $SE_{400\text{-}600\ ms} = .097$, $t(31) = .767$, $p = .449$; PLA: $M_{200\text{-}400\ ms} = .202$, $SE_{200\text{-}400\ ms} = .100$; $M_{400\text{-}600\ ms} = .108$, $SE_{400\text{-}600\ ms} = .103$, $t(31) = 1.764$, $p = .088$). People items led to different power changes between time-bins. The 200-400 ms interval ($M = .081$, $SE = .202$) endorsed synchronized power while a desynchronized Theta activity was observed in the 400-600 ms time-window ($M = -.219$, $SE = .186$, $t(31) = 4.071$, $p < .001$). However, in the objects category, Theta activity was suppressed in both time intervals, whereas, in the places category, the opposite pattern was observed (sustained synchronization). Moreover, when further inspected by time, post-hoc results indicated a significant change in power across categories in each time-bin. Compared to objects, places items led to a larger increase in Theta power changes in both time-bins (200-400 ms: $t(31) = -2.650$, $p = .013$; 400-600 ms: $t(31) = -2.136$, $p = .041$). For people items, Theta power changed in comparison to objects and places. However, people-related power did not differ significantly in each time-bin (p´s > .085). Notably, people items elicited synchronized Theta activity in the 200-400 ms, which did not occur in objects. In sum, a dissociated Theta activity was observed across categories seemingly as a function of their requirements of episodic-related memory processing, being largely observed in places items through a long-lasting sustained increase in Theta power (no differences in time-bins) and earlier Theta synchronization for people items.

Table 2. Summary table of statistics for significant main and interaction effects for Theta and Alpha band by category, time-bin, and ROI

Effect type	Statistics	Follow-up analysis
THETA		
Time	$F(1,31) = 7.518$, $p = .010$, $\eta^2_p = .195$	T1 (M = .048, SE = .098) > T2 (M = -.107, SE = .077)**
ROI	$F(2,62) = 2.933$, $p = .061$, $\eta^2_p = .086$	Frontal (M = -.239, SE = .186) $<$ Temporoparietal (M = .069, SE = .072)*
Cat*Time	$F(2,62) = 4.399$, $p = .016$, $\eta^2_p = .124$	*By category:* PEO: T1 (M = .081, SE = .202) > T2 (M = -.219, SE = .186)*** *By time:* T1: OBJ (M = -*.138*, SE = .077) $<$ PLA (M = .202, SE = .100)* T2: OBJ (M = -.209, SE = .097) $<$ PLA (M = .108, SE = .103)*
Cat*Time*ROI	$F(4,55.409) = 3.828$, $p = .032$, $\eta^2_p = .110$	**In T1:** *Central***:** OBJ (M = -.012, SE = .038) $<$ PEO (M = .246, SE = .096)** OBJ (M = -.012, SE = .038) $<$ PLA (M = .187, SE= .083)** *Temporo-parietal:* OBJ (M = -.029, SE= .061) $<$ PEO (M = .226, SE = .135)* OBJ (M = -.029, SE = .061) $<$ PLA (M = .310, SE = .104)** **In T2:** *Central:* OBJ (M = -.148, SE = .041) $<$ PEO (M = .111, SE = .110)* OBJ (M = -.148, SE = .041) $<$ PLA (M = .105, SE = .078)** *Temporo-parietal:* OBJ (M = -.191, SE = .062) $<$ PLA (M = *.208*, SE = .111)*** PEO (M = -.110, SE = .104) $<$PLA (M = *.208*, SE = .111)*
ALPHA		
Time	$F(1,31) = 12.938$, $p = .001$, $\eta^2_p = .294$	T1 (M = .031, SE = .109) > T2 (M = -.197, SE = .109)***
Cat*Time	F (2,62) = 4.753, $p = .012$, $\eta^2_p = .133$	*By category:* OBJ: T1 (M = -.134, SE = .146) > T2 (M = -.429, SE = -186)* PEO: T1 (M = .128, SE = .147) > T2 (M = -.327, SE = .181)** PLA: T1 (M = .098, SE = .156) = T2 (M = .167, SE = .187) *By time:* In T1: NO differences (all p's > .170) In T2: OBJ (M = -.429, SE = .186) $<$ PLA (M = .167, SE = .187)* PEO (M = -.327, SE = .180) $<$ PLA (M = .167, SE = .187)*

Note. Only significant results are reported at $^{*}p$ <.05; $^{**}p$ <.01; $^{***}p$ <.001.
OBJ – Objects; PEO – People; PLA – Places. T1 – 200-400 ms; T2 – 400-600 ms.

The triple interaction of Semantic category* Time-bin*ROI was significant, $F(4,55.409) = 3.828$, $p = .032$, $\eta^2_p = .110$. Follow-up analysis showed differences in Theta power changes between objects, people, and places in the ROIs for each time-bin. For instance, in the 200-400 ms time-bin, objects led to lower Theta power changes than people over central (M_{obj} = -.012, SE_{obj} = .038; M_{peo} = .246, SE_{peo} = .096, $t(31) = -3.031$, $p = .005$) and temporoparietal (M_{obj} = -.029, SE_{obj} = .061; M_{peo} = .226, SE_{peo} = .135, $t(31) = -2.402$, $p = .022$) ROIs. Moreover, a lower Theta power change in objects was observed when compared to places also in the central (M_{pla} = .187, SE_{pla} = .083, $t(31) = -3.034$, $p = .005$) and temporoparietal (M_{pla} = .310, SE_{pla} = .104, $t(31) = -3.072$, $p = .004$) ROIs. No relevant differences appeared across categories in the frontal ROI. Regarding to the central and temporoparietal recording sites, no differences were observed between people and places (*p´s* > .09). Relatively to the 400-600 ms time-bin, objects presented reduced Theta power changes in the central recording sites compared to people (M_{obj} = .148, SE_{obj} = .041; M_{peo} = .111, SE_{peo} = .110, $t(31)$ = -2.293, p = .029). Moreover, an increased Theta power was observed for places in comparison to objects in the central recording sites (M_{pla} = .105, SE_{pla} = .078, M_{peo} = .111, SE_{peo} = .110, $t(31)$ = - 3.339, p = .002) and overrepresented in the temporoparietal recording sites (M_{obj}= -.191, SE_{obj}= .062; M_{pla}= .208, SE_{pla}= .111, $t(31)$ = - 3.608, p = .001). Although people and places items did not differ across central and frontal ROIs in the 400-600 ms time-bin (all *p´*s > .120), places presented a higher increase in Theta power changes in temporoparietal sites at 400 to 600 ms (M_{peo} = -.110, SE_{peo} = .104; M_{pla} = .208, SE_{pla} = .111; $t(31)$ = - 2.693, p = .011). No other interaction was significant. Together, these findings suggested that common objects presented different Theta power signatures than places names over central and temporoparietal sites. Moreover, retrieving names of people and places involved a similar Theta activity observed in the central and frontal recording regions, with differences in temporoparietal sites over time. The early Theta increase for people suggests an initial activation of episodic traces. At the same time, the longer-lasting Theta synchronization for places, particularly in temporal sites, indicates an increased dependency on the episodic system.

Alpha power changes

Regarding the event-related Alpha activity, the main effects of category, $F(2,62)$ = 2.076, p = .134, and ROIs were not significant, $F(2,42.591)$ = 2.703, p = .096. The mean Alpha power changes differed according to time-bin, $F(1,31)$ = 12.938, p = .001, η^2_p = .294), with overall increased Alpha power changes in the 200-400 ms time-bin relatively to the 400-600 ms time-bin ($M_{200\text{-}400\ ms}$ = .031, $SE_{200\text{-}400\ ms}$ = .109; $M_{400\text{-}600\ ms}$ = -.197, $SE_{400\text{-}600\ ms}$ = .109, $t(31)$ = 3.597, p = .001). These findings point to an Alpha suppression predominantly at the 400-600 ms time-bin.

