The Influence of Scenes in Memory Object Recognition.

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I. Abstract

The overarching aim of this thesis is to investigate the influence of scenes on the recognition of objects. In pursuit of this objective, two studies were performed using the same old-new recognition task. The first of the two studies investigated behavioral responses and the second included an additional functional component with electrophysiological recordings.

Objectives. The first study elucidated how features of an object interact with other potential factors, such as the context in which a target object is seen, as well as the role of individual characteristics of the observer. The aims of the first study were to examine: i) how context influences recognition memory; and ii) how this effect is influenced by the familiarity of objects and the manner by which subjects process information (i.e., cognitive style). The second study investigated the underlying mechanisms of the influence of context on the recognition of objects in healthy subjects and aimed to: i) examine the effect of scene on object recognition by extracting the functional brain signals previously shown to be associated with familiarity and recollection; and ii) to examine whether the influence of scenes on old and lure objects was defined by dissociable mechanisms.

Methods. The stimuli of both studies were composed of objects appearing in various scenes. At recognition, half of the objects that were previously studied (i.e. old) were placed in either the same scene or in a different scene. The remaining objects were novel, and resembled the previously studied objects (i.e., lures). Lures appeared either in the same scene as a similar, previously-studied object, or in a distinct scene. For the first study the cognitive style of the subjects was assessed with the group embedded figure test (GEFT), which determines whether subjects have a field dependent (FD) (i.e. sensitive to context) or field independent (FI) way of processing information.

Results. The results of the first experiment demonstrated that the similarity of scenes increased the feeling of familiarity of objects, that is, the likelihood of believing that an objects was previously studied (i.e., old). In FD subjects, the effect of scene was the same for familiar and unfamiliar objects, in contrast to FI subjects where the effect of scene was found only for unfamiliar objects. The context thus influences the memory of an object, and intriguingly, individuals who are less sensitive to context still use information gathered from the scene when the presented object is unfamiliar. The second experiment indicated that the influence of scenes on object recognition was driven by a process of familiarity, but that a recollection process may also be influential in the effect of scene. This latter finding suggests that the effect of scene underlying true (i.e., hits) and false recognition (i.e., false alarms) of objects is defined by distinct mechanisms.

Conclusions. Similarity of scenes influence the recognition of objects as showcased by an overall increase of 'old' responses. Thus, the similarity of scenes influences both responses, hits and false alarms, and this influence of scenes is interacting with the perceived level of object familiarity and the cognitive profile of an individual. In addition, the event-related potentials further corroborate that the influence of scenes on object recognition is driven not only by familiarity, but also by a recollection process.

II. Résumé

L'objectif global de cette thèse est d'explorer l'influence des scènes sur la reconnaissance des objets. Dans la première étude, les réponses comportementales ont été étudiées, tandis que dans la deuxième étude, des enregistrements électro-physiologiques ont été faits.

Objectifs. Le but de la première étude était de comprendre comment les caractéristiques d'un objet cible peuvent interagir avec le contexte dans lequel celui-ci est présenté, ainsi que le rôle des caractéristiques individuelles de l'observateur. Les objectifs de cette étude étaient d'explorer : i) l'effet du contexte sur la mémoire de reconnaissance ; ii) comment cet effet est influencé par le degré de familiarité des objets, et la façon dont une personne traite l'information (i.e., le profil cognitif). Le but de la deuxième étude était d'explorer les mécanismes sous-jacents de l'influence du contexte sur la reconnaissance des objets: i) les corrélats fonctionnels cérébraux de l'effet des scènes sur la reconnaissance des objets, en évaluant les signaux fonctionnels cérébraux qui ont déjà été associés à la perception de familiarité et au processus de récupération; et ii) examiner si les mécanismes de l'effet du contexte sur la reconnaissance d'objets sont différents pour des objets qui ont déjà été présenté (ancien), en comparaison avec des objets similaires qui n'ont jamais été présentés (leurre).

Méthodes. Dans les deux études, des objets apparaissant dans différentes scènes ont servi de stimuli pour les tâches. Durant la phase de reconnaissance, la moitié des objets qui avait déjà été étudiés (i.e. ancien) étaient présentés dans une scène différente que la scène dans laquelle ils avaient été présentés précédemment, ou dans la même scène. Le reste des objets étaient similaires aux objets qui avaient déjà été étudiés (i.e., leurres). Les leurres étaient présentés soit dans une scène dans laquelle un ancien objet avait été présenté, ou une scène différente. Dans la première étude, les profil cognitif de chaque participant fut évalué par l'administration du *Group Embedded Figure Test (GEFT)*, un exercice qui sert à déterminer si un sujet est influencé par le contexte lors du traitement d'information, *field dependent* (FD), ou moins influencé par le contexte *field independent* (FI).

Résultats. Les résultats de la première étude ont démontré que le degré de similarité entre des scènes augmente la perception de la familiarité des objets. Chez les participants ayant

un profil cognitif FD, il n'y avait pas de différences dans le degré d'influence des scènes pour la reconnaissance d'objets familiers ou non-familiers. Par contre, pour les participants avec un profil cognitif FI, les scènes avaient une influence seulement sur la reconnaissance d'objets non-familiers. Le contexte peut donc influencer la mémoire d'un objet, et étonnement, les personnes qui sont plus influencées par le contexte utilisent l'information des scènes même lorsque l'objet qui est présenté est non-familier. Les résultats de la deuxième étude ont démontré que le degré d'influence des scènes sur la reconnaissance d'objets est déterminé par la perception de familiarité des objets, ainsi que par un processus de récupération. Ceci suggère que les mécanismes qui expliquent l'effet de scène sont différents pour les faux et les vrais souvenirs.

Conclusions. Il a été démontré que la similarité des scènes influence la reconnaissance des objets, ce qui est représenté par une augmentation de réponses « objet ancien » durant une tâche de reconnaissance et la similarité des scènes semble influencer le nombre de faux et vrais souvenirs. De plus, l'effet des scènes varie en fonction du niveau perçu de familiarité des objets, ainsi que le profil cognitif de l'individu. Finalement, l'influence des scènes sur la reconnaissance des objets est déterminée par le niveau de familiarité, et par un processus de récupération.

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IV. Preface and Contributions of Authors

Mathieu B. Brodeur designed the study. Data analyses were completed by Gloria Castaneda under the guidance of Mathieu B. Brodeur. All material appearing in this document was written by Gloria Castaneda. Two written manuscripts comprise Chapter 3 and 4, respectively, as follows:

Chapter 3 Study #1:

The Influence of Object Familiarity, Cognitive Profiles and Contextual Scenes in the Recognition Memory of Objects.

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Chapter 4 Study #2:

The Influence of Scene in Object Memory Recognition: An ERP Study

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Chapter 1: Introduction and objectives

Memory is not a perfect faculty, as information can be lost or distorted at the moment of recovery, generating memories that in fact did not occur. This phenomenon occurs as a result of numerous conditions that influence memory in different ways, such as our emotional state (Windmann, 2002), or the environment we were in when we first encountered the information at hand (D. R. Godden & Baddeley, 1975; K Murnane & Phelps, 1994; Russo, Ward, Geurts, & Scheres, 1999; Rutherford, 2004b). Thus far, the study of variables influencing memory has been largely limited to the task instructions and characteristics of the stimuli (Windmann, Urbach, & Kutas, 2002). Importantly, it is clear that other variables also likely influence memory, including the context in which the stimuli are perceived and the individual characteristics of the perceiver, among others. Recall and recognition, for example, are facilitated through the use of specific encoding strategies and for certain types of stimuli, that will be described in detailed in the next section.

Although scenes influence how we perceive an object (Bar, 2004b), its effect on memory has not been largely studied. One of the main limitations of the majority of memory studies is that the stimuli are often presented as single items (words or objects) rather than integrated within a context. Recognition and memory research would significantly benefit from more ecologically built tasks, namely by adding contextual information to the target objects.

The present dissertation sought to examine some of these influential factors during the recollection of objects. The features of the stimuli were manipulated by changing the level of familiarity of the objects (i.e., a balloon exemplifies a highly familiar object, and a smoke detector would be less familiar). Context was also altered to tap into memory processes, by using similar and different scenes at study and test phases. The first experiment manipulated the features of the stimuli, the context, and individual characteristics of subjects as defined by their cognitive profiles. Thus, the objectives of this thesis were four-fold: i) to examine the context influence on object recognition memory; ii) to examine how this effect is influenced by the familiarity of objects, and the manner by which subjects process information, via the subjects' cognitive profiles; iii) to examine the influence of scene by using the event-related potentials of memory familiarity and recollection and; iv) to examine the manner by which scenes influence old and lure objects. While the majority of the present thesis places emphasis on the influence of scenes in object memory recognition, Chapter 3 investigates if the influence of context interacts with other variables, such as object familiarity and cognitive profiles of the subjects. Thus, the central objective of the study outlined in Chapter 3 was to better characterize the influence of scenes on memory recognition. Finally, Chapter 4 examines the influence of scenes on the recognition of old and lure objects by looking at the event-related potentials tapping into memory familiarity and recollection, as previously established in the literature. This study included a smaller subset of participants and lacked sufficient power to examine the influence of object familiarity and/or the individual characteristics of the subjects; thus, the study was limited to scene influence on object recognition.

Chapter 2: **Literature review**

2.1 Objects Memory Recognition

2.1.1 Dual process models. Dual process models posit that there are two distinct processes in memory: recollection and familiarity. The distinction of these two processes is an important determining factor in the understanding of memory, as has been supported by previous research (Atkinson & Juola, 1971; Jacoby, 1991; Mandler, 1980; Mandler & George, 1991; Yonelinas, 2001).

By definition, recollection is the retrieval of information from its original encoding time and event (Morcom, 2015; Yonelinas, 2002). If there is a disruption during the retrieval process, then a false recognition will occur. In memory tasks, false recognitions occur when a stimulus that has recently been seen or heard is incorrectly claimed by the subject. In these type of studies, participants are asked to indicate if the object has been shown during the study phase (i.e., old) or if it is a novel object (i.e., new).

Familiarity, on the other hand, is a subjective feeling of having encountered information and as opposed to recollection, tends to be more susceptible to changes in perceptual and conceptual processing (Collen M & Larry L, 2000). In memory tasks, familiarity is assessed by the utilization of lures, (i.e., items that resemble a previously studied item), or by using items that are familiar to the subject, due to previous exposure (e.g., images of celebrities or of famous landmarks).

2.1.2 Evidence from electrophysiological studies. An ERP is a measure of functional brain activity that has been largely used to distinguish different processes underlying memory performance. One prominently cited dichotomy differentiates between ERP components underlying recollection and familiarity, which are respectively reflected by a parietal and a mid-frontal old/new effect (Friedman & Johnson, 2000). The parietal old/new effect is a component found over parietal cortical sites 400 to 800 ms after stimulus that has also shown a tendency to be more positive for old stimuli compared to new stimuli (Curran & Cleary, 2003; Curran, 2000; Morcom, 2015; Rugg & Coles, 1995; see Friedman & Johnson, 2000 for review). Furthermore, if subjects are asked to identify the process that influenced their discrimination responses, larger parietal old/new effects are linked to 'remembering' as opposed to 'knowing' responses (Curran, 2004a). This is relevant as 'remember' and 'know' responses are thought to be linked to recollection and familiarity process, respectively.

The same component, but with an earlier mid-frontal negativity peak around 300 to 500 ms post-stimulus known as the FN400, has been linked to memory familiarity (Rugg & Curran, 2007). This frontal component was first reported by Rugg and collaborators (1998) and it was later corroborated by several other studies (Curran & Cleary, 2003; Morcom, 2015; but see: Voss & Federmeier, 2011). Finally, activity in the prefrontal cortex and parietal regions has been linked to familiarity in memory recognition, as reported with functional magnetic resonance imaging (Cansino, 2002; H. Kim & Cabeza, 2007).

2.2 Influential Factors of Memory Recognition

2.2.1 Features of the objects. The primary source of influence in memory relies on the stimulus itself. Stimuli are often perceived in light of their similarities with known stimuli. Stimulus similarity has such a strong influence on memory due to the way by which memory recovery operates. Determining whether an object is seen for the first time (i.e., new) or has previously been seen (i.e., old) requires its comparison with other objects in memory that fall into the same category or share prominent features (Windmann, 2002).

The probability of responding that an object has been previously seen and is 'old' is enhanced when features retrieved from memory match those of the perceived object. This in turn increases accurate responses of old objects, and false recognitions of new objects (Morcom, 2015; Windmann, 2002). In contrast, noticing a dissimilarity between a novel object and the objects stored in memory encourages a subject to respond that an object has not been previously seen and is 'new', thus favoring a correct rejection (CR) (Slotnick & Schacter, 2004).

2.2.2 Context. Context refers to the information associated with a target stimulus (e.g., a sentence or a visual scene in which a target word or an object appears), and collectively has a strong influence on memory. Tulving and collaborators (1971) showed that the rate of recognized words was higher if a target word was presented with the same word that was presented during encoding, compared to when it was presented with a distinct or altered word, or without the paired word during encoding. In the described task, two words were presented at the same time; thus, one acted as the target and the other as the context (Tulving & Thomson, 1971). A similar effect occurs with scenes. Overall, similar contexts increase the accurate recognition rate of old objects (i.e., hits) (Hollingworth, 2006; Hocley, 2008; Rutherford, 2010;) as well as the accurate recognition of old faces (Tanabe-ishibashi, 2014).

