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Associative recognition processes are modulated by the semantic unitizability of memoranda

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ABSTRACT

Although memory of episodic associations is generally considered to be recollective in nature, it has been suggested that when stimuli are experienced as a unit, familiarity processes might contribute to their subsequent associative recognition. To investigate the effect of semantic relatedness during episodic encoding on the processes of retrieval of associative information, we had participants interactively encode pairs of object pictures, vertically arranged so as to suggest a functional or configural relationship between them. Half the pairs were independently judged to be of related objects (e.g., a lamp over a table) and half of unrelated objects (e.g., a key-ring over an apple). At test, participants discriminated between intact, recombined, and new pairs while event related potentials (ERPs) were recorded. In an early ERP marker of retrieval success generally associated with familiarity processes, differences related to associative memory only emerged for related pairs, while differences associated with item memory emerged for both related and unrelated pairs. In contrast, in a later ERP effect associated with recollection, differences related to associative memory emerged for both related and unrelated pairs. These findings may indicate that retrieval of episodic associations formed between two semantically related visual stimuli can be supported by familiarity-related processes.

1. Introduction

Remembering episodic associations – that several objects, people, or actions were experienced conjointly – is a vital cognitive function that enables us to reconstruct environments in which we have been present, and to relive events in which we have participated. In many cases, experiencing the conjoint presence of multiple items is shaped by our pre-existing knowledge of the world, such as the probability of finding two or more objects in certain settings and in specific spatial configurations. For example, when entering a kitchen we would expect to find a pot on a stove, but we may be surprised to see a bicycle on a stove, or to see a stove placed on top of a pot. Such expectations may not only shape our momentary experience, but may further affect the formation of episodic associations between objects in particular contexts (e.g., Henson & Gagnepain, 2010; Morris, 2006; Van Kesteren, Ruiter, Fernández, & Henson, 2012; Wang & Morris, 2010). Thus, it is possible that the processes that enable us to remember associations that are in accord with our expectations differ from those involved in remembering associations that diverge from our expectations. Indeed, it has been posited that schematic knowledge may affect the formation of contextually congruent and incongruent episodic memories via different neural mechanisms (e.g., Van Kesteren et al., 2012).

One method of accessing associative episodic memory is recognition, the judgment that currently presented items were previously experienced together in a specific episodic context. The widely accepted dual-process theory of episodic recognition posits that recognition might be supported by two functionally and neurally separable processes: familiarity and recollection. Familiarity refers to the basic feeling of having previously encountered something or someone without retrieval of additional information, while recollection provides additional contextual details about that encounter and integrates contextual details associated with a particular item (Yonelinas, 2002; Yonelinas, Aly, Wang, & Koen, 2010). Although there is also evidence that recognition may be understandable in terms of a single mnemonic process (e.g., Slotnick, 2013) the dual process approach is supported by evidence from many behavioral, neuroanatomical and neurophysiological studies. These include event-related potential (ERP) studies showing that

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two qualitatively distinct ERP components are associated with old/new judgments. The first is an early mid-frontal negative deflection associated with episodic novelty, arising between 300 and 500 ms post-stimulus presentation, which is often referred to as FN400 (or early mid-frontal effect). This effect has been widely described as the putative electrophysiological correlate of familiarity (reviewed by Mecklinger, 2000; Rugg & Curran, 2007; Wilding & Ranganath, 2011), although it might also reflect other rapid, automatic retrieval processes (see Paller, Voss, & Boehm, 2007; Tibon & Levy, 2014a, 2014b). In contrast, a late positive component (LPC; also called parietal old/new effect), prominent over left parietal scalp regions between 400 and 800 ms post-stimulus presentation, is considered to be a correlate of recollection (Mecklinger, 2000; Rugg & Curran, 2007; Wilding & Ranganath, 2011).

While it is generally agreed that recognition of single items can be supported by both recollection and familiarity, it has traditionally been asserted that in associative recognition tasks, recollection is required to retrieve novel episodic associations, and that such associative memory is not accessible via familiarity processes (e.g., Donaldson & Rugg, 1998; Hockley & Consoli, 1999; Yonelinas, 1997). Associative recognition tests typically require subjects to discriminate between intact (studied) and recombined (studied items in new combinations) stimulus pairs. As the individual members of intact and recombined pairs are equally familiar, it is argued that recollection is required to retrieve the newly formed associations between items. In recent years, however, a growing corpus of research has suggested that under certain circumstances familiarity might also contribute to associative memory – specifically, when the to-be-associated stimuli are bound together to form a unitized representation during study, and are thus perceived and encoded as a single unit entity (Jäger & Mecklinger, 2009; Jäger, Mecklinger, & Kipp, 2006; Quamme, Yonelinas, & Norman, 2007; Rhodes & Donaldson, 2007, 2008; Tibon & Levy, 2014a, 2014b; Tibon, Ben-Zvi, & Levy, 2014; Yonelinas, Kroll, Dobbins, & Soltani, 1999; for review, see Mecklinger & Jäger, 2009; Yonelinas et al., 2010).[1] Arguably, in such cases familiarity can contribute to associative recognition due to direct links between the components comprising the encoded representation (e.g., Mayes, Montaldi, & Migo, 2007).