Again, a significant interaction between semantic category and time-bin was observed ($F(2,62)$ = 4.753, p = .012, η^2_p = .133). Follow-up analysis showed differences in Alpha power changes between time-bins for objects ($M_{200\text{-}400\ ms}$ = -.134, $SE_{200\text{-}400\ ms}$ = .146; $M_{400\text{-}600\ ms}$ = -.429, $SE_{400\text{-}600\ ms}$ = -186, $t(31)$ = 2.658, p = .012) and people ($M_{200\text{-}400\ ms}$ = .128, $SE_{200\text{-}400\ ms}$ = .147; $M_{400\text{-}600\ ms}$ = -.327, $SE_{400\text{-}600\ ms}$ = .181, $t(31)$ = 3.201, p = .003), but not for places ($M_{200\text{-}400\ ms}$ = .098, $SE_{200\text{-}400\ ms}$ = .156; $M_{400\text{-}600\ ms}$ = .167, $SE_{400\text{-}600\ ms}$ = .187, $t(31)$ = -.691, p = .495). When inspected by time-bin, mean changes of Alpha power across categories in 200-400 ms were not significant (all *p´*s> .170). However, the 400-600 ms time-bin revealed a marginally significant difference with larger Alpha suppression for objects when compared to places (M_{obj} = -.429, SE_{obj} = .186; M_{pla} = .167, SE_{pla} = .187, $t(31)$ = -2.034, p = .051) but not to people (M_{peo} = -.327, SE_{peo} = .167, $t(31)$ = -.392, p = .698). Moreover, the differences between people and places, $t(31)$ = -2.287, p = .029, in this time-bin were also significant. The remaining interactions were not significant (*p´*s > .290). In sum, the current findings indicate an early Alpha suppression in the objects category that persists and increases over time. In contrast, places and people categories led to some increase in Alpha power. People category presented a late Alpha suppression while the places category presented an increase and sustained Alpha synchronization.

Discussion

The current study aimed to further inspect the time-frequency neural signatures associated with naming retrieval of well-known places, famous people, and common objects in recruiting different memory systems. We attempted to dissociate Theta and Alpha power activity (i.e., power changes) associated with name retrieval in each category as reflecting the engagement of episodic or semantic memory-related processing, respectively (Klimesch et al., 1994; 2001). In particular, we were interested in understanding whether places, as proper name categories, differed from people in their memory systems dependency by comparing the time-course dynamics (magnitude, duration, and topography) of Theta and Alpha activity (see Klimesch et al., 2005; 2006).

Our behavioral results confirmed differences in performance in naming objects, people, and places categories, with objects being easier to name than people and places (see also Souza et al., 2022). These differences seem to be related to lexical-semantic retrieval processes rather than their difficulty level since those categories were equivalent in processing time. As observed, people category was the most challenging to name, congruent with the idea that retrieving people´s names involves complex processing (see Brédart, 2017). Other studies have already shown that the lexical retrieval of famous people is more difficult than objects and known places (see Milders, 2000; Souza et al., 2022). However, the oscillatory neural underpinnings subserving those differences had not been explored yet.

Our neural outputs indicated a coordinated Theta and Alpha activity for the efficacy of naming retrieval. Overall, event-related power changes differed significantly between the time-bins in both frequency bands. While apparently following similar trends of power changes going from positive at earlier times to negative at a later time window, the oscillatory patterns observed in the two bands reflect different functional properties (Klimesch et al., 1999). For instance, an increase in Theta power change was observed in naming retrieval at the earlier time-bin (200-400 ms) that became suppressed over time (around 500ms), reflecting the disentangling of the episodic system (see Klimesch 1996; Klimesch et al., 1994; 2001) along time while recovering the lexical form of the item. Alpha power, on the other hand, started increasing and then shifted and became suppressed in the later time-bin congruently with the upper Alpha in response to a semantic-based task (see Klimesch et al., 1997; 1999). Moreover, the event-related Theta power was overall not significantly different in topographical distribution, although the Theta power change dynamics was synchronized in posterior regions (i.e., central and temporo-parietal) and desynchronized at the frontal sites. Although not anticipated, this suppressed Theta at frontal sites is congruent with the monitoring needs arising from the mixed demands of semantic and episodic systems (Klimesch et al., 1994; 1999) expected in this task involving different categories as well as exemplars with diverse levels of difficulty.

The influence of category was only not relevant to promote significant differences in the amount of overall event-related power for Theta and Alpha across places, people, and objects. Notably, a different pattern of Theta and Alpha activity dissociated across objects, people, and places naming, particularly over time. As expected, an overall increased event-related Theta was observed for places compared to common objects in the first and second time-bins. People category also differed significantly in Theta power between time-bins. Moreover, the remarkably synchronized Theta activity for places and people compared to common objects was observed earlier and predominantly over the posterior recording sites (see also Doppelmayr et al., 2005; Klimesch et al., 2006). As expected for well-known proper names, people and places seem to recruit a particular and more complex processing route to re-instantiate, select, and bind information that is likely to engage hippocampus-based systems (e.g., Ahmed et al., 2008; Liu et al., 2016). Therefore, these categories differ from the almost purely semantic-based category of common objects (Gorno-Tempini et al., 1998; Provérbio et al., 2001), which does not seem to recruit the episodic system at all. Furthermore, although no category effect emerged in Alpha, a dissociated event-related Alpha activity was observed across categories over time. For instance, event-related Alpha power was equivalent across categories in the earlier time-bin. However, synchronized and sustained Alpha power in places differed from the desynchronized power in objects and people at a later time-bin. Previous studies had already documented a pronounced decrease in upper Alpha around 400-500 ms due to semantic demands (Klimesch et al., 1997; 2005).

The examination of Theta and Alpha power dynamics by category showed a dissociated functional pattern. A long-lasting Theta synchronization prevailed for places items over time in conformity to an episodic-based retrieval (Klimesch et al., 1997; 2001). Symmetrically, a large and sustainable suppression in Theta power changes was shown for objects in both time-bins and decreasing over time, reflecting the absence of relevant episodic-related processing (Klimesch et al., 2001). Moreover, people also synchronized in Theta at earlier times (200-400ms) but inverted the pattern at the later time window (i.e., starting desynchronizing around 400-600ms), thus, differing from the power dynamics observed in places. The earlier Theta synchronic activity in people category is not surprising since the recruitment of episodic-dependent processing (likely involving MTL structures) seems to be required to process unique face-name associations (see Semenza et al., 2003; 2011). Moreover, this transient Theta synchronization gave place to a desynchronized activity along time, suggesting an initial stage for processing discriminability and novelty in face stimuli while recognizing them as known items (see Hanslmayr et al., 2009; Köster et al., 2017 for further examples of novelty-based episodic Theta). Regarding the Alpha dynamic, we observed that objects desynchronized persistently with time, whereas people and places presented Alpha synchronization at some point. Notably, the earlier and sustained Alpha suppression observed in the objects category seems to reflect the essentially semantic nature of item names from this category (Klimesch et al., 1994; 1997; 2001). In contrast, places showed a long-lasting and stable synchronization in upper Alpha starting at earlier times and enduring for a while. The people category showed a different dynamic in which Alpha power started decreasing in later times, leading them to differ from places items in Alpha power at 400 to 600ms. The later-occurring Alpha suppression for famous people category represents the possible need for semantic information not contemplated in early processing.

Together, these results reveal a functionally symmetrical power activity for objects (long-lasting suppression) and places (long-lasting increasing) in both Theta and Alpha. This symmetry in power dynamic reflects dissociated memory systems engagement driven by semantic knowledge properties over time (see Klimesch et al., 2001; 2006). For instance, Theta synchronizes for episodic requirements, as it happens for naming places, while Alpha desynchronizes largely in processing semantic content as observed for common objects (see Klimesch et al., 1994, 1997). Notably, people category presented a time-dependent functional dissociation between Alpha and Theta oscillation dynamic (shift from synchrony to desynchrony in activity for both bands), suggesting that the semantic system alone cannot support naming people items. In contrast, an enhanced and sustained engagement of the episodic system was selective for places along time while performing this semantic task. In this sense, neural oscillation dynamics in people's naming are quite particular compared to the other categories.