While the influence of presenting same scenes is clear, that is, it tends to increase hit rates, there is disagreement as to whether same scenes contribute equally to the increment of false alarms (FA). Some studies have found that same scenes increase both hits and FA (Gruppuso, Lindsay, & Masson, 2007; Hockley, 2008; Tsivilis, Otten, & Rugg, 2001) but others only found an increment in hit rates and not in FA (Rutherford, 2004) . Therefore, at the present time, findings implicating the effect of scenes on false recognition remain inconsistent.

2.3 Context Processing.

There is evidence suggesting that context, familiarity, non-contextual expectations, top-down facilitation and movement all interact with object recognition (Bar, 2004). In order to better understand the influence of context in memory recognition, it is therefore necessary to describe how context is perceived and to define the mechanisms underlying context processing, as well as the key conditions in a scene that distort or facilitate the perception of objects.

2.3.1 The relation between object and context influences perception. The relation that a certain object has with another object affects how individuals process both objects. Object processing will be prolonged and more prone to errors if it does not respect certain relations with the context it is placed in, such as its position, probability, or size (Bar, 2004). Some of the most influential relations between an object of interest and its context (i.e., other objects that together form a scene) can be summarized by three key concepts:

1. *Plausibility.* The logic that a context and an object maintain is referred to as plausibility and it directly influences how an object is perceived. For example, when viewing luggage and a person within a scene, the person carrying the luggage is a more plausible outcome than a luggage carrying a person.
2. *Semantic congruency*. Consistency between objects and context is also influential. Objects that are consistent or *congruent* with the context (e.g., someone wearing a swimsuit in a pool) are easier to process compared to when the object and context are inconsistent (e.g., someone wearing a swimsuit in an office). In recognition tasks, more accurate responses are obtained from objects presented in consistent scenes, than from objects presented in inconsistent scenes (Davenport & Potter, 2004).
3. *Object ambiguity*. Context has also been shown to facilitate the recognition of ambiguous objects. For example, if an ambiguous object is appropriately placed along with another object, then the recognition of the ambiguous object will be

facilitated by the second object. Among the same lines, the recognition of an ambiguous object is also facilitated if placed over a congruent scene (Dyck & Brodeur, 2015).

Biederman and collaborators (1982), proposed five types of relations between an object and its context that characterize real-world scenes (Biederman, Mezzanotte, & Rabinowitz, 1982).

1. *Support*: the object appears resting on a surface.
2. *Interposition*: objects do not pass through other objects in the scene.
3. *Probability*: the presented objects are reasonable to appear in the given scene.
4. *Position*: the presented object is positioned on a reasonable location within the scene.
5. *Size*: the relative size of objects in the scene are plausible and are coherent.

The above evidence not only corroborates the high impact that a context has on an object, but also supports the idea that semantic information is extracted at an early processing stage, and thus affects the perception of objects. Also, the relation between object and context is bidirectional in such a way that objects influence context and vice versa (Bar, 2004).

2.3.2 Neural correlates of contextual information processing. Presently, the process of contextual information is thought to involve regions in the medial temporal lobe (MTL), prefrontal cortex (PFC), parahipocampal cortex, (PHC) and retrosplenial cortex (RSC) (see below).

In the model of contextual facilitation of object recognition, Bar et al. (2004) proposes that low spatial frequency images are sent to the PHC and PFC from the visual cortex to activate the possible identities of a certain object, based on expectancies that a certain object could plausibly appear in a given context. In the PHC, assumptions about the context are activated and then propagated to the inferior temporal cortex (ITC), where associations between the relevant context and the target object interact and allow the identification of single objects. Later, high frequency information is incorporated in order to confirm the identity of the object and add the specific details.

The parahippocampal place area (PPA), a sub-region of the PHC, has been shown to elicit a major response to scenes compared to other type of visual stimuli (Epstein, Graham, & Dowing, 2003) and has also been related to associative information processing (Li, Han, Lu, Liu, & Zhong, 2012). Furthermore, there is an important distinction between posterior and anterior PHC. Posterior PHC was activated in the presence of a spatial context (i.e., triplets of objects located in the same spatial location), whereas the anterior PHC was activated in the presence of a non-spatial context (i.e., triplets of objects shown in random locations within a given space) (Aminoff, Gronau, & Bar, 2007).

It has also been suggested that scene and object relations involve the lateral occipital cortex (LOC) (Biederman, 1972; Biederman et al., 1982; Green & Hummel, 2006). However, a more recent study compared the activity of both PPA and LOC when images of interacting objects were presented to the subjects. They found significantly greater activation in the LOC when objects were interacting with another object (e.g., a bird entering to a house bird), compared to isolated non-interacting objects. On the other hand, the PPA showed weaker ties with scene processing, suggesting that it is only involved in scene processing when interacting with the lateral occipital cortex (J. G. Kim & Biederman, 2011).

Chapter 3 Article #1: The influence of object familiarity, cognitive profiles and contextual scenes in the recognition memory of objects.

3.1 Introduction.

The subjective experience of real-world object recognition is a critical aspect of episodic memory and is strongly influenced by the natural scene in which the object is perceived. More precisely, recognition of objects is affected by whether these objects are seen in their usual location or in a new location. For instance, one recognizes his own car more readily when it is seen on the street of his house, as opposed to in a public parking lot. Empirically, this phenomenon has been demonstrated by increased recognition (i.e., hit rates) and better old/new discrimination of objects appearing in their studied scenes compared to objects appearing without their studied scenes (Hayes, Nadel, & Ryan, 2007; Hollingworth, 2006) or in novel scenes (Ecker, Zimmer, Groh-Bordin, & Mecklinger, 2007; Tsivilis, Otten, & Rugg, 2001). This effect of context has also been shown in socio-cognitive settings for faces presented with scenes (Gruppuso, Lindsay, & Masson, 2007; Park, Puglisi, & Sovacool, 1984; Tanabe-Ishibashi, Ikeda, & Osaka, 2014; Winograd & Rivers-Bulkeley, 1977), and in psycholinguistics (Macken, 2002; Murnane & Phelps, 1994)

The effect of the scene on object recognition may not necessarily be the result of a better recovery of object information, but may be explained by a bias that brings people to believe that they are more familiar with the object, regardless of whether this is the case or not. This could happen because scenes are not always fully attended and may not be remembered in detail. In episodic memory tasks, a familiarity bias is expected to increase both hit and false alarm (FA) rates. This bias can be extrapolated in Tsivilis et al. (2001), where both hit and FA rates were higher for objects that were presented in a studied scene compared to a different scene. Similar findings have been reported for words over background colors (Hockley, 2008; Macken, 2002) and for faces with context photographs (Gruppuso et al., 2007).

False recognition of a new object may happen when this object is presented within a studied scene, but is more likely to occur if the object is a lure. New objects have no a priori memory associations with the scene in which they are presented because they are seen for the first time. Thus, the picture of a new cell phone will not necessarily look more familiar if seen over a studied scene than over an unstudied scene. Associations between novel objects and their scene can nevertheless be activated if these objects look similar to other objects previously seen or studied in the same scene. Without this similarity, the increase in FA as a result of the scene may still be possible (Tsivilis et al., 2001), but it may also be weak or even absent (Ecker et al., 2007; Hayes et al., 2007).

The influence of scene context on object recognition does not only depend upon the existence of a former association between the object and the scene, but also on the need of the individual to use the information contained in the scene. This need is inversely proportional to the perceiver's familiarity with the object, that is to say that scene information is more needed for recognition of less familiar objects. For instance, the level of familiarity of a face has been shown to play a critical role in building a strong association with the context (Dalton, 1993; Davies & Milne, 1982). In the two experiments by Dalton (1993), changing the environmental context (i.e., room) across study and test phases worsened the recognition of unfamiliar faces, but not that of familiar faces. Along the same lines, Davies and Milne (1982) found that different contexts at test had a lesser influence on the recognition accuracy of celebrity faces compared to unknown faces. Therefore, being less familiar with a face leads to greater use of contextual information, which is thought to help recognition. The same relationship is expected with objects. Less familiar objects are harder to recognize in isolation than more familiar objects. As a result, their recognition should benefit more from collecting additional external information.

The individual's sensitivity to surrounding information is another factor that is expected to modulate the effect of scene context on object recognition. This sensitivity has been conceptualized as a cognitive style (i.e., field dependence/independence) based on people's capacity to focus on a specific item and to distinguish it from surrounding information (Witkin, Moore, Goodenough, & Cox, 1975). Field-dependent (FD) individuals have more difficulties perceiving the specific features of a figure without being influenced by external information. Accordingly, they are more sensitive to surrounding information (Eagle, Fitzgibbons, & Goldberger, 1966; Fitzgibbons, Goldberger, & Eagle, 1965). In contrast, field-independent (FI) individuals are more able to focus their attention on a target without being much affected by the surrounding (Kozhevnikov, 2007). Some studies have reported that FI individuals have higher recognition rates compared to FD individuals in memory tasks using geographical scenes or pairs of words (Berry, 1984; Frank, 1983). In the context reinstatement paradigm, where participants are tested with either the same or different context conditions as at study, the memory performance of FD participants is shown to be more influenced by the context than it is for FI participants (Emmett, Clifford, & Gwyer, 2003). To our knowledge, no study has examined thus far the influence of scene context on recognition memory performance for objects presented within scenes as a function of field dependence.

The aim of the present study is to advance further our understanding of the effects of scene on object recognition memory. We seek to measure the influence of object familiarity and individual field dependence cognitive style on this effect of scene. We hypothesize that presenting objects in the original scene will increase both true and false recognition rates, compared to objects presented in a different scene. This effect is expected to be larger for less familiar objects and for field-dependent participants. Therefore, we do not expect an important effect of scene for field-independent participants.

3.2 Methods

3.2.1 Participants. Sixty-seven volunteers (37 females, 30 males, mean age: 24.32, SD: 5.27) were recruited through an advertisement posted on a public website targeting students at McGill University, Montreal. Informed consent was obtained from all the participants. The Douglas Mental Health University Institute's Research Ethics Board approved the protocol and the consent form. Participants received a monetary compensation for their time and inconvenience. None of the participants reported being color blind or had vision problems.

3.2.2 Cognitive profile assessment. The GEFT test (Witkin, Olman, & Raskin, 1971) was used to assess the field dependence cognitive style of the participants, and to assign accordingly each of them into the field dependent or field independent subgroup (see below). This test measures the ability to subtract a simple geometric shape from a complex geometric figure, which provides a reliable index of an individual's field dependence (Davis & Frank, 1979; Jesky & Berry, 1991). The GEFT has three timed sections: a five-minute practice section of seven items and two five-minute test sections of nine items each. One point is scored for each correct response, for a maximum score of 18 points and a minimum score of 0. Higher scores correspond to field independence, whereas lower scores correspond to field dependence (Demick, 2014).

3.2.3 Stimuli of the experiment. A total of 624 trial stimuli was used. As shown in Figure 1, each trial stimulus was presented in sequences of three images: 1) the scene, 2) the scene with a cross indicating where the object will appear, and 3) the scene with the object. Each image was immediately followed by the next one, meaning that the scene remained visible for the whole trial duration. Objects were taken from the Bank of Standardized Stimuli (BOSS); a set that includes photos of objects normed for various dimensions including familiarity (Brodeur et al., 2010; Brodeur et al., 2014). The majority of the scenes were created for the purpose of this experiment with a subset taken from Dyck & Brodeur (2015).

One half of the stimuli was presented during study phase and the other half during test phase. In one half of the trials, the objects presented at test were the same as those presented at study (i.e., old objects), and in the remaining trials, they were lure objects. Lures were new objects that served the purpose of being associated to a scene in which a similar type of object was presented previously during the study phase. This way, the association between an object type and its scene was preserved across phases. Old objects were presented in a different position from the study phase. This measure was taken to prevent a priming effect that would have facilitated the recognition of old objects (Dalton, 1993; Tulving, Schacter, & Stark, 1982), but not that of lure objects.

Stimuli presented at test belonged to four experimental conditions defined by two variables, each comprised by two levels (see figure 2). Firstly, half of the scenes in which the 156 old objects and the 156 lure objects appeared at test were the same as those presented during the study phase, although they were photographed from a different angle. The remaining half of presented scenes were different. Secondly, the stimuli were categorized as a function of their normative familiarity. The normative familiarity is a score that reflects the extent to which people are familiar with a type of object or concept. This score was also taken from the BOSS (Brodeur et al., 2014) in which objects were rated on a 5-point Likert scale by 39 participants instructed to: “Rate the level to which you are familiar with the object”. The total mean score of familiarity of the objects used in the present study was 4.20 (SD: 0.42). On the basis of this, objects were then split into two subsets including the less familiar objects (mean: 3.77, SD: 0.32, Min: 2.70, Max: 4.18) and more familiar objects (mean: 4.44, SD: 0.17, Min: 4.20, Max: 4.90).

3.2.4 Procedure. The experiment was carried out at McGill University. Open Sesame software (Mathôt, Schreij, & Theeuwes, 2012) was used to generate the stimuli presentation and to register the responses. The experiment started after the participants signed the informed consent form and completed the GEFT.

The experiment began with the sequential presentation of all trials of the study phase. The study phase was intentional; in other words, participants were aware that a test phase would follow. Each trial within this study phase started with the presentation of a scene displayed for 1000 ms, followed by a fixation cross of 500 ms, and the appearance of an object for 2000 ms. A blank screen of 500 ms appeared between each trial. Participants were instructed to press the left arrow of a standard keyboard when they thought that the target object in terms of its real life size could fit into a shoebox, and to press the right arrow when they thought it could not. After completing the study phase, participants immediately started the test phase. In this session, scenes were presented for 1000 ms, followed by a fixation cross of 500 ms, the presentation of an object for 2500 ms, and a blank screen of 500 ms. Participants were required to press the left arrow when they thought they had seen the object during the study phase (old) and to press the right arrow when they thought the object was novel. Participants were asked to answer regardless of the scene. Stimuli were presented in random order.

