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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

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, and 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 with 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

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episodic and semantic memories resembles, both functionally and structurally, the contrast between recollection and familiarity-based processes (Czernochowski et al., 2004; Tulving, 2002; Vargha-Khadem et al., 2003; Wang et al., 2018). 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 to be schematic knowledge constituting an abstraction and an average representation of the attributes of the category (Murphy, 2002; Murphy & Medin, 1985). 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-h 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, Rijpkema, et al., 2013b; van Kesteren et al., 2014; but see Mäntylä, 1997, and Sakamoto & Love, 2004, for opposing results). Likewise, information that is not (or is less) consistent with the schema (e.g., atypical items that 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 results). 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 and Mervis, 1975). Specifically, atypical items are expected to enhance Remember responses because they trigger a 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_p^2 = .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 years, SD_{age} = 4.94; $M_{schooling}$ = 12.36 years, $SD_{schooling}$ = 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: $M = 6.58$, $SD = 0.93$, $t(94)= -13.90$, $p < .001$, $d_z = 1.42$, 90% CI [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 two encoding (Categorical vs. Perceptual) and two 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 provided signed 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 5 min 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[1] seeing the image?") about the recognized images (see Gardiner, 1988). Detailed instructions are provided in Appendix A. (Fig. 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 (five practice trials in each condition), where their doubts and questions were addressed.

Data analysis

All statistical analyses were conducted with R Version 4.0.2 (R Core Team, 2019).[2] 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 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 (RTs) 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

[1] 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.

[2] 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.

Fig. 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 vs. 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

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 did we reduce 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 RTs were faster in the perceptual condition (M = 1,388, SD = 668) than in the categorical condition (M = 1,416, 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.[3] 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. A summary of the results is provided in Fig. 2.

Know versus Remember The results revealed a significant effect for the encoding factor (estimate = 0.20, 95% Bayesian credible 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., 2014; van Kesteren, Beul, et al., 2013a; van Kesteren, Rijpkema, et al., 2013b; 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

[3] 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.

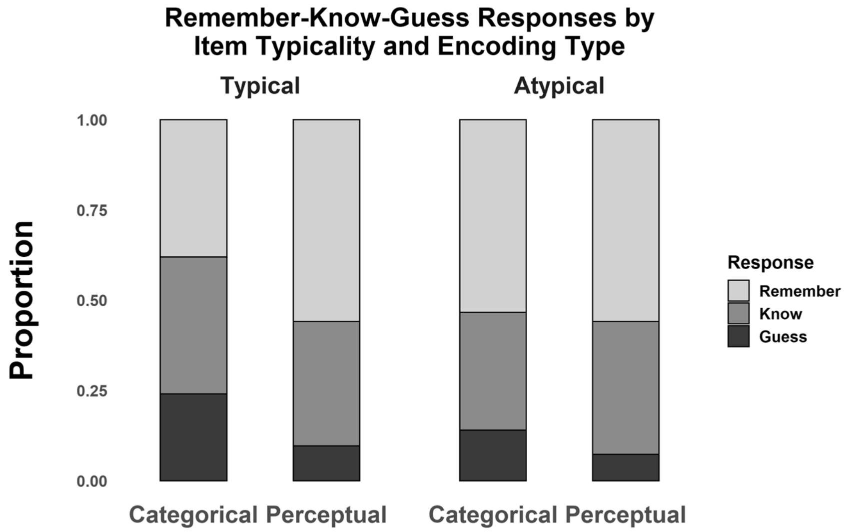

Fig. 2. Proportions of "Remember", "Know," and "Guess" responses as a function of Item-typicality and Encoding type in Experiment 1. *Note.* Overall, there were 1372 responses (52%) for "Remember", 943 responses (35%) for "Know" and 347 responses (13%) for "Guess"

(estimate = − 0.20, 95% Bayesian credible interval = [−0.41; 0.01], pd = 96.57%) was not significant (see Fig. 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 a 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 experience. 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 versus 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.[4] Eighty-seven participants (M_{age} = 25.09 years, SD = 6.35; $M_{schooling}$ = 14.77 years, 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, 90% CI [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., 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 instructions 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 RTs and accuracy analyses). The best converging linear mixed-effects regression model demonstrated that, in contrast to Experiment 1, RTs became faster in the categorical condition (M = 819, SD = 501) than in the 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 Fig. 3.

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 =

[4] 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 an interaction we used the standard medium effect size reported in statistical literature (Cohen, 1988; Miles & Shevlin, 2001).