People and places different signatures

People items constitute complex semantic knowledge of arbitrary identity-based content of socio-affective relevance and largely depend on contextual information (Brédart, 2017; Semenza, 2011). As we observed, this semantic category presented a transient oscillatory dynamic of Theta and Alpha power over time. This transitional power in both bands (from synchronous to de-synchronous) represents the differential engagement of memory systems over time. In this respect, people category seems to rely more on the involvement of the episodic system and its interaction with the semantic system. Likely, the interplay between semantic and episodic information is necessary for the early processing stages of naming, which is relevant to briefly confirm and contextualize the identity of known people. After this recognition phase, lexico-semantic processing seems to be needed to support naming retrieval (see Brédart et al., 1995; Valentine et al., 1996). Prior findings provide evidence for the interplay between memories by showing that famous faces and names elicit the activity of semantic-related structures (i.e., parietal and ATL regions), supporting both face identification and associated factual knowledge (Nielson et al., 2010; see also Werheid & Claire, 2007 for a summary of cognitive and clinical evidence). This complex processing connecting semantic and episodic systems is made possible by engaging HP structures to re-instantiate memories (Hoscheidt et al., 2010; Renoult et al., 2019). We suggest that face naming requires an earlier distinctiveness-based processing of the item, as well as the further rehearsal of semantic and autobiographic content of each famous person-item in later times to support correct naming in such category (see Westmacott et al., 2004). This distinctive process of identifying a known person is guided by contextual-based requirements. As in "the butcher on the bus" classic phenomenon (Mandler, 1980), when this contextual information fails, we may recognize someone as familiar but are not able to identify, for instance, the person's identity like being the butcher or even that the person's name is "Mike". Furthermore, naming people requires a different type of recollection processing that is more associative and supports the binding of prior knowledge about faces and the stimulus itself (see Liu et al., 2016), along with the retrieving processing. This is congruent with the earlier increase in Theta, which is then suppressed as the role of the episodic system becomes expendable. At the same time, a shift from Alpha synchronization to an Alpha desynchronization also occurs. Accordingly, a larger Alpha decrease at posterior sites has been observed in response to face processing for famous faces compared to non-famous, mirroring semantic processing related to prior known faces (Zion-Golumbic et al., 2010). It is possible that after the earlier interplay between memory systems, a shift from increased to reduced episodic requirements together with enhanced semantic-based operations are expected. This might be because face recognition, although mandatory, is insufficient to surpass the threshold for correct naming retrieval. In sum, our findings suggest that naming well-known people is firstly driven by an episodic system engagement to achieve the contextual source of the known face, and, later on, the semantic system is required to attain lexical retrieval. However, in the absence of contextual distinctiveness in supporting vivid recollection of a person's face, recognition might recur essentially to semantic-based processing. In any case, a necessary search for semantic information seems to be needed to confirm people´s label identity. The transient mnesic processes involved in naming people could lead to reduced performance in this category due to the more complex interactive mechanism involved (see Gorno-Tempini et al., 1998; Brédart, 2017), being probably the source of the difficulties observed in naming people.

Despite being proper names as well, places present distinct neural signatures. Places names refer to topographical identities that likely depend on episodic and spatial content, both contextual-based and supported by the hippocampus structures (Tse et al., 2007; Winocur et al., 2010; Moscovitch et al., 2006). Our findings of increased and sustained Alpha and long-lasting Theta synchronization for places, mainly at temporoparietal sites, indicate that this category is a distinct type of proper names with specific requirements in the processes and mechanisms involved (see also Engst et al., 2006; Fairhall et al., 2014). The enhanced Theta synchronicity in places is congruent with a need to continuously access and evaluate the diverse episodic traces for successful recollection (see Klimesch et al., 2005) and might be related to the contextual nature of the spatial and topographical-based information inherent to place items. The topographical information might increase places' contextual demands regardless of how semanticized these representations are (see Hoscheidt et al., 2010). The high requirement of topographical content in places implies fully episodic-based processing (Moscovitch et al., 2005; 2006), which makes places a potentially relevant category in informing functional and structural correlates of episodic-based memory processing. Naming places might even be a better category (than objects and people) when inspecting episodic decline. Taken together, these results suggest the robust involvement of contextual-based episodic mechanisms in retrieving places (Klimesch et al., 1994; 1997), with the long-lasting Theta activity reflecting the engagement and maintenance of the episodic memory system to support episodic-like neural network for this type of unique semantic memories (see also Bastiaansen et al., 2008, for similar Theta response to specific semantic properties).

To our knowledge, this is the first study scrutinizing the oscillatory dissociation of episodic and semantic memory systems (see Klimesch et al., 1999 for a review) related to the lexical-semantic retrieval of places, people, and objects categories. Overall, our results provided brain signatures of memory-related dissociable processes supporting naming retrieval across different categories, questioning the dual perspective of the lexical-dependent dissociation of common and proper names. Some evidence of proper and common names dissociation at the behavioral and neural levels suggests that neural structures subserving different naming categories are driven by their lexical classes and their different mnesic processing involved (see Gorno-Tempini et al., 1998; Semenza et al., 2003; 2011). However, the cases reported in the literature are inconclusive regarding proper and common names dissociation (e.g., Martins & Farrajota, 2007; McCarthy et al., 1996). The current study goes beyond the classical proper vs. common names dissociation and sheds light on this question by showing that even two categories of unique semantic memories may present distinct neural underpinnings (i.e., places and people as proper name categories). Therefore, the dissociated neural underpinnings of each category reflect their different contextual dependence, with objects category being mainly context-free, people category initially based on contextual distinctiveness, and places category being continuously and highly contextual-dependent. Finally, the current findings may help conciliate inconsistent outputs in classic case studies by showing that apparently similar semantic operations may engage dissimilar processing routes at the hippocampus-cortical network or even surpass those complex connections.

It is worth noting that the high occurrence of errors observed in the current study might compromise the consistency of the results across the oscillatory patterns obtained. However, by-item data treatment and analysis using a high number of trials across all participants per condition is expected to reduce this bias. Moreover, some caution is required in generalizing these results since both age, different levels of accumulated knowledge, and cognitive reserve could impact both naming, oscillation patterns, and mnesic processes, and our sample comprised mostly young and highly educated participants.

Overall, the reported findings provide evidence of intertwined episodic and semantic memories processing while naming different semantic representations, supporting the interaction approach of declarative memories. Notably, our results emphasize the type of knowledge (i.e., if more general or more contextual) as essential to determine the mnesic processes involved. Our study also provides evidence regarding the diversity of semantic representations, helping to clarify inconsistencies across single cases reporting a common and proper names dissociation. Finally, these findings might also encourage changes in the way clinical professionals assess declarative memories and support novel interventions taking advantage of the demonstrated interplay between those memory systems in a simple naming task to promote memories and prevent memory decline.

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Open practice statements: The present study was not pre-registered in an open-source database, although the current study is part of a project approved by the Ethical Committee of the Host institution. The stimuli and main data are available online at the Open Science Framework, <https://osf.io/vej2x/?view_only=741fef639855498b89f772b9fc39addc>.

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PART III | DISCUSSION AND IMPLICATIONS

CHAPTER 6.

General Discussion

The dissociation between episodic (contextual) and semantic (abstract) memory, two types of conscious declarative representational systems, has long been established in the literature (e.g., Gardiner et al., 1998; Tulving, 1985; Yonelinas, 2002; Yonelinas et al.., 2010). Recently, the interdependence between these memory systems has gained attention (e.g., De Brigard et al., 2022; Winocur et al., 2010), but the way functions and mechanisms of memories support such interdependence is still debatable (see for a contrasting perspective Squire & Alvarez, 1995 vs. Winocur et al., 2010). To fulfill this gap, we designed a set of studies to further examine the declarative memory interdependence hypothesis (see Winocur et al., 2010; Winocur and Moscovitch, 2011).

Our main assumption was that the episodic system participates not only in the initial formation of memory and subsequent transformational processes but also in the retrieval of semantic knowledge (at least of some types), suggesting the interplay between declarative memory systems. This argument is based on the multiple memory systems perspective (Moscovitch et al., 2016; Tulving, 2002), in which there are two different declarative memory systems. Those systems seem to coexist and work together to support information processing (Winocur et al., 2010). The episodic system is considered essential for the encoding and retrieval of contextual information (Sekeres et al., 2017; Winocur et al., 2010; Winocur & Moscovitch, 2011). However, we argue that the episodic system is always highly implicated as episodic representations are involved, including during the processes of binding traces extracted from the experience and prior knowledge available as well as in the re-establishment of information (see Maurer & Nadel, 2021; Winocur et al., 2010; Yonelinas et al., 2010). The episodic system becomes expendable when purely abstract information (semantic) is in demand (see Dudai et al., 2015; Nadel & Moscovitch, 1997).

Based on these arguments, the current work approached the influence of distinct types of conceptual knowledge in declarative memories as a possible research avenue to clarify the functional and structural aspects of episodic and semantic systems and their interactions. We did so by manipulating conceptual knowledge involving different contextual and episodic requirements on memory encoding and retrieval, in well-established paradigms, across different samples within the functional and neural domains. We circumscribed the domain of conceptual knowledge to well-known *categories* (i.e., in both their pictographic version of concepts and their labels) of different domains (i.e., objects, people, and places) as they constitute contents easily found in everyday life and with specific organizational properties.