3.2.5 Analyses. Performance was measured in terms of discrimination efficiency (Pr) and familiarity bias (Br). These indices were calculated using the following formulas: Pr=*[(number of hits)-(number of FA)]* and Br=*[(number of FA)/(1-Pr)]* (Snodgrass & Corwin, 1988). To facilitate reading the Br, 0.5 was subtracted from the total formula, such that a value of 0 would be equivalent to no bias.

The scene effect was calculated by subtracting the responses obtained with same scenes from the responses obtained with different scenes. The stimuli were split into two subsets as a function of their normative familiarity score, as described earlier, and participants were split into two subgroups as a function of their field-dependence score. The scene effect, defined as the difference in performance between same and different scenes, and its interaction with other variables was statistically tested with a repeated measures ANOVA, with scene (i.e., same, different) and normative familiarity (i.e., high, low) as within-subjects variables, and field cognitive style (i.e., dependent, independent) as a between-subjects variable. Another analysis was conducted on the accuracy of responses for old objects (i.e., recognition rate). This allowed us to quantify hits (i.e., true recognition) when objects were truly old and FA (i.e., false recognition) when objects were lures. To determine whether our independent factors influenced true and false recognition differently, recognition rate was examined in relation to the similarity of scene, normative familiarity of object, and field dependency of participants.

3.3 Results

From the 67 recruited participants, 6 were excluded, due to five outlier cases (i.e., five participants had a Pr measured across all conditions that was two standard deviations above or below the mean) and one case where the subject did not answer in over 50% of the trials. The 61 remaining participants to be included in analyses (34 females and 27 males), age range 18-48 years (mean: 24.5, SD: 5.4), were split into two subgroups according to their GEFT score (mean: 13.94, SD: 4.50). The same median split method used by Goode et al. (2002) and Ohnmacht (1966) (Goode, Goddard, & Pascual-Leone, 2002; Ohnmacht, 1966) to separate the subgroups was applied in the present study. The obtained median GEFT score was 16, yielding 29 subjects who scored below 16 into the dependent field (mean: 10.21, SD:3.89) and 32 subjects who scored 16 or above into the independent field (mean:17.33, SD:0.74). There was no significant difference of gender and age between the subgroups (FD: 16 females and 13 males, mean age: 25.93, SD:6.75; FI: 18 females and 14 males, mean age: 23.26, SD:3.39).

The mean Pr of the 61 participants for all conditions was significantly above 0 ($t(60)=14.810$), $p<0.001$). The Pr was 17.84% (SD: 0.11) when scenes were the same across the study and test phases, and 19.09% (SD: 0.11) when they were different. The 1.25% decrement observed in the Pr of same and different scenes was not significant ($F(1,59)=.944$, $p=0.335$). Although not significant, the three-way interaction between cognitive styles, scene effect and familiarity of objects revealed a trend ($F(1,59)=3.755$, $p=.057$) (see figure 3). The Pr scene effect did not significantly interact with the normative familiarity of the objects ($F(1,59)=2.171$, $p=0.146$). However, of note, there was a trend-like effect between Pr scene effect and field-dependent/independent cognitive styles of the participants ($F(1,59)=3.066$, $p=0.085$). The scene and normative familiarity interaction was significant in the FD subgroup ($F(1,28)=6.712$, $p=.015$) but not in the FI subgroup ($F(1,31)=.098$, $p=.756$).

On the other hand, there was a tendency for participants to respond more often 'old' than 'new' ($t(60)=5.042$), $p<0.001$). This was interpreted as a familiarity bias. Notably, the Br was significantly greater for objects that appeared in the same scenes (12.95%, SD: 0.15) than for objects that appeared in different scenes (6.41%, SD:0.16). This effect was significant ($F(1,59)=60.451,p>0.001$).

There was a trend-like three-way interaction between scene effect, familiarity, and the cognitive style subgroups ($F(1,59)=3.897$, $p=0.053$). The Br scene effects are reported for each condition in Figure 4. Post-hoc analyses indicated there were significant Br scene effects for less ($t(60)=6.730$, $p<.001$) and for more ($t(60)=3.743,p<.001$) familiar objects. This effect was significantly larger for less familiar objects ($F(1,59)=6.298$, $p=.015$). The influence of the object normative familiarity on Br scene effect was thus examined separately for each subgroup. It was found that this two-way interaction was significant for the FI subgroup ($F(1,31)=10.326$, $p=.003$) and that the Br scene effect was significant for less familiar objects ($t(31)=5.439$, $p<.001$) but not for more familiar objects ($t(31)=1.193$, $p=.242$). The two-way interaction was not significant for the FD subgroup ($F(1,28)=.140$, $p=.711$); although, the main Br scene effect was significant ($F(1,28)=28.206$, $p<.001$).

Additional analyses were conducted on the hit and FA rates to investigate whether the studied variables influence true recognition of old objects (i.e., hits) in a different manner compared to false recognition of lures (i.e., FA). The three-way interaction on Pr made this analysis possible given that the Pr is computed by subtracting the FA from the hits. It was found that the interaction between similarity of scene, the normative familiarity, and cognitive styles was significant when objects were old ($F(1,59)=10.347$, $p=0.002$) but not when objects were lures ($F(1,59)=0.000$, $p=0.987$). The scene effect on hit rates ($F(1,59)=27.713$, $p<0.001$) and FA rates ($F(1,59)=58.638$, $p<0.001$) were then compared within each subgroup and within each condition of normative familiarity. Results showed there was no significant difference in the way scenes influenced the hit rates and FA rates in the FI subgroup. A similar finding was obtained for the FD subgroup in more familiar objects. Less familiar objects, however, demonstrated a smaller scene effect for old objects compared to lure objects ($t(28)=3.026$, $p=.005$). Results displayed in Figure 5.

3.4 Discussion

This experiment investigated how scenes influence the recognition memory of objects, and how this effect is modulated by the cognitive style of the perceiver (i.e., field dependence) as well as by the nature of the stimulus (i.e., normative familiarity). Old objects were more readily recognized when perceived in the scene in which they were initially studied. Similarly, lure objects were more falsely recognized when perceived in the scene where a similar type of object was presented at study. Thus, objects seen in studied scenes appear more familiar regardless of whether they were old or new. This familiarity bias depended on an interaction between the field dependence of the participants and the normative familiarity of the objects. In FD participants, both less and more familiar objects were equally biased by the similarity of scene, whereas only less familiar objects were biased in FI participants. This result suggests that individuals who have a holistic approach and who are more sensitive to their surroundings, tend to have their memory systematically influenced by the scene. On the other hand, individuals who are more analytic and who tend to focus on details have their memory influenced by the scene only when they look at less familiar objects, as if they use more information from outside the to-be-remembered stimuli. This experiment showed that recognition memory of objects depends on its familiarity, on contextual information, and on the perceiver's tendency to apprehend this information.

The influence of scene contexts on memory has long been a topic of interest, but to this day, no effect is systematically replicated and no explanation for the scene effect is fully satisfactory. The effect of context is often described as a reduction in memory accuracy for items presented in different contexts (Dalton, 1993; Hayes, Baena, Truong, & Cabeza, 2010; Hayes et al., 2007), rather than an increase in memory accuracy for objects presented in similar contexts. This reduction, known as the context shift decrement (CSD) (Hayes et al., 2007), is consistent with other studies showing that scene backgrounds, either consistent or inconsistent, undermine the recognition of a target item presented inside of it (Davenport & Potter, 2004). However, according to Dalton (1993), CSD is observed for local contexts, but not for global contexts such as environments or scenes. This is in agreement with the present results, where accuracy was not significantly affected by the scenes. In fact, context effects may more generally be the result from simultaneous facilitating and disturbing effects (Tanabe-Ishibashi et al., 2014)

While the present simultaneous increase of general hit and FA rates was interpreted as a familiarity bias, it cannot be excluded that these two measures were distinct. This is even more likely given that the context effect had more impact on the FA than on the hit for less familiar objects in the FD subgroup. Distinction between scene effects for hit and FA is plausible given the fact that true and false recognitions are differently driven by recollection and familiarity (Yonelinas, 2002). Smith (2013) noted that hit rates are increased when contexts are rich or when they are intentionally associated with the target items, arguably through the retrieval of item-context associations (Macken, 2002) and the activation of source memory. Brain imaging studies have shown that true recognition activates more sensory brain areas than false recognition, likely because the perceptual experience can be retrieved in this condition (Schacter, Alpert, Savage, Rauch, & Albert, 1996; Slotnick & Schacter, 2004). Meanwhile, FA rates could be increased because the schemas that are referred to in order to make a decision are not entirely available (Mather, Henkel, & Johnson, 1997) and because they integrate stored perceptual details of the scene and expectancies (Miller & Gazzaniga, 1998). Nevertheless, recollection can occur during FA (Mather et al., 1997; Norman & Schacter, 1997), but brain imaging evidence indicates that this recollective process is different from that of true recognition (Abe et al., 2013).

Despite possible independent influence of the scene on hit and FA, there was likely a context-dependent recognition effect (Smith, 2013) caused by a feeling of familiarity, like in other studies (Murnane, Phelps, & Malmberg, 1999; Tsivilis et al., 2001). Scenes would make objects look more familiar because their gist is processed quickly and automatically (Bar, 2004; Oliva & Torralba, 2006). Thus, scenes may not be remembered in details, but sufficient information may be retained to make the stimuli look familiar when perceived again at test. This would occur even when the task does not require to memorize the scene and when a cue (i.e., fixation cross) is used to focalize attention on a target location, like in Ecker et al. (2007).

The familiarity scene effect was possibly attributed to the use of lures for new objects. This manipulation gave to new objects the capacity to initiate the retrieval of studied information. The impact of this retrieval is twofold. First, the retrieval of the scene presented at study may have accentuated the feeling of familiarity of the scene presented at test. Second, the retrieval property of the lures may have compromised the reliability and the efficiency of the old objects to act as copy cues (Tulving, 1983). The outshining hypothesis of Smith (1988) states that copy cues are powerful enough to reactivate memories without referring to contextual information, but in the present study, this hypothesis does not stand because lures also act as retrieval cues.

While the familiarity scene effect is intuitively sound, it goes in contradiction with the conclusions of other studies. For instance, Hayes et al. (2007) found no difference in FA rates between new objects presented alone and new objects presented in scenes. However, scenes of new objects were seen for the first time making it unlikely that they would induce a feeling of familiarity. In two other studies, Ecker, Zimmer and Groh-Bordin, (2007a, 2007b) showed that the electrophysiological correlate of familiarity, the FN400, was sensitive to the similarity of intrinsic features of objects presented at study and test but not to the similarity of extrinsic contextual features. In their experiments, contexts were either simple shapes or frames. Using more complex contexts, Ecker et al. (2007) found an FN400 for similar scenes (see also Tsivilis et al., 2001) which they assumed was independent of the familiarity of the object. At the behavioural level, similarity of scenes did not affect the FA rate of new objects. However, unlike the present study, the new objects were not lures, meaning that they had no a priori associations with the studied scenes when they were perceived at test. In such case, the familiarity induced by the studied scene could not have been transferred to the object.

Even if scenes are processed automatically, it was expected that their influence on the recognition of objects would depend on the need for such external information during the retrieval effort. This need could be implemented by using objects with varying levels of familiarity. Familiar objects are already associated to stored information in memory, or knowledge, like verbal labels that typically improve memory performance (Brodeur, Chauret, Dion-Lessard, & Lepage, 2011; Clark, 1968; Clark & James, 1965; Price & Slive, 1970). Therefore, familiar items are generally more recalled and recognized than unfamiliar items (Brandt, Cooper, & Dewhurst, 2005; Goldstein & Chance, 1971; Jackson & Raymond, 2008; Reder et al., 2013). These already established associations for familiar items could prevent the influence from other sources of associations, namely contextual information. This is supported by several studies showing that changing the backgrounds or associated labels of celebrity faces affected the recognition memory less than for unknown faces (Dalton, 1993; Davies & Milne, 1982; Russo, Ward, Geurts, & Scheres, 1999; but see Reder et al., 2013). Similar findings were also reported with words

(Russo et al., 1999). Based on Tulving's (1972) distinction between episodic and semantic memories, Dalton (1993) argued that with time and repetition, familiar items become more abstract, more semantic, and more decontextualized. This argument could apply to the normative familiarity in the present study considering that this familiarity referred to the concept and not to the image (Snodgrass & Vanderwart, 1980). Unfamiliar items, on the other hand, could be more susceptible to contextual influence because they need additional information to be identified. For instance, individuals use more scene information to identify ambiguous objects than non-ambiguous objects (Biederman, Mezzanotte, & Rabinowitz, 1982; Palmer, 1975), and this increased use of contextual information activates object recognition brain mechanisms to a greater extent (Dyck & Brodeur, 2015).