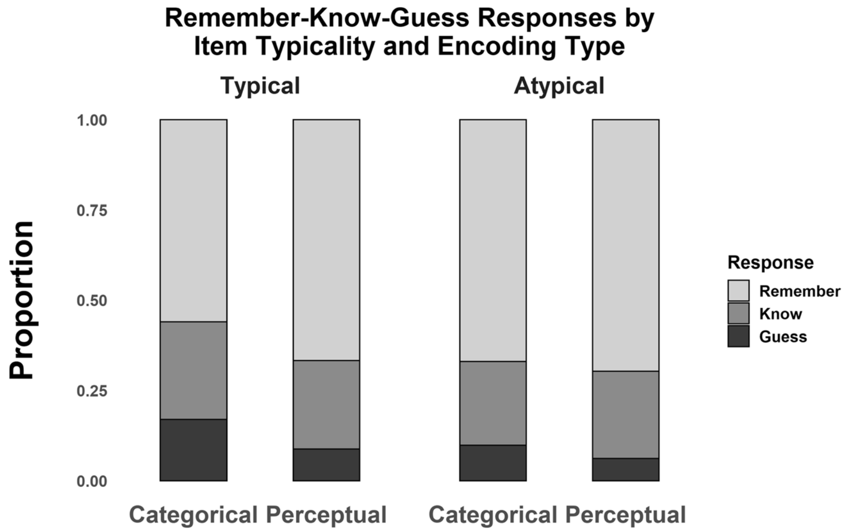

Fig. 3. Proportions of “Remember”, “Know,” and “Guess” responses as a function Item-typicality and Encoding type in Experiment 2 (Rec1). *Note.* Overall, there were 4,603 responses (65%) for “Remember,” 1,742 responses (25%) for “Know,” and 711 responses (10%) for “Guess”

[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), which 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 Fig. 4.

The results from Rec2 replicate the item-typicality effect for Remember, with more Remember responses for atypical items (see 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 Rec1, respectively, which might have prevented us from observing the exact same pattern of results found in Experiment 1 and in Rec1. 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, 2,064 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%; 2,010 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, $F(1, 76) = 6.416$, $p = .013$, $\eta_p^2 = .08$, 90% CI [.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, $F(1, 76) = 28.861$, $p < .001$, $\eta_p^2 = .275$, 90% CI [.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, $F(1, 76) = 10.353$, $p = .002$, $\eta_p^2 = .120$, 90% CI [.03, .24], with increased accuracy of source task for atypical items encoded in categorical conditions (Atypical: M = 6.19, SE =

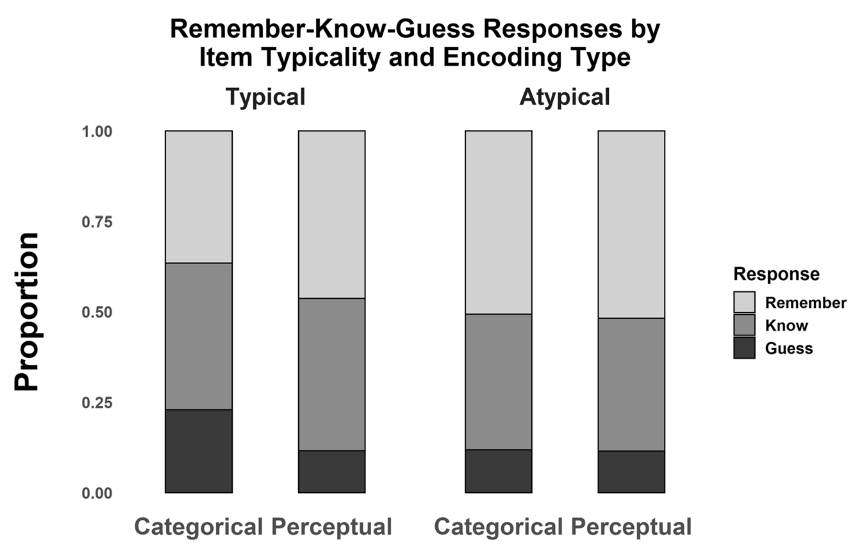

Fig. 4. Proportions of "Remember", "Know," and "Guess" responses as a function Item-typicality and Encoding type in Experiment 2 (Rec2). *Note.* Overall, there were 2,010 responses (47%) for "Remember," 1,686 responses (39%) for "Know," and 605 responses (14%) for "Guess"

.47, Typical: $M = 4.01$, $SE = .41$; $t(76) = -6.642$, $p < .001$, $d_z = 1.07$, 90% CI [0.766, 1.368]). No difference was observed for perceptual encoding, $t(76) = -1.222$, $p = .226$.

Source descriptions

The 2,010 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.

Regarding prior conceptual knowledge modulation on source description, distinct rmAnova 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, $F(1, 84) = 11.59$, $p < .001$, $\eta_p^2 = .121$, 90% CI [.03, .23] and for personal association, $F(1,84) = 10.07$, $p = .002$, $\eta_p^2 = .107$, 90% CI [.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 for opposing results, see Mäntylä, 1997; Sakamoto & Love, 2004) 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 a 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-

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

Code	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 response types considering the amount of remembering 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 event-related potential (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 information (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; van Kesteren, Beul, et al., 2013a), an advantage that was not observed for recollective memories. This finding suggests that the semantic system alone might be engaged in 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, Rijpkema, 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 et al. (2019), which 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 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 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 is 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, Rijpkema, 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, Beul, et al., 2013a). Our results provide important insights into 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.

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 3,000 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 = 1,388, SD = 668) compared to categorical condition (M = 1,416, 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 = 1,445, SD = 676) than in the typical condition (M = 1,361, 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.

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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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