The main theoretical arguments of the current work were first defined by reviewing relevant literature on the episodic and semantic systems dissociation and their interaction (Part I, Chapter 2) to provide a conceptual framework for the subsequent empirical work. We reviewed the evidence of the functional and structural dissociation of semantic and episodic memories (Carr et al., 2013; Mäntylä, 1997; Rajaram, 1998) and claimed that these systems interact supported by the transformation in nature of episodic into semantic memory traits based on the person´ experiences (Nadel & Moscovitch, 1997; Sekeres et al., 2018; Winocur et al., 2010). We also argued that it is the nature of the information to be processed that determines the systems to be involved during memory encoding and retrieval, not their time (Robin & Moscovitch, 2017; Winocur et al., 2010). We addressed the potential role of two different types of prior conceptual knowledge, such as categorical schemas (see van Kesteren et al., 2013; 2014) and item-typicality (Alves & Raposo, 2015), in selectively modulating semantic and episodic memory systems, respectively. In light of the neuropsychological dissociation between proper and common names as reflecting respectively the involvement of the episodic and semantic systems (see Martins & Farrajota, 2007), we argued that processing semantic categories richer in contextual information, such as people and places, requires the involvement of the episodic system together with the semantic system. We also assumed that applying those modulations in healthy older adults and autistic individuals would be informative to test the hypothesis of an interaction between memory systems. These groups have characteristic profiles of a declining episodic memory system and a spared semantic memory system, which makes them good models for memory scrutiny (Mäntyla, 1993; Koen & Yonelinas, 2014; Gaigg et al., 2015).

The prior conceptual knowledge manipulation was, thus, implemented in encoding and retrieval tasks with healthy young adults and samples with episodic constraints in two sets of studies. In both approaches, the interaction between episodic and semantic memory systems was examined by contrasting conditions in which one of the systems prevails in processing the information (e.g., the semantic system in schema-congruency at encoding and in processing common objects) with conditions in which the interplay between systems is likely activated to reach good performance in the task (e.g., item-typicality/schema-incongruency and processing proper names).

In the first set of studies, we contrasted the categorical schemas (more general; e.g., mammals, vehicles) vs. the item-typicality (more specific; e.g., in mammals, a cow is typical, but a dolphin is atypical) to examine how their availability during encoding influences subsequent episodic recognition and their operations of recollection (episodic-like memories) and familiarity (semantic-like memories). In other words, we examined the role of selectively activating the semantic system and its interactions on episodic memories. The second set of studies contrasted semantic categories of proper and common names, such as objects (context-free), famous people (context-related), and well-known places (context-rich), to examine the influence of their different contextual richness during naming retrieval as a more semantic task. In other words, we inspected the role of different episodic system engagement in semantic memories. The neural oscillation pattern of the naming retrieval was also examined to uncover the neural underpinnings associated with the requirements imposed by the different categories to the two memory systems. Moreover, we also tested the interdependence argument by contrasting samples with preserved episodic memory with samples with alleged episodic constraints (in this case, healthy older adults).

In the empirical chapters (Part II), we started by reviewing materials and procedures (Chapter 3, section 3.1.) and producing stimuli and norms for the subsequent experimental work (Chapter 3, section

3.2.; Chapter 5, section 5.1.). We then systematically and experimentally tested the declarative memory systems' functional and neural interdependence during encoding and retrieval using two different memory tasks modulated by conceptual knowledge types that could vary in their reliance on episodic engagement in samples of young adults (Chapter 4, section 4.1.; Chapter 5, sections 5.1. and 5.2.). Based on a neuropsychological and developmental approach, we also examined the influence of those types of prior conceptual knowledge on declarative memory performance in older adults (Chapter 4, section 4.2.; Chapter 5, section 5.1.) and autistic individuals (Chapter 4, section 4.3.), both with putative episodic impediments.

In the following sections, we integrate the outputs of this work with previous literature, emphasize their main theoretical and practical implications, discuss limitations and future research avenues, and present the main conclusions.

6.1. Summary of the main findings

Overall, the empirical work conducted presents evidence that: i) congruency with prior schemas available at encoding (semantic-like encoding) selectively benefits semantic-like memories; ii) in contrast, inconsistencies/novelty to prior schemas (i.e., atypical information), may enhance episodic-like memories; iii) individuals with episodic system constraints present difficulties in processing schema-inconsistent information; iv) an irregular pattern in using schematic knowledge, likely to circumvent their episodic difficulties, was observed in older adults; vi) increased contextual richness in semantic categories, as in naming people and places, adds complexity to the processing of this semantic information, reducing semantic retrieval; vii) as the contextual richness of the categories increases, the larger is the involvement of episodic-theta band (assumed to reflect episodic system engagement) during semantic retrieval.

This evidence suggests the engagement of the episodic system in processing novelty- and contextual-based information in semantic encoding and retrieval (see also Bonasia et al., 2018; Dudai et al., 2015). Therefore, our outputs favor the interactive view of semantic and episodic memory systems (Sekeres et al., 2017).

The main findings related to each chapter are summarized in the following paragraphs to further discuss their theoretical and practical contributions, limitations, and potential inputs for future research.

Categorical knowledge and their properties

By mapping and summarizing normed studies using real-world objects, we exposed the complex nature of object stimuli of a more ecological type (Souza et al., 2020). Objects have been established in the literature as visually simple (low complex), meaningful and well-known stimuli depending highly on semantic knowledge, as documented by the high levels of familiarity, typicality, high categorization, and naming agreement observed across the reviewed sample of studies (Souza et al., 2020). Nevertheless, the specific influence of categories and their domains was barely addressed in previous literature, which also misses the influence of other sensorial, motor, and emotional inputs in the semantic processing of stimuli materials (Souza et al., 2020). In this respect, studies considering categories and the influence of other relevant dimensions outside the semantic field, such as, for instance, visual appeal or arousal, emerged as a possible avenue to understand semantic integration within the richness of real-life inputs.

Norming stimuli properties in several dimensions of affective, perceptive, and semantic domains was then required to ensure the quality of the stimuli, measurement procedures, and ecological validity of the materials, as well as to prevent confounding variables (Souza et al., 2021) in our experimental studies. In Souza and colleagues (2021), we normed object pictures that were assessed as positive, moderately arousing, visually appealing, and rated high on picture-name agreement and pictographic representation quality. Therefore, the influence of these dimensions from affective, perceptive, and semantic domains agrees with the view of multimodal representations gathered into a semantic concept (see Lambon Ralph et al., 2014; Rogers et al., 2004). Besides confirming the findings reported in the systematic review (Souza et al., 2020), these norms also emphasize that even neutral stimuli may involve some degree of affective information in their processing that should be further controlled. Moreover, we also observed some variability in the acceptable labels and categories attributed (as indicated by the h-index) (Souza et al., 2021). This variability, particularly influenced by linguistic and country-based contexts, reflects the semantic nature of common objects concepts. Notably, typicality ratings, assessed within a specific target category, did not vary as categorization did. This low variance of typicality ratings suggests that this dimension is a relatively stable organizational knowledge structure within a specific categorical schema (see also Souza et al., 2022a; Rosch & Mervin, 1975; Rogers et al., 2015). Our findings also suggest that an item can be assigned to different categories (e.g., a tomato can be categorized as a fruit or as a vegetable) but present consistent typicality ratings in the specific target category (e.g., always atypical for fruits) likely derived from how our brain organizes knowledge (see Patterson et al., 2007; Zhang et al., 2020). Therefore, although being interdependent, we concluded that categories and typicality are not overlapping dimensions of knowledge (Clarke & Ludington, 2017) and that typicality (although consistent within a specific category) is also adaptable to the framing context (see Dieciuc & Folstein, 2019).

We also anticipate here the overall outputs of the norms from the categories of proper names (presented in Chapter 5, section 5.1.) to present the big picture of the categories and their properties. We showed that proper names pictures (of famous people and well-known places) were normed as highly familiar, distinctive, highly famous, arousing, and of good representational quality (Souza, Carmo & Garrido, 2022, but see also Lima et al., 2021 for different results in familiarity). Of particular interest, we noted that distinctiveness is a relevant property reflecting the novelty information of a proper name item that might be equated with the low typicality scores measured in common objects norms as a measure reflecting the distinctiveness of the item in its own category (see Santi et al., 2015). Naming accuracy and name agreement showed that naming proper names (Souza, Carmo & Garrido, 2022) was more challenging than naming common objects (Souza et al., 2021). Proper names items also presented lower naming variability, which likely reflects that the uniqueness of the association between the name and the item is less supported by a semantic-based system than common objects (see Brédart, 2017; Semenza et al., 2003). In this sense, our findings indicate that both people and places pertain to a specific lexical category.