The expected decrease of Br scene effect for more familiar objects was observed in the FI subgroup but not in the FD subgroup. This finding strengthens the assumption that familiarity with an item reduces the use of external information, but this seems to happen only in individuals who had an analytic cognitive style. FI individuals tend to attend the details of a display and, more importantly, can focus more easily on targeted information than FD individuals (Guisande, Páramo, Tinajero, & Almeida, 2007). When presented with familiar objects, they probably did not look around in search for additional information that could either help them to identify the object or to encode additional information. As a matter of fact, FI individuals not only have better control on their focus of attention than FD individuals, but they also filter out task-irrelevant information more efficiently than FD participants (Avolio, Alexander, Barrett, & Sterns, 1981; Jia, Zhang, & Li, 2014). Evans, Richardson and Waring (2013) clearly described this capacity when they claimed that “Field-independent learners are able to minimize their cognitive load and maximize their working memory efficiency by placing more emphasis on selectively encoding information so that they have less information to process”. On the other hand, FD individuals use contextual information in a systematic, and arguably implicit manner during recognition regardless of the level of familiarity. Their cognitive style brings them to be more attentive to their surround even when it is not task-relevant.

The difference between FI and FD individuals lies essentially in their capacities to focus their attention on the target when it is familiar. This target may look visually more salient to FI individuals, and more salient items are known to be less affected by contexts (Smith, 1988; but see Cosman & Vecera, 2013). Saliency can also be extrinsically induced by noncontextual information (e.g., introspective thought) (Smith & Vela, 2001) or by cues (Ecker, Zimmer & Groh-Bordin, 2007a). In Ecker et al. (2007), objects presented in scenes elicited an electrophysiological response distinct from the scenes only when they were cued, as if such cue was necessary to distinguish its processing from that of the scene. A cue was also used in the present study but it may not be as constraining as the one described above because it disappeared before the target presentation. Accordingly, it may be possible that using a more constraining cue in the present study would have attenuated the scene effect and reduced the difference between FD and FI subgroups.

3.5 Conclusions

In conclusion, the present study showed that memory performance is determined by the interaction of multiple variables including the features characterizing the target stimulus, the information processing style of the individual, and the contextual information. Variables studied in this study were limited to normative familiarity, field dependence, and scene information but several others may also have been involved and could account for the inter-individual variability (Smith & Rothkopf, 1984). There is currently an increasing number of works trying to disentangle the influence of similar variables on various cognitive performances (e.g., Emmett et al., 2003), and efforts are being carried out to use these variables to adapt therapy trainings for patients (Riding & Sadler-Smith, 1997). Brain recording techniques were also put in contribution and helped to understand better the processes underlying the influence from each variable (e.g., Gevins & Smith, 2000; Hsu, Kraemer, Oliver, Schlichting, & Thompson-Schill, 2011).

Chapter 4 Article # 2: The influence of scene on object memory recognition: An ERP study

4.1 Introduction

Recognizing someone or something brings forth a feeling of familiarity, and is often also accompanied by the recollection of past memories (Collen & Larry, 2000; Diana et al., 2006; Yonelinas, 2002). Familiarity is a sense of having seen an item without recovery of specific details, whereas recollection refers to the conscious memory retrieval of specific pieces of time and information linked to the perceived item (Collen & Larry, 2000; Mandler, 2008; Yonelinas, 2002). These two processes can occur when looking at a known item, but can also be activated after seeing a new item that is perceptually similar to a familiar item, thus creating a false recognition (e.g., lures in experimental tasks).

The context or scenes in which items appear influence the recognition of the item to be remembered (Dalton, 1993; Davies & Milne, 1982; Hayes et al., 2007; Hollingworth, 2006; Tanabe-ishibashi, 2014). The presentation of same scenes during study and test phases increases the recognition of old items (i.e., hits) (Hollingworth, 2006; Smith et al., 1978) but also increases the false recognition of new lure items (Gruppuso et al., 2007). These findings raise two questions: Do scenes influence the recognition of items by increasing the feeling of familiarity or through memory recollection? Second, do the brain mechanisms increasing true recognition of old items similar to those underlying false recognition of new lure items?

The questions can be addressed by measuring the activation of familiarity and recollection with event-related potentials (ERPs). Familiarity is indexed by a negativity around 300 to 500 ms post-stimulus (Curran, 2000, 2004; Düzel et al., 1997; Tsivilis et al., 2015), peaking over the midfrontal site (Morcom, 2015; Rugg & Curran, 2007a). This component, also referred to as the FN400, has shown to be sensitive to stimulus repetition

(Riedel, 2003), and to other perceptual conditions that increase familiarity (Groh-Bordin et al., 2006; Schloerscheidt & Rugg, 2004). In a later time window, a positive component approximately 400 to 800 ms post-stimulus over left parietal sites indexes recollection (for review see Rugg & Curran, 2007). This parietal component has shown to be sensitive to the amount of recollected material (Vilberg et al., 2006).

Findings from previous ERP studies are discordant on the matter of whether context truly influences object familiarity (Tsivilis, Otten, & Rugg, 2001) or whether it is fueled by an independent contextual familiarity effect evoked by salient contexts (Ecker et al., 2007b). These two studies have utilized both, old and novel objects as stimuli, which precludes encoding of the association between new objects and specific scenes otherwise necessary for the reactivation of past memories (i.e. recollection). In the present study, lure objects were instead used to increase the probability of reactivation of object source memory, and to more plausibly and accurately investigate contextual effects on memory.

The second question of the present study is motivated by results indicating that true and false recognitions are mediated by different mechanisms, including the recruitment of different cortical areas (Cabeza et al., 2001; Slotnick & Schacter, 2004) and activation of distinct ERP components (Goldmann et al., 2003). The reasons for these differential activities have not been elucidated yet but one possibility could be that true and false recognitions activate familiarity and recollection to a different extent. Moreover, no studies have yet addressed whether the differences in activity between true and false recognition remain when they are caused by the scenes, rather than the objects themselves.

The first aim of this study was to determine whether the influence of scene on object recognition results from a familiarity effect reflected by an FN400, or from a recollection of scene information reflected by a parietal component. The second aim was to compare the neural activity profiles underlining the influence of scene on true and false recognition.

4.2 Methods

4.2.1 Subjects. Twenty-one right-handed volunteers, (17 females), ages 18-31 years (mean= 23.19, SD= 3.6) were recruited through an advertisement posted on a McGill University classified. Informed consent was obtained from all participants. The Douglas Mental Health University Institute's Research Ethics Board approved the protocol and the consent form. Participants with current or previous history of a neurological disorder or head trauma, a disorder of Axis I and or Axis II, first-order family history of major depressive disorder (MDD) or current state or history of MDD, were not eligible to participate.

4.2.2 Stimuli. The set of stimuli consisted of 624 trial photos, presented in a sequence of three images: the scene, the scene with a fixation cross, and the scene with the object. Each image was immediately followed by the next one thus, the scene remained visible for the whole trial duration. The objects used in this experiment were taken from the Bank of Standardized Stimuli (BOSS) (Brodeur et al., 2010; Brodeur et al., 2014). The majority of the scenes were created for this experiment, with a few taken from Dyck and Brodeur (2015).

One half of the stimuli were presented during study phase and the other half were presented during test phase (Figure 1). One hundred fifty-six objects presented at test were studied objects (i.e., old). Old objects were presented in a different position from the study phase to prevent a priming effect that would have facilitated recognition (Dalton, 1993; Tulving et al. 1982). The other 156 were new unstudied objects (i.e., lures) that resemble to the previous studied ones. Scenes were also manipulated. Half of the scenes of the old and lure objects were the same as those presented during the study phase, but photographed from a different angle. The other half of scenes was different.

4.2.3 Procedure. The experiment included a study phase and a test phase consisting in the random presentation of trial stimuli following the parameters described in Figure 1. In the study phase, participants had to decide whether the target object in terms of its real-life size could fit into a shoebox. Subjects were aware of the preceding test phase. In the test phase, participants were asked to discriminate the old objects from the new objects. Subjects were instructed to answer regardless of the scene. Responses were delivered by pressing one of two keys of a standard keyboard and stimulus presentation was monitored by E-Prime software 2.08 (Psychology Software Tools, Inc.).

4.2.4 Electrophysiological recordings. Before starting the experimental task, 64 Ag/AgCI actiCap electrodes attached to an elastic cap were placed according to the 10-20 configuration (American Electrophysiological Society, 1994) atop the subject's scalp. The impedance was reduced below 5kΩ. The electrode FCz was used as a reference during the recordings. The sampling rate was set to 1000 Hz and the EEG signals were amplified 20,000 times using BrainAmp DC amplifier (Brain Products Inc.). Low- and high-pass filter half-amplitude cut-offs were set at .01 and 100 Hz, respectively. The recordings were monitored using Brain Vision Recorder software (Brain Products Inc.). To reduce muscular and ocular artifacts, subjects were instructed to stay as still as possible during the recordings and to blink only between stimulus presentation.

4.2.5 Behavioral analyses. Performance was measured in terms of recognition rate (response 'old'), discrimination efficiency Pr [(*percentage of hits)-(percentage of false alarms)]* and familiarity bias Br [(*percentage of false alarms)/(1-Pr)]* (Snodgrass & Corwin, 1988). To facilitate reading the Br, 50% was subtracted from it, such that a value of 0 would reflect no bias. Repeated measure ANOVAs with object and scene as the within-subject variables were run to analyze respectively each performance.

4.2.6 Analyses of event-related brain potentials. Data were pre-processed and re-referenced offline to an average of all electrodes. Independent component analysis was carried out with BrainVision Analyzer 2.0 (Brain Products Inc.) to remove eye blinks and ocular movements. Low and high pass filters were set to cut-offs of .01 Hz and 30 Hz (12 dB/oct), respectively. Segments from -200 to 800 ms, relative to target onset, were extracted from the continuous EEG recording.

To test our specific hypotheses, analyses included repeated measure ANOVAs of the mean voltage amplitude of ERPs using the time windows of the effects of interest; that is, 300 to 500 ms post-stimulus onset over the midfrontal electrodes to measure the activity of the FN400 component, and from 500 to 800 ms post-stimulus onset over the parietal sites to measure the activity of the parietal effect. All epochs were corrected relative to a baseline of -200 ms to 0ms preceding the onset of stimuli.

The time windows and cluster of electrodes chosen for analysis have been used in previous studies using similar procedures (e.g., Michael D. Rugg et al., 1998; Tsivilis et al., 2015). Electrodes were grouped into two regions per hemisphere according to the effects of interest: 1) midfrontal left (F3, F5, F7, Ft7, Fc3, Fc5) and midfrontal right (F4, F6, F8, Ft8, Fc4, Fc6), and 2) parietal left (P3, P5, P7), and parietal right (P4, P6, P8).

Statistical analysis included a four-way ANOVA, with region (midfrontal, parietal), object (old, new), context (difference, same), and hemiscalp (right, left) as within-subjects variables using pooled data extracted from the aforementioned time windows. A Greenhouse-Geisser adjustment was utilized to control for the violation of assumption of sphericity.

4.3. Results

In total, 17 subjects (14 females) mean age of 22.8; SD= 3.7 were included in the analysis. Four subjects were excluded because they had less than ten EEG segments in the averages of at least one experimental condition.

4.3.1 Behavioral results. The objects that appeared in the same scenes across study and test had a Pr of 16.80% (SD=11.80%) and a Br of 12.49% (SD=10.88%) whereas objects that appeared in different scenes had a Pr of 21.26% (SD= 10.91%) and a Br of 6.39% SD=13.31%). The main effect of scene on Pr was trend-like ($F(1,16)= 3.468$, $p=0.081$) whereas the main effect on Br was significant ($F(1,16)= 13.925$, $p=0.002$).

Same scenes increased the rates of recognition responses given to old objects (i.e., hits, mean=68.76%, SD=10.52%) and lures (i.e., FA, mean=51.96%, SD=11.63%) compared to different scenes (hits, mean=65.59%; SD= 11.98%; FA, mean=44.33%, SD=11.99%). The increment on hit rates was marginally significant ($F(1,16)=4.131$, $p=0.059$). By contrast, the increment of FA attained significance ($F(1,16)=14.85$, $p=0.001$).

4.3.2 Event-related brain potentials results. The ERPs and voltage maps are illustrated in Figure 2 and the mean voltage amplitudes are reported in Figure 3. The four-way interaction of region, object, context and hemiscalp was significant ($F(1,16) = 5.436$, $p=.033$). Given this result, three-way ANOVAs were conducted separately for the midfrontal and the parietal brain regions for the FN400 and the parietal component, respectively.

The analysis of the FN400 showed a significant interaction of object (i.e., old, lure) and scene (i.e., same, different) ($F(1,16)=10.678$,$p=0.005$). Post-hoc analyses indicate a significant effect of scene for old objects ($F(1,16)=8.711$,$p=0.009$) and a marginally significant effect of scene for lures ($F(1,16)=4.037$,$p=0.062$). Hemiscalp did not interact with scene for old ($F(1,16)=2.181$,$p=0.159$) neither it did for lure objects ($F(1,16)=0.230$,$p=0.638$) (Fig. 3).

Analysis of the parietal component showed a significant interaction between object and scene ($F(1,16)=6.075$,$p=0.025$). However, the main effects of scene in old objects ($F(1,16)=2.449$, $p=0.137$) and lures ($F(1,16)=2.170$, $p=0.160$) were not significant. As a follow-up to these results, a second round of analysis was restricted to the left parietal site as done in previous studies (for review see: Rugg and Curran, 2007; Tisivilis et al. 2001). An interaction between object and scene was once again found ($F(1,16)=7.409$, $p=0.015$) and this time, old objects showed a significant main effect of scene ($F(1,16)=7.345$, $p=0.015$) but not lures ($F(1,16)=2.875$, $p=0.109$).