While the notion of unitization as a characteristic of memory formation is appealing, the encoding conditions that might enable unitization require further specification. Two broad types of experimental strategies have been employed to promote unitization; these can be viewed as driven by either top-down or bottom-up cognitive processes. Top-down approaches to unitization focus on encoding instructions to process pairs of memoranda as a single unit (in high-unitization conditions) or as separate elements of the same episode (for low-unitization conditions). Unitizing instructions can take the form of compound definition versus use-in-sentence encoding of words (Bader, Mecklinger, Hoppstädter, & Meyer, 2010; Haskins, Yonelinas, Quamme, & Ranganath, 2008), or of encoding source and item information in an internal versus an external manner, thus forming intra- versus inter-item associations, e.g., "imagine each item in the color indicated by the background screen color" versus "imagine why the item would be associated with a stop sign or dollar bill" (Bastin et al., 2013; Diana, Van den Boom, Yonelinas, & Ranganath, 2011), or the "strategy type" manipulation employed by Rhodes and Donaldson (2008).

In contrast to these top-down manipulations that are based on explicit encoding instructions, bottom-up approaches are based on maximizing item features or associative information that might foster unitization. In this case, instructions are the same in all conditions, but inherent or presentation-related features of the memoranda are manipulated, so as to engender differential degrees of unitization. In one type of bottom-up approach, the manipulation is primarily perceptual. This may take the form of comparing encoding presentations of unimodal, within-domain associative memoranda (e.g., picture pairs) with those of crossmodal, between-domain associative memoranda (e.g., picture-environmental sound pairs; Tibon & Levy, 2014b; Tibon et al., 2014). Alternatively, simultaneous versus sequential presentation of associative memoranda may differentially engender unitization at encoding (Tibon & Levy, 2014a).

In the second type of bottom-up approaches, the high-unitization stimulus pairs differ from low-unitization pairs in the pre-existing semantic or schematic relationships between them. This latter case includes the episodic encoding of a word compound such as "bus-stop" (i.e., two words comprising one unit), versus "bus–car" (two semantically related words that do not necessarily comprise such a unit), and versus "bus-pillow" (two unrelated words). It is asserted that in the first case, compared to the other two, the association is inherently unitized (as it corresponds to the traditional definition of unitization – "perceiving and encoding of several discrete stimuli as one single unit"). Furthermore, for two semantically related words that do not necessarily comprise a standard linguistic unit (e.g., "bus–car" pairs), unitization might still occur more readily than for two unrelated words (as the former would be grouped together more easily than the latter). This approach to unitization is of interest, as it bridges semantic and episodic aspects of associative memory, and can potentially explain how these two aspects interact during memory formation and retrieval.

Studies using a perceptual bottom-up unitization approach, such as those cited above, support the assertion that although associative retrieval in general requires recollection, when two items are unitized, their retrieval can be supported by familiarity. The studies that have explored semantic bottom-up unitization processes have commonly used verbal stimuli (Greve, van Rossum, & Donaldson, 2007; Kriukova, Bridger, & Mecklinger, 2013; Rhodes & Donaldson, 2007; and see also the relation factor in Rhodes & Donaldson, 2008). However, unitization of word pairs, in which the semantic knowledge is always mediated by verbal materials, may not generalize to the formation of associations in ecological conditions, in which we perceive combinations of objects in our visual environment. In one study that employed pictorial stimuli (Jäger et al., 2006), recognition memory for arbitrarily paired items (i.e., pairs of faces of two different persons, termed inter-item associations) were compared with recognition memory for pairs of highly overlapping stimuli that can be coherently unitized (i.e., two different face pictures of the same person; intra-item associations). In that study, the electrophysiological correlate of familiarity was significantly larger for successfully retrieved intra- than for inter-item associations, whilst the electrophysiological correlate of recollection was significantly larger for successfully retrieved inter- than for intra-item associations. Nonetheless, since faces form a specific class of visual stimuli (either because their processing is mediated by domain-specific mechanisms [e.g., Kanwisher, 2000], or due to the effects of expertise with such stimuli, [e.g., Gauthier, Tarr, Anderson, Skudlarski, & Gore, 1999]), the examination of face memory might not fully capture the processes used for visual memory. Furthermore, in two of the abovementioned studies (Bader et al., 2010; Rhodes & Donaldson, 2008) in which dissociations between recollection and familiarity processes were based on electrophysiological evidence, comparisons were

[1] Though unitization arguably creates an integrated representation, the objects comprising the unitized representation do not necessarily lose their individual identity. This is the case for words (e.g., after encoding of "bus stop", it is possible to remember having seen the word "bus", and seemingly even more so for the visual objects employed in the present study (e.g., cup and saucer). Therefore, it is still appropriate to speak of associative memory even in cases of unitization.