We concluded regarding the importance of providing country-based norms for supporting adequate manipulations and increasing the quality of future experimental studies. In addition to their stand-alone contributions, these studies were also useful in selecting stimuli according to their semantic organization across categories and domains, but also other perceptive and affective, and novelty-based dimensions while controlling for potentially confounding variables.

Conceptual knowledge selectively modulates memory retrieval of common items

We departed from the question of how different types of categorical knowledge influence recognition, and recollection and familiarity operations. In Chapter 4, we first explored, in two studies (using the Remember-Know paradigm and its replication with source memory descriptions), the way categorical schemas activation and item-typicality affect recollection (episodic-like memories) and familiarity (semantic-like memories) depending on the item-congruence with the available categorical schema during learning in healthy young adults (section 4.1; Souza et al., 2022a) and in samples with alleged episodic remembering difficulties (older adults – section 4.2, Souza et al., 2022b; ASD – section 4.3, Souza et al., 2022c). We expected different activation of episodic and semantic systems and their interactions, according to the different semantic information available at encoding (i.e., the schema knowledge activation or not and the high or lower fit between the item and the schema) and, thus, impacting the retrieval of episodic-like or semantic-like memories differently.

Our main findings informed that categorical schemas activation only improved semantic-like memories while perceptual encoding enhanced episodic-like memories in young adults. Moreover, low typicality enhanced young people's recollection (Souza et al., 2022a; Souza et al., 2022b; Souza et al., 2022c), a memory operation that was confirmed as vivid and detailed representation supported by the episodic system as also indicated by the source information provided (Souza et al., 2022a). In contrast, high typical items (with greater fit to the stored schema) are assumed to surpass the episodic system and engage the semantic system only; and, therefore, enhanced semantic-like memories only. On the other hand, when categorical schemas are violated (i.e., low-typical items in categorical encoding), only memory traces supported by the episodic system are enhanced (i.e., recognition and recollection memories). Low-typical information seems to activate a novelty-based episodic system that is particularly dependent on access to the available schema for detecting item knowledge inconsistencies (see also Dudai et al., 2015; Sekeres et al., 2017; 2018). Furthermore, the absence of typicality influence in perceptual encoding suggests no additional advantage in this already episodic-based encoding condition. The observed selective influence of schema (Souza et al., 2022a) challenges the generalized advantage of schemas in improving memories (Liu et al., 2016; Tse et al., 2007). Explaining the conditions in which schemas constitute an advantage or a disadvantage also contributes to clarifying conflicting outputs in the literature (see Newman & Garry, 2014; van Kesteren et al., 2010; van Kesteren et al., 2013; van Kesteren & Meeter, 2020).

Notably, the current results revealed the interdependence of memories, in which encoding low typical items (as an instance of conceptual knowledge) seems to engage and depend on the episodic and semantic system. This interaction between memory systems seems critical to inspect, monitor, and decide about the item and its semantic relatedness with its own category and, subsequently, to reinstantiate the experience during episodic retrieval. In fact, a fronto-temporoparietal network is known to be engaged in the executive processes supporting the formation and use of coherent representations comprising multimodal instances of knowledge and generalized concepts structures (Lambon Ralph et al., 2016; Rogers et al., 2004).

The studies reported in the second and third papers confirmed at first the expected episodic memory decline in both older adults and autistic individuals by showing their worse (lower and slower) recognition than their controls (Souza et al., 2022b; Souza et al., 2022c). We interpreted these findings as an indicator of a disrupted episodic memory system. Note, however, that in autistic individuals, recollection-based memory was also decreased (Souza et al., 2022c), while older adults' recollection was preserved (Souza et al., 2022b). This finding indicates that older adults are able to provide details about memories they retrieve, while autistic individuals are not. This is an interesting finding since previous literature suggested that recollection is more sensitive to pathological memory decline than overall recognition, with a closer relationship between recollection and altered hippocampus volume (Schoemaker et al., 2014). We also showed that familiarity is not affected in these two cases of episodic system disruption (Souza et al., 2022b, 2022c), suggesting that such retrieval operation is less dependent on the episodic system (Yonelinas, 2002; Yonelinas et al., 2019), in certain circumstances or when it suffices. Interestingly, when indirectly comparing the observed pattern across aging and autistic samples, autistic people did not show compensatory resources in recognition and tended to recognize more through familiarity than older adults. This finding indicates more pervasive episodic deficits in autistic individuals (likely moderate) than in older adults (very mild). Moreover, the fact that older adults are competent in both conscious judgments of metamemory (recollection and familiarity-based) does not corroborate the generalized decreased recollection previously observed in this group (e.g., Koen & Yonelinas, 2014; Prull, 2015). In our view, this finding, together with observed recognition deficits and increased response time for providing phenomenological judgments, suggests a complementary plausible explanation for their episodic deficits as also a by-product of a simultaneous reduction in their executive function capacities (e.g., Clarys et al., 2009; Nyberg et al., 2009). This executive decay is likely emergent in early aging stages (since our sample was mostly between 60-70 years old) and, as previously showed, might have also contributed to the limitations in processing specific semantic information (as item-typicality), in which control and monitoring processes might be relevant to interchanges between both episodic and semantic systems.

Once autistic people and older adults present episodic deficits to some extent and their semantic memory is preserved, and considering that both declarative systems are intertwined, we should expect some difficulties in taking advantage of the systems' interactions.

Regarding the conceptual knowledge modulation, a perceptual advantage (vs. conceptual schema) for episodic-like memories in both autistic and older adults' samples was observed, indicating that these groups are using their episodic system to some extent but taking longer to access it. We speculate that this later unexpected output indicates that episodic memories may somehow be more preserved for meaningful visual materials, considering their multimodality of representation (see Lambon Ralph, 2015). As presented in Chapter 2, the literature provides evidence of an episodic decline in both older adults and autistic samples, particularly for words (e.g., Gaigg et al., 2015; Peters & Daum, 2008). Nevertheless, the processing of item-typicality information was largely affected by an inefficient episodic system in the autistic group but not in the older one (still, older adults showed an overall delay in using typicality information during conscious judgments of recollection and familiarity). Specifically, the information unfitting with a categorical prototype (low typicality items) did not improve recognition in autistic individuals (as found in Carmo et al., 2016) as it did in the aging group, likely related to more profound episodic system constraints in autism. Low-typical items might request the engagement of the interaction between episodic and semantic systems that is necessary for a successful retrieval in this inconsistency-driven condition (see also Dudai et al., 2015).

Another relevant evidence of the interdependence of the episodic-semantic systems was the older adults' capability to use the schema benefit (semantic) to minimize their episodic loss by increasing their subsequent remembering when categorical knowledge was available at encoding compared to the young adults. This compensation was likely the reason for the absence of recollection deficits in our sample of older adults. Moreover, differently from the autistic group, older adults seem to present milder deficits in their episodic system that are likely motivated by their reduced executive resources to operate with memories and their interaction (Clarys et al., 2009; Parkin & Walter, 1992). The conscious awareness component is inherent and necessary to the recollection and familiarity operations to allow metacognitive inspection (see Tulving et al., 2002). Therefore, older adults circumvent their remembering difficulties by using their accumulated knowledge, requiring more time to use this. The slower processing was also demonstrated by the time-consuming processing of typicality information in older people suggesting some difficulty in searching for details to support the metacognitive phenomenological judgment of memory (Souza et al., 2022b). It is possible that the cortically-based semantic system may be helping to surpass the requirements of the hippocampal-based episodic system (Dudai et al., 2015). Because the episodic system is allegedly required to process information that violates the available categorical schema, typicality knowledge is not helpful when the episodic system is disrupted (see also Bonasia et al., 2018), as occurs in autistic samples. Therefore, indicating a necessary interplay between memory systems and a fully functional episodic system to efficiently support the processing of typicality information.

Taken together, these results suggest that the interaction between declarative memory systems seems less efficient in these groups, particularly in the autistic sample. In conclusion, the episodic memory system seems to interplay with the semantic system to support the encoding and processing of specific conceptual knowledge. Autistic individuals and older adults presented episodic systems constraints that likely precluded this interplay and, consequently, the efficient processing of specific semantic content.