4.4. Discussion.

The findings of the present investigation provide evidence that scenes influence object recognition by increasing the sense of familiarity, but also by allowing the recollection of studied information when objects are known. Seeing an object in a studied scene increases the chance of recognizing the object. This comes with a modulation of the

FN400 indexing familiarity, as well as with a modulation of a left parietal component indexing recollection. On the other hand, seeing a lure in a scene where a similar object was studied increases the chance of false recognition and modulates the FN400 but not the parietal component. The lack of a parietal scene effect during false recognition and the fact that the modulation of the FN400 scene effect was inverted relative to true recognition suggest that scenes contribute to true and false recognition in different manners.

The behavioral results suggest participants exhibited a global familiarity bias, where the feeling of familiarity was greater for objects that appeared in the same scenes than for objects that appeared in a different scene. Furthermore, hit and false alarm rates obtained in the present study are concordant with the results obtained from the Br. These response rates were both increased when objects were presented within a same scene, but the increase was significantly more pronounced for lure objects. At first sight, using solely the behavioral data, it is difficult to draw strong conclusions regarding the influence of scenes. However, the integration of ERPs underlying the influence of scenes on object recognition provides additional valuable information to suggest that this process is influenced by both the FN400 and the parietal effect, and not by a single exclusive process.

The data obtained from the FN400 further corroborated this notion. A familiarity FN400 effect of scene was observed for hits, as well as for false alarms. Although both types of objects were influenced by the scene, the FN400 scene effect was stronger for old objects. This finding is consistent with Tsivilis et al. (2001) who reported a familiarity effect driven by the presence of same and rearranged scenes. In a later replication, Ecker et al. (2007b) concluded that similar scenes indeed elicited an FN400, but only when the objects were salient. Both studies used similar logic for their stimuli; that is, a salient object placed over a scene (i.e. a coat hook in a forest). However, Ecker et al. argued that if subjects were given a cue (i.e. the target object was framed), the FN400 was no longer affected by the scenes. The authors rationalized that when backgrounds lack salience, subjects treat the background as contextual information no longer affecting the scene effect of familiarity at recognition. Our findings are in contradiction with this, as objects in this study were presented after a fixation cross, this is contexts were no salient, and yet familiarity effects induced by scenes were observed.

It was also predicted that a parietal effect would not be evoked by a scene effect in either type of object (i.e., old, new). The fact that a significant left parietal old/new effect for old objects was found in different scenes does not reject our initial hypothesis. On the contrary, it contributes to the literature of the parietal effect. First, as seen in other studies (Curran, 2004; Düzel et al. 1997; Friedman and Johnson, 2000; Wilding et al. 1995) the parietal effect here also showed a maximal distribution over the left scalp and this laterality was demonstrated to be sensitive to contextual information. This finding also calls into question the lack of laterality in this component proposed by other studies (Ecker, Zimmer, Groh-Bordin et al. 2006, 2007b). Secondly, similar scenes tended to induce a response bias; thus it is logical that when old objects were placed over different scenes, the scene bias was no longer influencing the subjects' responses and was indeed ameliorating memory.

Another point warranting further discussion is the magnitude of negativity observed with the FN400 for old objects in same scenes versus old objects in different scenes, at odds with the expected positivity of old items as described in the literature (Rugg et al., 1995; Friedman and Johnson, 2000) the old same scenes were expected to be more positive than old different scenes, which was not the case. This discrepancy is postulated to be driven by the inclusion of scenes previously to the appearance of objects and to the level of expectancy that subjects had to seeing at test a certain scene paired with a certain object. This could have altered the expected positivity of the old items in the FN400. To the present time no studies have reported such altercation in polarity with same and new contexts hence, it is difficult to jump into any final conclusions at the moment. However, differences in polarity in the parietal component have been reported in other studies using certain type of contexts (Johansson and Mecklinger, 2003; Mecklinger et al. 2007). It is then possibly that under certain conditions contexts altered the described polarity in the literature of single items. This is clearly an area of research that should be addressed in further studies in other to investigate if changes in polarity are due to the inclusion of context and if it is related to the time in which the contexts appears (i.e., objects before contexts versus contexts before objects)

Several limitations should be discussed. Firstly, we used one group of participants without further categorization, due to our limited sample size. Other behavioral studies have shown differences across recognition pertaining individual differences (e.g., first study of the present thesis). In addition, evidence from other behavioral data also show that individual differences have a direct influence over the response bias on object memory recognition (for review see Schacter, 1999). Moreover, in ERP studies the FN400 effect has also shown to be sensitive to individual differences (Morcom, 2015). Therefore, brain potentials of scene effects on object recognition and intra-individual differences remain unsolved. Another limitation which could be considered is the lack of a “new object” condition. Future studies with larger samples are encouraged to incorporate analyses of correct rejections and misses as well as to continue investigating for context effects in recognition memory.

4.5. Conclusions.

In conclusion, this study demonstrates that scenes influence the recognition of objects through both familiarity and recollection memory processes, and this influence is distinct in polarity for true and false object recognition.

Chapter 5: General Conclusions

5.1 Summary and Conclusions

The main interest of this dissertation was to study the influence of scene context on the recognition of studied (i.e., old) and unstudied objects (i.e., lures). In Chapter 3, the effect of context and its relation with the cognitive styles and object familiarity were examined behaviorally in healthy individuals. In Chapter 4, the effect of context on object recognition was examined by using the same task protocol as in the previous Chapter but this time it also included the recordings of the event-related brain potentials of familiarity (i.e., midfrontal effect) and recollection (i.e., parietal effect).

The first study pinpointed that as expected, and in agreement with other studies, the similarity of scenes was related to an increase of accurate responses (i.e., hits) (Rutherford, 2010; Tanabe-ishibashi, 2014; Tulving & Thomson, 1971; cf. Opitz, 2010). In addition to that finding, by including lures in the stimuli conditions, it was possible to observe that the influence of scenes also increased the false recognition of objects. This is, there was a significant increment of the overall rate of "old responses" when objects were placed in same scenes rather than in different scenes and this increment occur regardless if the object was a lure or a truly old object.

It is well known that false recognitions memory responses are more driven by familiarity whereas true recognition is more driven by recollection (Yonelinas, 2002). In the first study both type of responses: true recognition (i.e., hits) and false recognitions (i.e., false alarms) were augmented; albeit, it will be somehow logic to assume that scene similarity influenced memory familiarity and recollection process, the scope of the first study could not reach to make such conclusions.

The behavioral data of the second study also showed that the similarity of scenes increased false and true recognition but again by only looking at the behavioral data it was not possible to make further conclusion regarding which memory process was underlying the scene effect. Adding the brain potential data to the second study revealed that it is highly possible that scenes influence recognition memory on the basis of familiarity and recollection. This results will need further investigation with bigger samples in order to corroborate those findings. Finally, Chapter 4 also reported differences among true and false recognition. True recognition was marked by a negativity in midfrontal and a positivity in parietal scalp while false recognition depicted the opposite polarity - a positive activity in midfrontal and a negative activity in the parietal. The other possible implications of this findings are still unknown. Nonetheless the purpose of looking true and false recognition was to examined whether they behave in similar or different manners. The findings corroborate the initial hypothesis by revealing that true and false recognition of objects in scenes are driven by distinct mechanisms.

One innovation of this dissertation was clearly the inclusion of the cognitive styles assessment (i.e., GEFT). The categorization of subjects according to their dependence or independence cognitive style showed that the influence of context varies. Briefly, FD individuals will nonetheless use context information during recognition whereas FI individuals use the context only when they need to or when in doubt.

5.2 Limitations Implications and Future Directions

One of the main limitation of this investigation was the one previously stated in Chapter 4. That is, the lack of power to subdivide our sample and stimuli as we did in Chapter 3. The utilization of ERPs implicates the segmentation of the data, and in order to have reliable results, conditions including less than ten segments should not be included in the analyses. For this reason, in the second study subdividing the stimuli and the division of subjects in FD and FI would have need more data availability in order to have appropriate results. The possible implications of object familiarity and cognitive styles in the brain potentials of familiarity and recollection remain unsolved and it is recommended that future similar studies utilize bigger sample in order to examine these two factors and its possible implications in memory recognition process.

Recognition memory research could perhaps be one of the most ancient areas of research; however, there are still many gaps to be fill. This dissertation not only contributes to the findings in recognition of objects but also it proposes novel methodologies that could help future studies to analyze their data in more detail. Such methodologies are the inclusion of cognitive tests that subdivide the entire sample and have the purpose of a better characterization of the subjects. Additionally, this work provides evidence of the importance of the stimuli that is used in an experimental task. It was observable that the inclusion of lures, normative familiarity of the target objects and finally the inclusion of contextual scenes in a congruent manner was key in this study and allowed us to make distinctions in the results. The implications of this is that memory is interacting with other variables, and then these variables should be included in future tasks. Furthermore, it was noted that most of the utilized salient objects within context scenes. As reviewed in the literature of this dissertation, there are several implications of using objects placed on scenes that violate the "typical relations between object and context", and it is highly likely that results of those studies will differ if scene and objects are presented congruently.

Among the clinical implication of this work some of them are: the importance of understanding the mechanisms of recognition so that in the future this knowledge could be used towards preventing false recognition. Second, this knowledge could be also beneficial for future investigations on the neural correlates of memory dysfunctions in neuropsychiatric populations who have memory dysfunctions. For instance, studies in Alzheimer have shown that in this population, familiarity responses are not as affected as recollection responses are (Yonelinas, 2002). The findings of this dissertation regarding contextual information could be extended to such areas of research by investigating; for example, what is the role of context in populations with Alzheimer disease and if the inclusion of same context scenes will also increase the familiarity of the studied objects, and if this if this increment would be greater than the one observed in healthy subjects. As seen in Chapter 4 this work also highlights the importance of including electrophysiology techniques in memory research. Finally, the importance of taking into account contextual information due to its implications in recognition memory, could mark a turning point in clinical and legal fields where accuracy in recalling is highly important.

The present dissertation contributes to the general understanding of recognition memory which has thus far paid little attention to influential factors on memory. This knowledge could be extended to different areas of research such as education, clinic psychology, or social interactions, among others. It is important to continue examining and identifying such variables, to target intra-individual differences, avoid the generalizations of conclusions and generate more accurate and ecological memory research.

Appendix 1: Study # 1 Figures

Figure 1. Example of the Presentation of the Stimuli

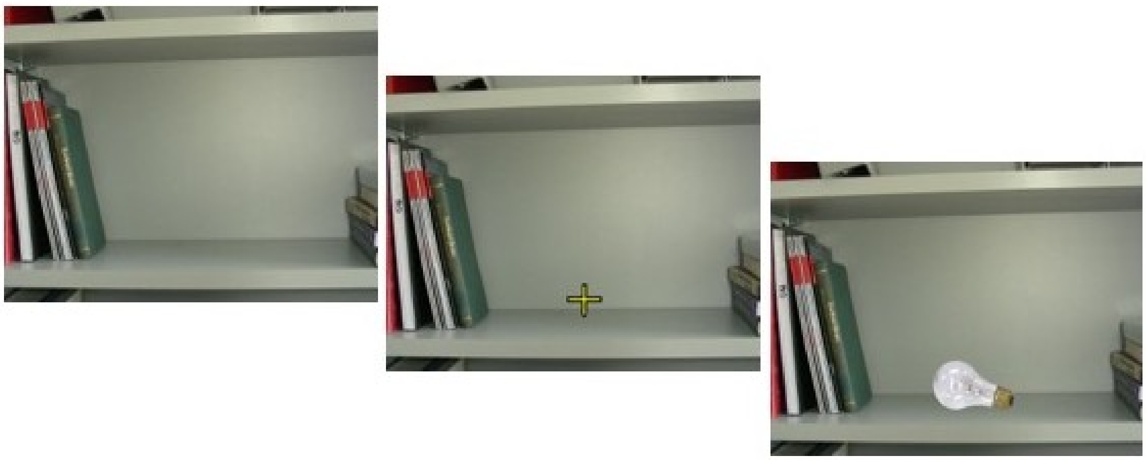

Figure. 1. The three sequences of presented stimuli used in each trial. Left: a scene; middle: the same scene with a fixation cross indicating the location where the target object will appear; right: the same scene with the target object.

Figure 2. Example of the Stimuli

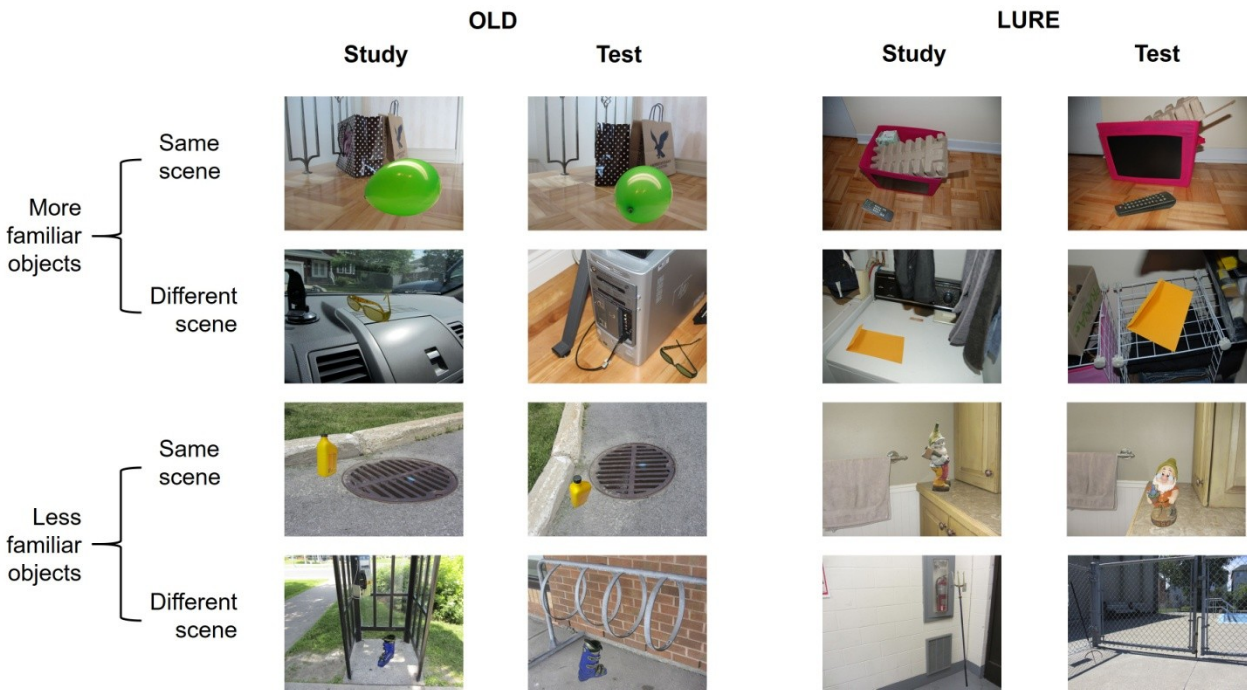

Figure. 2. Old, more familiar objects included a balloon and sunglasses presented in the same and a different scene, respectively. Old, less familiar objects included a motor oil bottle and a ski boot. Lure, more familiar objects included a remote control and an envelope. Lure, less familiar objects included a garden gnome and a trident.

Figure 3. Discrimination Performance (Pr) Results on Scene Effect

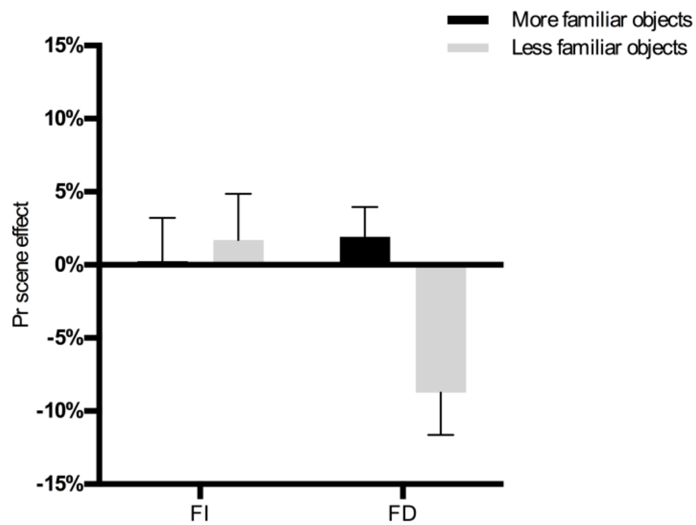

Figure 3. Pr scene effects (same scene–different scene) for each experimental condition. The Pr scene effects for more and less familiar objects were respectively 0.25% and 1.70% in the field independent (FI) subgroup, and respectively 1.92% and -8.74% in the field dependent (FD) subgroup. Error bars show standard error of the mean.

Figure 4. Familiarity Response (Br) Results on Scene Effect

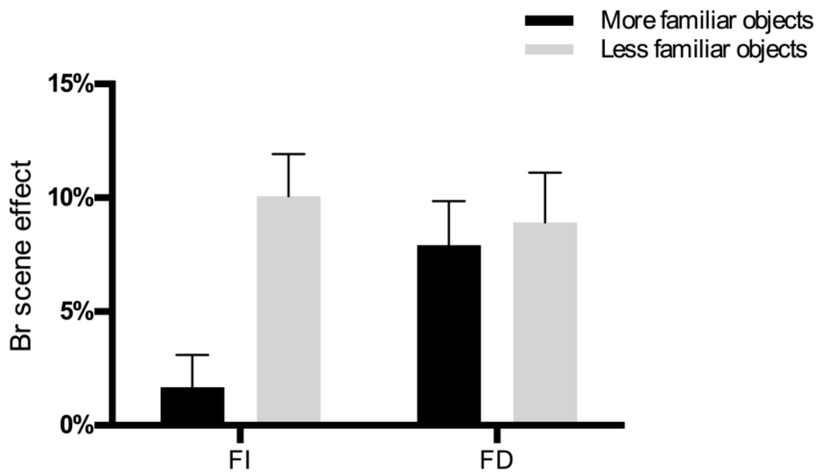

Figure 4. Br scene effect (i.e., same scene-different scene) for each experimental condition. The Br scene effects for more familiar objects and less familiar objects was 7.92% and 8.92%, respectively, in the field dependent (FD) subgroup and 1.68% and 10.07%, respectively, in the field independent (FI) subgroup. Error bars show standard error of the mean.

Figure 5. Percentage Rates of Scene Effect on Recognition Memory Performance

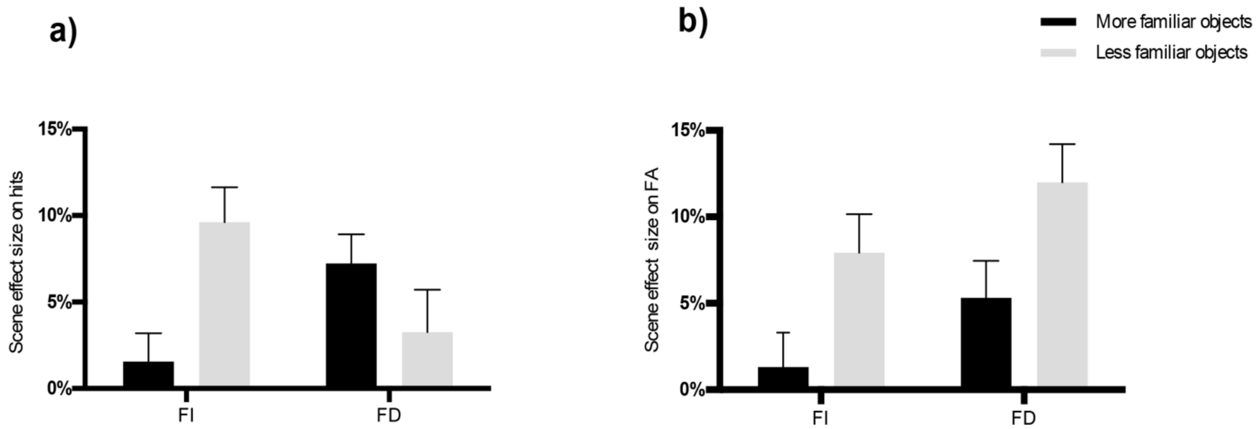

Figure 5. Percentage rates of scene effect on recognition memory performance for a) old objects (i.e., hits), and b) lure objects (i.e., false alarms). The scene effect on hits for more familiar objects and less familiar objects was 7.23% and 3.26% respectively in the field dependent (FD) subgroup, and 1.56% and 9.62% respectively in the field independent (FI) subgroup. The scene effect on false alarms (FA) for more familiar objects and less familiar objects was 5.31% and 12.00% respectively in the field dependent (FD) subgroup, and 1.32% and 7.92% respectively in the field independent (FI) subgroup. Error bars show standard error of the mean.

Appendix 2: Study # 2 Figures

Figure 1. Example of the Stimuli.

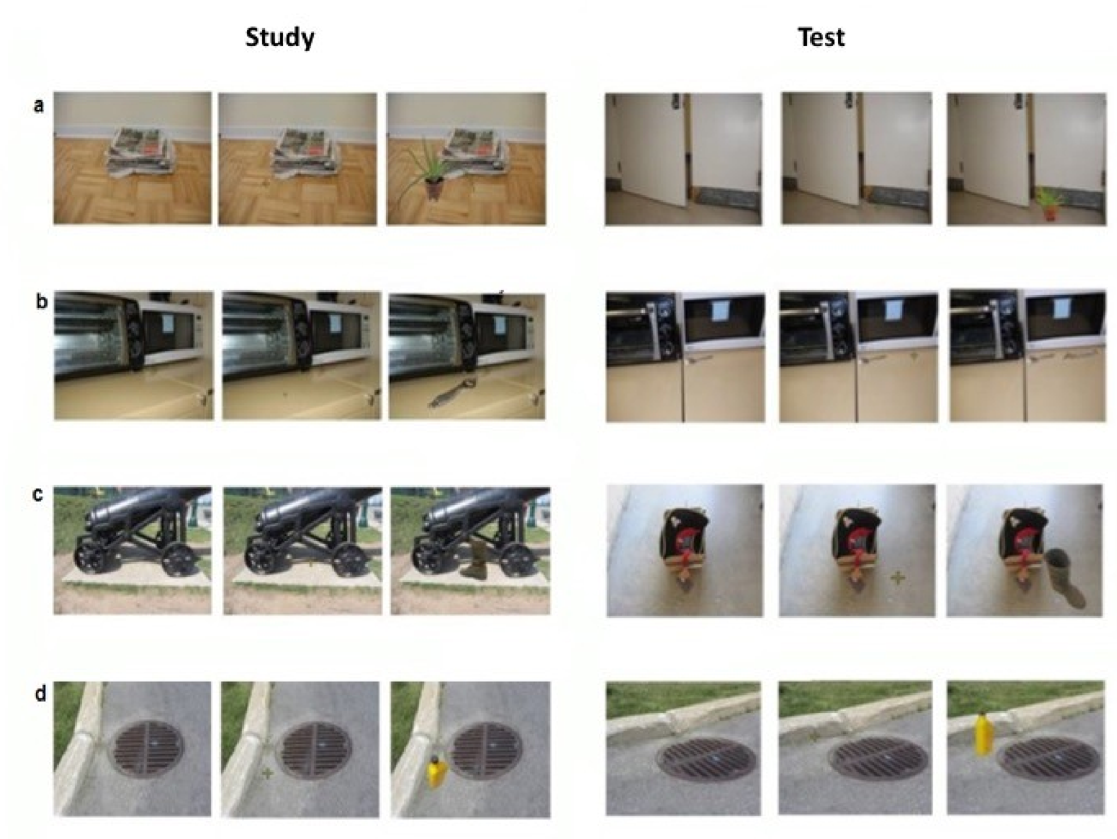

Figure 1. Examples of stimuli. a) A lure object placed within a different scene during study and test phases; b) a lure object within the same scene; c) an old object within a different scene and d) an old object within a same scene.

Figure 2. FN400 and Parietal Brain Potential Data and Voltage Maps

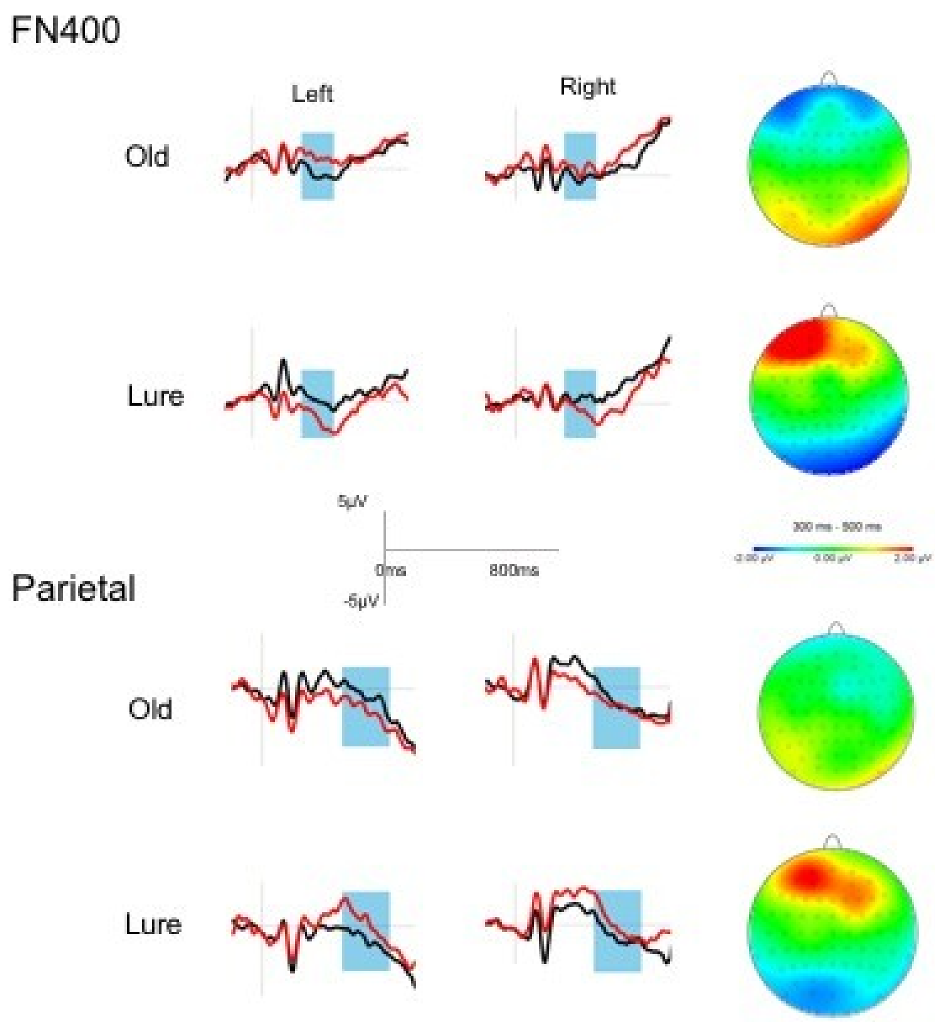

Figure 2. ERPs of pooled data of all subjects in the time windows of interest for old and lure objects in the left and right hemisphere, presented in same scenes (black) and different scenes (red) and voltage maps at time window 1 corresponding to the FN400 and at time window 2 corresponding to the parietal component, representing the scene effect.