The findings from this set of studies confirmed the interaction between episodic and semantic systems by the selective influence of different types of conceptual knowledge in modulating encoding and their impact on memory retrieval. Subsequently, we asked whether the type of information (more conceptual or contextual) also determines the memory systems reassembled during retrieval when memories are more consolidated. This question led us to examine the role of contextual information in the retrieval of different semantic categories.

Categories differences and naming retrieval: Evidence of episodic and semantic interaction

This set of studies was driven by the question of whether episodic and semantic systems support the retrieval of semantic labels of different categories. We expected that object, people, and places categories would differently engage the episodic system and its interaction with the semantic system in naming retrieval, according to the type of information they entail, and that naming would be difficult for categories with increased contextual information due to its episodic system dependency (see Semenza et al., 2003). We also expected differential episodic system engagement in each semantic category that would be reflected in enhanced theta band power (see Klimesch et al., 1994; Piai et al., 2016; Piai & Zheng, 2019).

In our results, the psycholinguistic measures reported in Chapter 5, section 5.1 (Souza, Carmo & Garrido, 2022) showed an aging effect in naming agreement, naming, and category accuracy measures, with older adults presenting better results for proper name items than young ones. Since an impairment in naming retrieval of proper names was expected along with increasing age (see Semenza et al., 2003), these results were unexpected. We interpreted these findings as a consequence of the selection of the stimuli in the database, namely well-known items embedded in semantic knowledge, which we confirmed by the high familiarity ratings. Moreover, better performance in proper names by older adults may derive from a high education of the sample, together with increased accumulated semantic knowledge in increasing the benefit of familiarity. The involvement of schematic knowledge (as categories) in all items could favor some compensatory strategies, such as the use of semantic information to support retrieving enough details to trigger an acceptable label.

The role of familiarity in these results was further confirmed since older adults were better at naming people while younger adults were better at naming places. As the people items used in this study covered an extended time period and places (mainly the monuments) also depended in some extension on accumulated knowledge, they were probably more familiar to older people. Therefore, they may have led to the generational differences observed (Souza, Carmo & Garrido, 2022).

Famous people and well-known places also showed a category effect in which naming and categorization variability was higher for people than for places items (Souza, Carmo & Garrido, 2022). These findings suggest that place items constitute a more contextual-based category while people are more complex representations influenced by both episodic and semantic components (Brédart, 2017).

A final study contrasting the semantic categories of common objects, people, and places confirmed this assumption (Chapter 5, section 5.2; Souza et al., 2022d). We also highlight that in this last study, we controlled the items for familiarity across the categories to minimize familiarity effects in naming, as occurred in Souza, Carmo, and Garrido (2022). The results indicate that objects were easily named compared to people and places, and people was the most challenging category (Souza et al., 2022d). These results partially confirm prior literature showing that proper names are more challenging compared to common names and that these are two possible dissociable categories (e.g., Evrard, 2002; James, 2004, 2006; Provérbio et al., 2001; Semenza, 2006, 2009: Valentine et al., 1996). Moreover, the different pattern observed between people and place categories strengthened the idea that proper names seem to comprise diverse categories requiring likely the different engagement of an episodic system and its interaction with the semantic system.

In this last paper, we also examined the neural correlates of the episodic and semantic interactive systems during naming retrieval of semantic categories as a function of their contextual richness (Souza et al., 2022d). The neural oscillatory patterns of the contrast across objects, people, and place semantic categories constituted a relevant indicator to infer the neural systems involved in processing those different semantic categories. According to brain oscillations' memory literature, upper alpha suppression appears correlated to semantic-like processing, and the synchronized theta power is related to episodic and monitoring demands (see Klimesch et al., 1994; 1997; 2006). The symmetrical power dynamics in both alpha and theta was functionally dissociated for objects (long-lasting suppression) and places (long-lasting increase). This pattern indicates that these two categories are supported by different memory systems. Another interesting finding in this study was the transient dynamic in alpha and theta band power observed in the people category, which reflected the initial engagement of the episodic system possibly to support recognition (i.e., theta increase) and, subsequently, in an interchanging with the semantic system in finding a label to the recognized item (i.e., by means of alpha suppression combined with theta decrease) during lexical-semantic processing. Therefore, our findings showed that the retrieval of different semantic categories engages episodic and semantic neural systems differently. People category seems to particularly activate the concurrence of episodic and semantic systems, likely indicating a complementarity between the hippocampal-based and hippocampal-free systems to support the recruitment of different memories representations in encoding and retrieval (see also O´Rourke & de Diego Balaguer, 2020). The different neural correlates observed across the three categories challenge the classic literature pointing to the (partially) dissociable neural correlates between common vs. proper names (see Adorni et al., 2014; Provérbio, 2009; Semenza, 2006; 2009). Specifically, the observed category dissociation revealed the neural dissociation between objects and places but also partially dissociable neural oscillation signatures between people and places. In this way, our work gathers functional and neural evidence of the interchange between context-based and abstract-based systems as a function of the type of knowledge to be retrieved, with episodic and semantic neural systems cooperating in a complementary way to support the retrieval of specific types of semantic knowledge.

Altogether, the findings from all empirical studies provided evidence of the interdependence between episodic and semantic systems in two different ways (i.e., semantic-to-episodic and episodic-to-semantic). Moreover, they also provide indirect cues regarding the necessity of the episodic system and its neural instantiation in interaction with other cortical regions in learning and retrieving long-term memories.

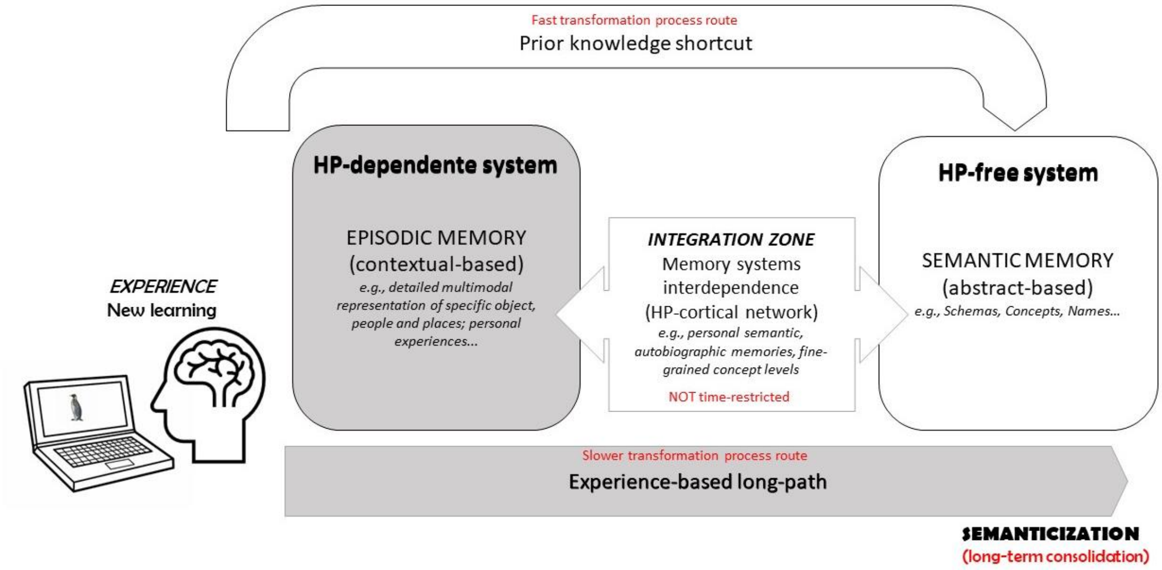
6.2. Theoretical and practical implications

In this section, we discuss how our work contributes to solving some gaps in the literature, informing neurocognitive models of declarative memories and also categorization approaches. Additionally, we discuss our findings from an applied perspective by showing how they may provide practical inputs to the assessment and intervention in clinical, health, and psychoeducational contexts.

Our results contribute to *memory consolidation models* by clarifying the potential role of the episodic system and its neural instantiation in declarative memories. In the context of the interdependence hypothesis, our results imply the existence of a hippocampal-cortical network that sustains memories' formation, (re)activation, and cooperation (see Dudai et al., 2015; Sekeres et al., 2017; 2018). To clarify these theoretical implications, we summarize how our results provide inputs for developments in the memories transformation perspective (see Figure 1).