Figure 3. Mean Amplitudes of the Average Waveforms of all Subjects

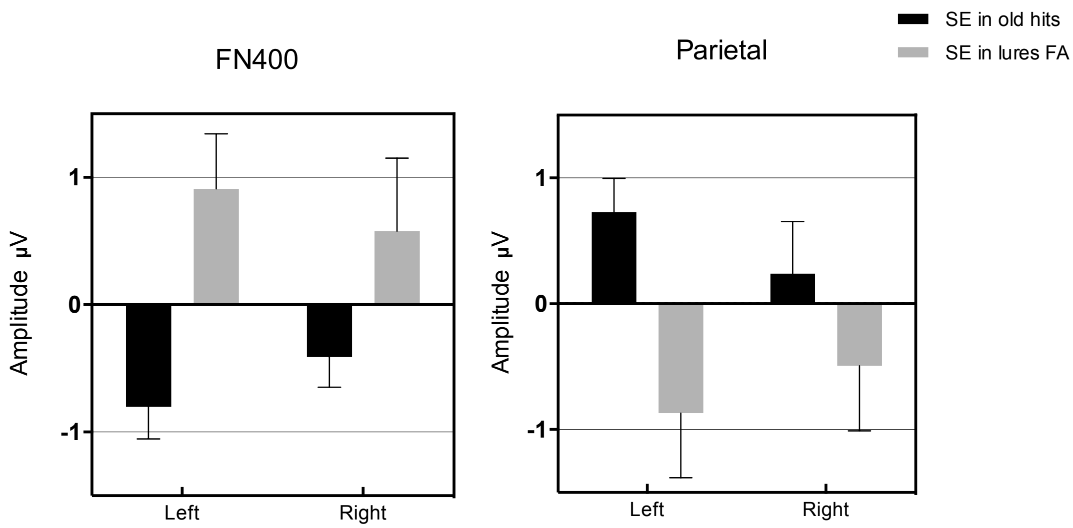

Figure 3. The mean voltage amplitude on scene effect (same-different) at time window 1 for the FN400 on pooled data of all subjects on midfrontal electrodes was as follows: on old objects (i.e., hits): Left hemisphere: Mean=-0.80 (SD=1.03), Right hemisphere: Mean=-0.41 (SD= 0.98), and on lure objects (i.e., false alarms): Left: Mean=0.91 (SD= 1.78), Right: Mean= 0.58 (SD= 2.36). Means at time window 2 for the parietal component on parietal electrodes was as follows: on old objects: Left: Mean=0.73 (SD=1.10), Right: Mean= 0.24 (SD=1.70), and on lure objects: Left: Mean=-0.87 (SD=2.11), Right: Mean=-0.49 (SD=2.13). Error bars denote standard error of the mean.

References

Abe, N., Fujii, T., Suzuki, M., Ueno, A., Shigemune, Y., Mugikura, S., Takahashi, S., & Mori, E. (2013). Encoding- and retrieval-related brain activity underlying false recognition. *Neuroscience Research, 76*(4), 240–250. doi:10.1016/j.neures.2013.05.006

American Electrophysiological Society, 1994. Guideline for standard electrode position nomenclature. J. Clin. Neurophysiol. 11,111–113.

Aminoff, E., Gronau, N., & Bar, M. (2007). The parahippocampal cortex mediates spatial and nonspatial associations. Cerebral Cortex, 17(7), 1493–1503.

Atkinson, R. C., & Juola, J. F. (1971). Factors influencing speed and accuracy of word recongition. Attention and Performance IV.

Avolio, B. J., Alexander, R. A., Barrett, G. V., & Sterns, H. L. (1981). Designing a Measure of Visual Selective Attention to Assess Individual Differences in Information Processing. *Applied Psychological Measurement, 5*(1), 29–42. doi:10.1177/014662168100500105

Bar, M. (2004). Visual objects in context. *Nature Reviews Neuroscience, 5*(8), 617–629. doi:10.1038/nrn1476

Berry, L. H. (1984). The role of cognitive style in processing color information: a signal detection analysis. Paper presented at the Annual Meeting of the Association for Educational Communications and Technology. IR 011 020.

Biederman, I. (1972). Perceiving Real-World Scenes. Science, 177(4043), 77 LP-80.

Biederman, I., Mezzanotte, R. J., & Rabinowitz, J. C. (1982). Scene perception: Detecting and judging objects undergoing relational violations. *Cognitive Psychology, 14*(2), 143–177. doi:10.1016/0010-0285(82)90007-X

Brandt, K. R., Cooper, L. M., & Dewhurst, S. A. (2005). Expertise and recollective experience: recognition memory for familiar and unfamiliar academic subjects. *Applied Cognitive Psychology, 19*(9), 1113–1125. doi:10.1002/acp.1163

Brodeur, M. B., Chauret, M., Dion-Lessard, G., & Lepage, M. (2011). Symmetry brings an impression of familiarity but does not improve recognition memory. *Acta Psychologica, 137*(3), 359–370. doi:10.1016/j.actpsy.2011.04.005

Brodeur, M. B., Dionne-Dostie, E., Montreuil, T., & Lepage, M. (2010). The Bank of Standardized Stimuli (BOSS), a New Set of 480 Normative Photos of Objects to Be Used as Visual Stimuli in Cognitive Research. *PLoS ONE, 5*(5), e10773. doi:10.1371/journal.pone.0010773

Brodeur, M. B., Guérard, K., & Bouras, M. (2014). Bank of Standardized Stimuli (BOSS) Phase II: 930 New Normative Photos. *PLoS ONE, 9*(9), e106953. doi:10.1371/journal.pone.0106953

Cabeza, R., Rao, S. M., Wagner, A. D., Mayer, A. R., & Schacter, D. L. (2001). Can medial temporal lobe regions distinguish true from false? An event-related functional MRI study of veridical and illusory recognition memory. Proceedings of the National Academy of Sciences of the United States of America, 98(8), 4805–10. doi.org/10.1073/pnas.081082698

Cansino, S. (2002). Brain Activity Underlying Encoding and Retrieval of Source Memory. Cerebral Cortex, 12(10), 1048–1056.

Clark, H. J. (1968). Random shape recognition at brief exposure durations. *Psychonomic Science, 12*(6), 245–246. doi:10.3758/BF03331292

Clark, H. J., & James, H. (1965). Recognition memory for random shapes as a function of complexity, association value, and delay. *Journal of Experimental Psychology, 69*(6), 590–595. doi:10.1037/h0022011

Collen M, K., & Larry L, J. (2000). Recollection and familiarity. (The Oxford, pp. 215–228).

Cosman, J. D., & Vecera, S. P. (2013). Context-dependent control over attentional capture. *Journal of Experimental Psychology: Human Perception and Performance, 39*(3), 836–848. doi:10.1037/a0030027

Curran, T. (2000). Brain potentials of recollection and familiarity. Memory & Cognition, 28(6), 923–938. doi.org/10.3758/BF03209340

Curran, T. (2004). Effects of attention and confidence on the hypothesized ERP correlates of recollection and familiarity. Neuropsychologia, 42(8), 1088–106. doi.org/10.1016/j.neuropsychologia.2003.12.011

Curran, T., Schacter, D. L., Johnson, M. K., & Spinks, R. (2001). Brain potentials reflect behavioral differences in true and false recognition. J Cogn Neurosci, 13(2), p201-16. doi.org/10.1162/089892901564261

Dalton, P. (1993). The role of stimulus familiarity in context-dependent recognition. *Memory and Cognition, 21*(2), 223–234. doi:10.3758/BF03202735

Davenport, J. L., & Potter, M. C. (2004). Scene consistency in object and background perception. *Psychological Science, 15*(8), 559–564. doi:10.1111/j.0956-7976.2004.00719.x

Davies, G., & Milne, A. (1982). Recognizing faces in and out of context. *Current Psychological Research, 2*(1–3), 235–246. doi:10.1007/BF03186766

Davis, J. K., & Frank, B. M. (1979). Learning and memory of field independent-dependent individuals. *Journal of Research in Personality, 13*(4), 469–479. doi:10.1016/0092-6566(79)90009-6

Demick, J. (2014). Group Embedded Figures Test (GEFT) Sampler Set. Manual, Sample Figures and Scoring. Mind Garden, Inc.

Diana, R. A., Reder, L. M., Arndt, J., & Park, H. (2006). Models of recognition: a review of arguments in favor of a dual-process account. Psychonomic Bulletin & Review, 13(1), 1–21.

Düzel, E., Yonelinas, a P., Mangun, G. R., Heinze, H. J., & Tulving, E. (1997). Event-related brain potential correlates of two states of conscious awareness in memory. Proceedings of the National Academy of Sciences of the United States of America, 94(May), 5973–5978. doi.org/10.1073/pnas.94.11.5973

Dyck, M., & Brodeur, M. B. (2015). ERP evidence for the influence of scene context on the recognition of ambiguous and unambiguous objects. Neuropsychologia, 72, 43–51. doi.org/10.1016/j.neuropsychologia.2015.04.023

Eagle, M., Fitzgibbons, D., & Goldberger, L. (1966). Field dependence and memory for relevant and irrelevant stimuli. *Perceptual and Motor Skills, 23*(3f), 1035–1038. doi:10.2466/pms.1966.23.3f.1035

Ecker, U. K. H., Zimmer, H. D., Groh-Bordin, C., & Mecklinger, A. (2007). Context effects on familiarity are familiarity effects of context — An electrophysiological study. *International Journal of Psychophysiology, 64*(2), 146–156. doi:10.1016/j.ijpsycho.2007.01.005

Ecker, U. K., Zimmer, H. D., & Groh-Bordin, C. (2007a). Color and context: An ERP study on intrinsic and extrinsic feature binding in episodic memory. *Memory and Cognition, 35*(6), 1483-1501. doi:10.3758/BF03193618

Ecker, U. K., Zimmer, H. D., & Groh-Bordin, C. (2007b). The influence of object and background color manipulations on the electrophysiological indices of recognition memory. *Brain Research, 1185*, 221-230. doi:10.1016/j.brainres.2007.09.047

Emmett, D., Clifford, B. ., & Gwyer, P. (2003). An investigation of the interaction between cognitive style and context reinstatement on the memory performance of eyewitnesses. *Personality and Individual Differences, 34*(8), 1495–1508. doi:10.1016/S0191-8869(02)00131-9

Epstein, R., Graham, K. S., & Dowing, P. E. (2003). viewpoint-specific scene representation in human parahippocamapl cortex. Neuron, 37(5), 865–876.

Evans, C., Richardson, J. T. E., & Waring, M. (2013). Field independence: Reviewing the evidence. *British Journal of Educational Psychology, 83*(2), 210–224. doi:10.1111/bjep.12015

Fitzgibbons, D., Goldberger, L., & Eagle, M. (1965). Field dependence and memory for incidental material. *Perceptual and Motor Skills, 21*(3), 743–749. doi:10.2466/pms.1965.21.3.743

Frank, B. M. (1983). Flexibility of information processing and the memory of field-independent and field-dependent learners. *Journal of Research in Personality, 17*(1), 89–96. doi:10.1016/0092-6566(83)90063-6

Friedman, D., & Johnson, R. (2000). Event-related potential (ERP) studies of memory encoding and retrieval: A selective review. Microscopy Research and Technique, 51(1), 6–28.

Gevins, A., & Smith, M. E. (2000). Neurophysiological measures of working memory and individual differences in cognitive ability and cognitive style. *Cerebral Cortex, 10*(9), 829–839. doi:10.1093/CERCOR/10.9.829

Godden, D., & Baddeley, A. (1980). When does context influence recognition memory? British Journal of Psychology.

Godden, D. R., & Baddeley, A. D. (1975). Context-Dependent Memory In Two Natural Environments: On Land And Underwater. British Journal of Psychology, 66(3), 325–331. doi.org/10.1111/j.2044-8295.1975.tb01468.x

Goldmann, R. E., Sullivan, a L., Droller, D. B., Rugg, M. D., Curran, T., Holcomb, P. J.,Budson, a E. (2003). Late frontal brain potentials distinguish true and false recognition. Neuroreport, 14(13), 1717–1720. doi.org/10.1097/01.wnr.0000087908.78892.23

Goldstein, A. G., & Chance, J. E. (1971). Visual recognition memory for complex configurations. *Perception and Psychophysics, 9*(2), 237–241. doi:10.3758/BF03212641

Green, C., & Hummel, J. E. (2006). Familiar interacting object pairs are perceptually grouped. Journal of Experimental Psychology: Human Perception and Performance, 32(5), 1107–1119.

Groh-Bordin, C., Zimmer, H. D., & Ecker, U. K. H. (2006). Has the butcher on the bus dyed his hair? When color changes modulate ERP correlates of familiarity and recollection. NeuroImage, 32(4), 1879–90. doi.org/10.1016/j.neuroimage.2006.04.215

Gruppuso, V., Lindsay, D. S., & Masson, M. E. J. (2007). I'd know that face anywhere! *Psychonomic Bulletin and Review, 14*(6), 1085–1089. doi:10.3758/BF03193095

Guisande, M. A., Páramo, M. F., Tinajero, C., & Almeida, L. S. (2007). Field dependence-independence (FDI) cognitive style: An analysis of attentional functioning. *Psicothema, 19*(4), 572–577.