According to the transformation account of memories, the hippocampus is always involved in processing contextual information (Nadel et al., 2013; Nadel & Moscovitch, 1997; Sekeres et al., 2018; Winocur et al., 2010). With cumulative experiences, the emergence of a schematic version of memory transformed in nature and independent of the hippocampus develops in the cortical region, and both contextual and schematic versions of memories may coexist and interact to support retrieval (Winocur et al., 2010). We established that declarative systems coexist and work together in what we called the integration (virtual) zone, where multiple representations of an event concur to support learning and retrieval according to the information available. This collaborative work seems to reflect the existence of multiple traits from episodic and semantic sources (see Nadel & Moscovitch, 1997) that, together, build a complex memory representation. In other words, we provided evidence that the episodic and semantic systems work together towards a processing goal, allowing the different types of knowledge to be constructed, effectively stored, and retrieved. This process of memory transformation requires the interaction between the hippocampus and cortical regions (Sekeres et al., 2018; Winocur et al., 2010).

Figure 1. Conceptual Model of episodic and semantic memory systems interaction



Note: Graphic representation of a dual-process conceptual model of the episodic-semantic interdependence and the role of prior conceptual knowledge. Hippocampus-dependent system supports episodic representations comprising details of the experiences. Hippocampus-free system serves the schematic information that reflects an abstract-based representation of the experiences. Both episodic and semantic memory traits from a given experience may coexist and support further use via interaction. The integration zone represents a virtual zone in which episodic and semantic systems interplay to form and reactivate memories depending on the nature of the information available (contextual or abstract), following two alternative pathways: 1) *Experience long-path*: a slow process transforming memories based on the events experienced with cumulative experiences along life that changes the nature of memory traits from more hippocampus-dependent to more hippocampus-free, called as semanticization process (consolidation). This path is also necessary to retrieve episodes/events and memories of conceptual nature that still maintain some degree of experienced and vivid details by means of the interplay between systems; 2) *Prior knowledge shortcut*: a faster transformation process in which prior schematic knowledge available during learning favor an almost immediate integration of the new traces in an abstract-based network (faster semanticization), thus rapidly surpassing the hippocampus and its interaction with cortical regions in encoding and retrieval. It is the quality of the experience, in its personal relevance, distinctiveness, and vividness, that determines the activation of the episodic system during retrieval. This way, episodic representations are not necessarily limited in time but dependent on the nature of the memories (see Moscovitch et al., 2006; Robin & Moscovitch, 2017; Winocur et al., 2010).

The transformation of nature in memories also changes their related conscious awareness process (i.e., from more recollective to more factual-based and familiarity driven), becoming more detached from the context in which they were formed and, therefore, requiring possibly different neural pathways (see Harand et al., 2012). However, as we also demonstrated, some memories preserve their contextual-based traits and always require hippocampus-based episodic system involvement. In Souza et al., 2022d, the brain oscillation results of people and places provide evidence for these claims. For example, the fast and transient engagement of the episodic system (reflected in the earlier increase in theta and a shift to its suppression) observed in naming people suggests that this category follows a more relational process to support binding face recognition, face-name association, and semantic knowledge associated to the people item displayed. Moreover, the sustained theta enhancement (as a marker of episodic system involvement) observed in place items indicates an episodic-based recollection experience to support the reestablishment of a place name.

In sum, as anticipated, the episodic system seems crucial in both episodic learning and transfer process of memories, as well as to semantic retrieval of specific and contextual rich conceptual knowledge. In this regard, an episodic component is always involved in representing incongruent content (e.g., typicality) and unique factual knowledge (e.g., proper names), concurring both abstract- and contextual-based knowledge. This is likely the case since hippocampus structures exert a special and selective role in the encoding and retrieval of declarative memories, being necessary for building and retrieving contextual-based information while they persist (see Nadel et al., 2012; Winocur et al., 2010; Sekeres et al., 2018). The hippocampus, in interaction with cortical regions, acts in binding multiple traits to compose a schema, but also when flaws and inconsistencies are detected to ensure some flexibility and adaptations to new contexts (see Gilboa et al., 2019; Maurer & Nadel, 2021).

The current work also contributed to categorization *models* confirming the relevance of categorical schema to process item-typicality information and take advantage of it. Our studies exposed the difficulties in processing specific semantic knowledge, as item-typicality, in samples with episodic memory impairments (ASD; see also Carmo et al., 2016; Gatsgeb & Strauss, 2012). This pattern confirms the role of the episodic system and its interaction with the semantic systems in supporting the encoding and retrieval of item typicality. This finding also improves our understanding of the typicality processing and gives us clues regarding its neural correlates. Typicality network seems to involve a broad semantic representational system, including the inferior frontal gyrus (IFG) and also the anterior temporal lobe (ATL) (Delhaye et al., 2022; Chiou & Lambon Ralph, 2019; Lambon Ralph et al., 2010, 2016; Santi et al., 2015) and, as we showed, the use of contextual information supported by the hippocampus-based episodic system, likely to support the interplay of semantic and episodic content.

The development of memories during *neurodevelopmental conditions*, like ASD and natural aging, has long been the object of interest in neuropsychology. In the case of ASD, several pieces of evidence point to an episodic system decline and a semantic system preservation (Griffin et al., 2021 for review; see also Bowler et al., 2000; Carmo et al., 2020; Gaigg et al., 2014; 2015; Joseph et al., 2005; Souchay et al., 2013; Souza et al., 2016; Toichi & Kamio, 2003), which we confirmed in Souza et al., 2022b. In older adults, we found episodic deficits circumscribed to recognition (Souza et al., 2022d) but not recollection operations (as in Koen & Yonelinas, 2014; Peters & Daum, 2008). However, the absence of prior knowledge impairment in encoding (Souza et al., 2022d) and deficit in semantic retrieval of older adults (Souza, Carmo & Garrido, 2022). In both studies, older adults seem to use their preserved ability of crystalized intelligence to maintain and use their accumulated knowledge to diminish difficulties in contextual-based processing (Verhaeghen, 2003), suggesting some influence of their cognitive reserve (see Stern, 2012). Nevertheless, in the current work, we showed that a disrupted episodic system also affects semantic memory in its specific contents by evidencing some limitations in processing incongruent information for both autistic individuals (Souza et al., 2022c) and older adults (Souza et al., 2022b). The additional contribution of slower processing in the older sample results may derive from the decline in fluid cognition observed with aging (Elias & Saucier, 2006). Moreover, the potential of the preserved general semantic system (see Souza, Carmo & Garrido, 2022; Souza et al., 2022d), together with the isolation of specific deficits in processing semantic information, may inform more refined assessments as well as preventive and rehabilitation interventions in several contexts.

Below, we provide some examples of potential applications of the current findings.

Our results advocate the need for detailed *memory assessment*, including memory contents of different natures and the potential of using different types of conceptual knowledge to assess the multiple representation of the experience, which might favor the achievement of better cognitive performance. Further robust and detailed assessment regarding declarative memory systems might allow differential diagnosis along several conditions in which those memories present a characteristic pattern of episodic or semantic loss, such as in Alzheimer's disease, semantic dementia, schizophrenia, and autism spectrum disorder (see Bozeat et al., 2003; Gaigg et al., 2014; 2015; Lambon-Ralph et al., 2010; Semenza et al., 2003).

By showing the potential of information that is incongruent with the available stored knowledge in improving the reconstruction of contextual-based memories, this work also provides some clues regarding the updating of memories, indicating memories as flexible representations (McClelland et al., 1995; Moscovitch & Gilboa, 2021; Sekeres et al., 2018; Tse et al., 2007). Therefore, our findings may *inform intervention* in educational and clinical contexts in which salient and distinctive information could be strengthened to trigger, modify and improve learning. For instance, to correct common errors in factual knowledge during formal education or enhance the learning of new adaptive health beliefs and behavior (see also Nadel, 2020 and van Kesteren & Meeter, 2020, for the use of fit/unfit with the schema knowledge in clinical and educational settings, respectively).

It is a widespread idea that memory abilities are sensitive to natural aging and decline throughout life. When memory abilities start decreasing (even naturally), several life constraints may emerge and significantly impact people's lives in various domains, namely reasoning and decision-making, social adaptation, self-identity and self-esteem, and emotional stability. Our study confirmed episodic deficits in the aging group. This finding emphasizes aging as a pre-clinical condition (Small, 2001) and calls for *prevention and promotion* measures in early healthy aging to avoid critical cognitive loss.

Because not all memories seem to suffer from this decline, the complex nature of memories reveals itself as a possible solution to overcome or compensate for a memory system that fails. By confirming the potential gains in episodic memories of older adults triggered by the semantic system (schematic), this work brings some clues regarding possible compensation mechanisms. Therefore, *rehabilitation strategies* with aging groups could be based on boosting their semantic memory strengths to compensate for potential episodic decline. In this manner, it could be possible to minimize pathological memory conditions and provide support for developing adaptative strategies toward a healthy natural aging process.

The potential of the current findings may go beyond the illustrations mentioned above since declarative memories support basically all our social interactions, complex cognitive functions and might be largely affected by several diseases/conditions (i.e., degenerative diseases, diabetes, depression, anxiety, hypothyroidism, viral infections, etc.). The current outputs can thus be adapted and improved in several expertise domains.

6.3. Limitations and suggestions for future studies

In this section, we discuss some limitations of our work based on a critical analysis of what we could have done differently to further contribute to improving and advancing future research avenues in this research field.

i) Methodological issues

Sample characteristics: One of the main limitations we faced throughout the current work was sampling both clinical and aging populations, which was particularly aggravated by the COVID pandemic context. Outside the previously collaborating institutions, accessing a heterogenous aging sample was challenging. This constraint biased our sample towards a highly educated profile that is less representative of the Portuguese aging population. The sample of people with autism was restricted to males, influenced by the higher prevalence of diagnostics in populations with ASD (see Giarelli et al., 2010). We are aware that such an imbalance in the samples may limit the generalization potential of our results. Future studies should address this issue by diversifying the educational and age characteristics of the aging groups and also by balancing gender in the autistic sample.

Measures are differently sensitive to memory loss: Although in naming retrieval studies, we used different accuracy measures like name accuracy, name variability, and name agreement (see Souza, Carmo & Garrido, 2022), it could be informative to further examine those different measures and also other complementary measures of errors in their sensitivity to naming disorders along with aging studies, such as Alzheimer' disease, semantic dementias, and ASD (see Chen et al., 2022 for an example of the role of prior knowledge in errors). The examination of these measures could constitute an asset to improve differential diagnoses. We also think that adapting the designs used in the current work to enhance the occurrence of errors may provide interpretable and meaningful results regarding whether compromised conceptual knowledge disrupts memories (see Newman & Garry, 2014; Smith et al., 2000). Analyzing the errors should also be informative regarding the retrieval processes when strategies to monitor information fail. Finally, examining the schema congruency of item-typicality information using words (instead of pictures) could also contribute to the interactive perspective of declarative memories since images and words present different properties, with visual stimuli being complex representations, as mentioned above.

ii) Generalization

Localization perspective: We note that our contributions are still embryonic regarding the role of the hippocampus in the formation and recovery of semantic memory and in supporting the necessary dynamics of interaction between memories (see de Brigard et al., 2022). The direct examination of the role of the hippocampus was not accomplished because we did not employ localization measures. Instead, our assumptions regarding the systems involved and their related structures were motivated by a neuropsychological approach of dissociation between episodic and semantic memories in cases in which one of the systems is assumed to be disrupted. Without underestimating the contributions of this type of approach, it would be an asset to obtain direct localization data on the source of episodic requirements and regarding the activation of the hippocampus-cortical network in the conditions of semantic-to-episodic and episodic-to-semantic modulation. Nevertheless, the oscillation studies, also supported by the dissociative literature, complemented the functional perspective offered by our behavioral findings with dynamic information about the neural mechanisms involved. To broaden our comprehension of the phenomena, however, further studies could examine this interdependence hypothesis within a localization approach using neural measures such as fMRI, source estimates within scalp-based EEG, and intracranial EEG to confirm the proposed involvement of the hippocampal-cortical network.

Examine episodic and semantic system interdependence using other tasks: Despite the prevalence of a dissociative perspective in the literature, the interactive approach of memory adopted in this research was revealed to be as equally informative regarding memory functions (see also De Brigard et al., 2022; Greenberg, & Verfaellie, 2010; Renoult et al., 2019). Further studies might acknowledge this episodic-semantic interaction in other relevant classic memory tasks, such as associative and source memory, and alternative models for the remember-know paradigm. The interactive approach can also be tested in light of other relevant variables for encoding and retrieval processes and operations. For example, the influence of the encoding setting depends on the specific stimuli used and their contents, but also on the task requirements and retention intervals (see Mantÿla, 1997; Nadel et al., 2012; Renoult et al., 2019). Moreover, the different operations associated with naming categories of people and places might also be examined. This would be informative regarding the conscious processes associated with semantic retrieval. Previous studies observed that recollection additionally recruits prefrontal regions that, in interplay with the hippocampus, help activate relevant information and inhibit irrelevant ones (Davidson & Glisky, 2002). However, the medial temporal regions were also indicated as related to familiarity operations to some extent (see Davidson & Glisky, 2002; Harand et al., 2012; but see Aly et al., 2011, for the relevance of prefrontal regions also in familiarity processes for monitoring and deciding for items being old or new). Therefore, besides clarifying the interaction between memory systems, those possible research topics could help clarify the differential role of the hippocampus and/or the prefrontal cortex in supporting recollection and familiarity processes.

iii) Exploring other variables

Enlarging the analysis to potential determinants of memory preservation: From an applied perspective, the literature is still scarce regarding the way a stressful contemporary lifestyle might be accelerating cognitive decline (e.g., Franz et al., 2021), particularly in the memory domain. Therefore, understanding how personal, social, and health characteristics (e.g., cognitive reserve, health beliefs, physical exercise, socialization habits, etc.) may influence episodic memory performance is warranted. Particularly, addressing the influence of cognition resilience and reserve and the related personality and emotional style could help establish effective strategies that help individuals achieve a healthy life and, therefore, protect memories from deterioration (see Kremer et al., 2022; Nyberg et al., 2012). Our results highlight the need for preventive care to maintain the brain healthy by demonstrating the possibility of detecting subtle changes in memory along with natural aging at a very early stage. The potential of other variables, such as healthy lifestyles or engaging in stimulating activities to minimize the expected episodic memory decline, should be further inspected. Since memory is relevant for an autonomous life, self-knowledge, and well-being, the comprehension of memory processes and their interaction allow preventive interventions to avoid critical conditions that could cause suffering and limit life, particularly in advanced stages of aging.

To enlarge this comprehensive view of memories and their interaction, the compensatory mechanism observed in older adults could be further explored in the context of other cognitive functions and in other memories that are supported by both contextual and abstract knowledge, such as autobiographic memories and spatial knowledge. Additionally, the fluid cognition deficits, as executive functions decline, that appear associated with the initial episodic difficulties in aging (see Clarys et al., 2009; Elias & Saucier, 2006) could also be better understood from an interactive perspective to clarify possible compensation. For example, it would be interesting to evaluate the role of difficulties in executive functions in forming new schemas and making new entries flexible, particularly when processing incongruent information.

6.4. Conclusion

The current work contributed with evidence for the interplay between episodic and semantic memory systems. As expected, the different types of conceptual knowledge selectively impacted declarative memory systems or were impacted based on their engagement of the episodic system at encoding or retrieval.

We observed a selective influence of the specific type of semantic content available during encoding in modulating episodic recognition, which was not evidenced in samples with episodic constraints. Together with the advantage of semantic knowledge for recognition observed in older adults, the impact of a disrupted episodic system in processing semantic memories indicates the need for the hippocampus-cortical network dynamics to support memory interdependence. These findings support the interdependence between declarative systems. Complementarily, we demonstrated that the availability of rich episodic content in conceptual knowledge engages the episodic system during semantic retrieval. Naming retrieval becomes more difficult when cooperation between memory systems is required, engaging both episodic and semantic systems. These findings further favor the interplay idea between memory systems in processing semantic knowledge as a function of the type of information (e.g., if contextual or abstract) available.

Overall, our findings indicate that episodic and semantic systems concur and interact to support memory encoding and retrieval (Bonasia et al., 2018; Dudai et al., 2015), suggesting the role of the episodic system (HP-based) in supporting not only episodic memories but also some sort of semantic memories. This interaction between memory systems may be the source of the specific semantic memory impairments in alleged cases of hippocampus hindrance, as in ASD and older adults. Therefore, the current findings inform memory and categorization models while also constituting promising avenues to improve assessment and intervention in cases of natural and pathological memory decline.

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