Hayes, S. M., Baena, E., Truong, T.-K., & Cabeza, R. (2010). Neural mechanisms of context effects on face recognition: Automatic binding and context shift decrements. *Journal of Cognitive Neuroscience, 22*(11), 2541–2554. doi:10.1162/jocn.2009.21379

Hayes, S. M., Nadel, L., & Ryan, L. (2007). The effect of scene context on episodic object recognition: Parahippocampal cortex mediates memory encoding and retrieval success. *Hippocampus, 17*(9), 873–889. doi:10.1002/hipo.20319

Hicks, J. L., & Marsh, R. L. (2001). False recognition occurs more frequently during source identification than during old–new recognition. Journal of Experimental Psychology: Learning, Memory, and Cognition, 27(2), 375–383.

Hockley, W. E. (2008). The effects of environmental context on recognition memory and claims of remembering. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 34*(6), 1412–1429. doi:10.1037/a0013016

Hollingworth, A. (2006). Scene and position specificity in visual memory for objects. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *32*(1), 58-69. doi:10.1037/0278-7393.32.1.58

Hsu, N. S., Kraemer, D. J. M., Oliver, R. T., Schlichting, M. L., & Thompson-Schill, S. L. (2011). Color, Context, and Cognitive Style: Variations in Color Knowledge Retrieval as a Function of Task and Subject Variables. *Journal of Cognitive Neuroscience, 23*(9), 2544–2557. doi:10.1162/jocn.2011.21619

Jacoby, L. L. (1991). A Process Dissociation Framework: Separating Automatic from Intentional Uses of Memory. Jornal of Memory and Language.

Jackson, M. C., & Raymond, J. E. (2008). Familiarity enhances visual working memory for faces. *Journal of Experimental Psychology: Human Perception and Performance, 34*(3), 556–568. doi:10.1037/0096-1523.34.3.556

Jesky, R., & Berry, L. (1991). The effects of pictoral complexity and cognitive style on visual recall memory. Paper presented at the Annual Meeting of the Association for Educational Communications and Technology. IR 015 132

Jia, S., Zhang, Q., & Li, S. (2014). Field dependence–independence modulates the efficiency of filtering out irrelevant information in a visual working memory task. *Neuroscience, 278*, 136–143. doi:10.1016/j.neuroscience.2014.07.075

Johansson, M., & Mecklinger, A. (2003). The late posterior negativity in ERP studies of episodic memory: action monitoring and retrieval of attribute conjunctions. Biological Psychology, 64, 91–117. doi.org/10.1016/S0301-0511(03)00104-2

Kim, H., & Cabeza, R. (2007). Trusting our memories: dissociating the neural correlates of confidence in veridical versus illusory memories. The Journal of Neuroscience : The Official Journal of the Society for Neuroscience, 27(45), 12190–7.

Kim, J. G., & Biederman, I. (2011). Where do objects become scenes? Cerebral Cortex, 21(8), 1738–1746.

Kosmidis, M. H., Tsotsi, S., Karambela, O., Takou, E., & Vlahou, C. H. (2010). Cultural factors influencing performance on visuoperceptual neuropsychological tasks. Behavioural Neurology, 23(4), 245–7.

Kozhevnikov, M. (2007). Cognitive styles in the context of modern psychology: Toward an integrated framework of cognitive style. *Psychological Bulletin, 133*(3), 464–481. doi:10.1037/0033-2909.133.3.464

Li, M., Han, D., Lu, S., Liu, Z., & Zhong, N. (2012). Associative Information Processing in Parahippocampal Place Area (PPA): An fMRI Study. In International Conference on Brain informatics (pp. 1–9). Springer Berlin Heidelberg.

Macken, W. J. (2002). Environmental context and recognition: The role of recollection and familiarity. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 28*(1), 153–161. doi:10.1037//0278-7393.28.1.153

Mandler, G. (1980). Recognizing: The judgment of previous occurrence. Psychological Review, 87(3), 252–271. doi.org/10.1037/0033-295X.87.3.252

Mandler, G. (2008). Familiarity Breeds Attempts: A Critical Review of Dual-Process Theories of Recognition. Perspectives on Psychological Science, 3(5), 390–399. doi.org/10.1111/j.1745-6924.2008.00087.x

Mather, M., Henkel, L. A., & Johnson, M. K. (1997). Evaluating characteristics of false memories: Remember/know judgments and memory characteristics questionnaire compared. *Memory and Cognition, 25*(6), 826–837. doi:10.3758/BF03211327

Mathôt, S., Schreij, D., & Theeuwes, J. (2012). OpenSesame: an open-source, graphical experiment builder for the social sciences. *Behavior Research Methods, 44*(2), 314–24. doi:10.3758/s13428-011-0168-7

Mecklinger, A., Johansson, M., Parra, M., & Hanslmayr, S. (2007). Source-retrieval requirements influence late ERP and EEG memory effects. Brain Research, 1172, 110–123. doi.org/10.1016/j.brainres.2007.07.070

Miller, M. B., & Gazzaniga, M. S. (1998). Creating false memories for visual scenes. *Neuropsychologia, 36*(6), 513–520. doi:10.1016/S0028-3932(97)00148-6

Morcom, A. M. (2015). Resisting false recognition: An ERP study of lure discrimination. Brain Research, 1624, 336–48.

Murnane, K., & Phelps, M. P. (1994). When does a different environmental context make a difference in recognition? A global activation model. *Memory and Cognition, 22*(5), 584–590. doi:10.3758/bf03198397

Murnane, K., Phelps, M. P., & Malmberg, K. (1999). Context-dependent recognition memory: The ICE theory. *Journal of Experimental Psychology: General, 128*(4), 403–415. doi:10.1037/0096-3445.128.4.403

Norman, K. A., & Schacter, D. L. (1997). False recognition in younger and older adults: Exploring the characteristics of illusory memories. *Memory and Cognition, 25*(6), 838–848. doi:10.3758/BF03211328

Oliva, A., & Torralba, A. (2006). Building the gist of a scene: the role of global image features in recognition. *Progress in Brain Research, 155*, 23–36. doi:10.1016/S0079-6123(06)55002-2

Ohnmacht, F. W. (1966). Effects of field independence and dogmatism on reversal and nonreversal shifts in concept formation. *Perceptual and Motor Skills, 22*(2), 491-497. doi:10.2466/pms.1966.22.2.491

Palmer, T. E. (1975). The effects of contextual scenes on the identification of objects. *Memory and Cognition, 3*(5), 519–526. doi:10.3758/BF03197524

Park, D. C., Puglisi, J. T., & Sovacool, M. (1984). Picture memory in older adults: effects of contextual detail at encoding and retrieval. *Journal of Gerontology, 39*(2), 213–5. doi:10.1093/GERONJ/39.2.213

Price, R. H., & Slive, A. B. (1970). Verbal processes in shape recognition. *Journal of Experimental Psychology, 83*(3, Pt.1), 373–379. doi:10.1037/h0028847

Reder, L. M., Victoria, L. W., Manelis, A., Oates, J. M., Dutcher, J. M., Bates, J. T., Cook, S., Aizenstein, H. J., Quinlan, J., & Gyulai, F. (2013). Why it’s easier to remember seeing a face we already know than one we don’t: Preexisting memory representations facilitate memory formation. *Psychological Science, 24*(3), 363–372. doi:10.1177/0956797612457396

Riedel, G. (2003). Glutamate receptor function in learning and memory. Behavioural Brain Research, 140(1–2), 1–47. doi.org/10.1016/S0166-4328(02)00272-3

Riding, R. J., & Sadler-Smith, E. (1997). Cognitive style and learning strategies: Some implications for training design. *International Journal of Training and Development, 1*(3), 199–208. doi:10.1111/1468-2419.00020

Rugg, M. D., & Curran, T. (2007a). Event-related potentials and recognition memory. Trends in Cognitive Sciences, 11(6), 251–7.

Rugg, M. D., & Curran, T. (2007b). Event-related potentials and recognition memory. Trends in Cognitive Sciences, 11(6), 251–7. doi.org/10.1016/j.tics.2007.04.004

Rugg, M. D., Mark, R. E., Walla, P., Schloerscheidt, A. M., Birch, C. S., & Allan, K. (1998). Dissociation of the neural correlates of implicit and explicit memory. Nature, 392(6676), 595–598. doi.org/10.1038/33396

Russo, R., Ward, G., Geurts, H., & Scheres, A. (1999). When unfamiliarity matters: Changing environmental context between study and test affects recognition memory for unfamiliar stimuli. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 25*(2), 488–499. doi:10.1037/0278-7393.25.2.488

Rutherford, A. (2004a). Environmental context-dependent recognition memory effects: An examination of ICE model and cue-overload hypotheses. The Quarterly Journal of Experimental Psychology, 57A(1), 107–127.

Schacter, D. L. (1999). The seven sins of memory: insights from psychology and cognitive neuroscience. American Psychologist, 54(3), 182. doi.org/10.1037/0003-066X.54.3.182

Schacter, D. L., Alpert, N. M., Savage, C. R., Rauch, S. L., & Albert, M. S. (1996). Conscious recollection and the human hippocampal formation: evidence from positron emission tomography. *Proceedings of the National Academy of Sciences of the United States of America, 93*(1), 321–325. doi:10.1073/pnas.93.1.321

Schloerscheidt, A. M., & Rugg, M. D. (2004). The impact of change in stimulus format on the electrophysiological indices of recognition. Neuropsychologia, 42(4), 451–66.

Slotnick, S. D., & Schacter, D. L. (2004). A sensory signature that distinguishes true from false memories. *Nature Neuroscience, 7*(6), 664–672. doi:10.1038/nn1252

Smith, S. M. (1988). Environmental context—dependent memory. in D. M. Davies, Graham M.; Thomson, Ed. Oxford, England: John Wiley & Sons.

Smith, S. M. (2013). Effects of environmental context on human memory. In The SAGE handbook of applied memory (pp. 163–182).

Smith, S. M., & Rothkopf, E. Z. (1984). Contextual Enrichment and Distribution of Practice in the Classroom. *Cognition and Instruction, 1*(3), 341–358. doi:10.1207/s1532690xci0103_4

Smith, S. M., Glenberg, A., & Bjork, R. A. (1978). Environmental context and human memory. Memory & Cognition, 6(4), 342–353. doi.org/10.3758/BF03197465

Snodgrass, J. G., & Corwin, J. (1988). Pragmatics of measuring recognition memory: Applications to dementia and amnesia. *Journal of Experimental Psychology: General, 117*(1), 34–50. doi:10.1037/0096-3445.117.1.34

Snodgrass, J. G., & Vanderwart, M. (1980). A standardized set of 260 pictures: Norms for name agreement, image agreement, familiarity, and visual complexity. *Journal of Experimental Psychology: Human Learning and Memory, 6*(2), 174–215. doi:10.1037/0278-7393.6.2.174

Tanabe-Ishibashi, A., Ikeda, T., & Osaka, N. (2014). Raise two effects with one scene: scene contexts have two separate effects in visual working memory of target faces. *Frontiers in Psychology, 5*(400), 1–8. doi:10.3389/fpsyg.2014.00400

Tsivilis, D., Allan, K., Roberts, J., Williams, N., Joseph Downes, J., El-Deredy, W., … James Addante, R. (2015). Old-new ERP effects and remote memories: the late parietal effect is absent as recollection fails whereas the early mid-frontal effect persists as familiarity is retained. doi.org/10.3389/fnhum.2015.00532

Tsivilis, D., Otten, L. J., & Rugg, M. D. (2001). Context Effects on the Neural Correlates of Recognition Memory. *Neuron, 31*(3), 497–505. doi:10.1016/S0896-6273(01)00376-2

Tulving, E. (1972). Episodic and semantic memory. In E. Tulving & W. Donaldson (Eds.), Organization of memory (pp. 3824(4). NewYork: Academic Press.

Tulving, E. (1983). Elements of episodic memory (Oxford). New York.

Tulving, E., Markowitsch, H. J., & Craik, F. I. M. (1996). Novelty and Familiarity Activations in PET Studies of Memory Encoding and Retrieval, 71–79.

Tulving, E., Schacter, D. L., & Stark, H. A. (1982). Priming effects in word-fragment completion are independent of recognition memory. *Journal of Experimental*

Psychology: Learning, Memory, and Cognition, 8(4), 336–342. doi:10.1037/0278-7393.8.4.336

Underwood, B. J., & J., B. (1965). False recognition produced by implicit verbal responses. Journal of Experimental Psychology, 70(1), 122–129.

Vilberg, K. L., Moosavi, R. F., & Rugg, M. D. (2006). The relationship between electrophysiological correlates of recollection and amount of information retrieved. Brain Research, 1122(1), 161–170. doi.org/10.1016/j.brainres.2006.09.023

Voss, J. L., & Federmeier, K. D. (2011). FN400 potentials are functionally identical to N400 potentials and reflect semantic processing during recognition testing. Psychophysiology, 48(4), 532–46.

Wilding, E. L., Doyle, M. C., & Rugg, M. D. (1995). Recognition memory with and without retrieval of context: an event-related potential study. Neuropsychologia, 33(6), 743–67. doi.org/10.1016/0028-3932(95)00017-W

Winograd, E., & Rivers-Bulkeley, N. T. (1977). Effects of changing context on remembering faces. *Journal of Experimental Psychology: Human Learning and Memory, 3*(4), 397–405. doi:10.1037/0278-7393.3.4.397

Windmann, S. (2002b). Cognitive and Neural Mechanisms of Decision Biases in Recognition Memory. Cerebral Cortex, 12(8), 808–817.

Witkin, H. A., Moore, C. A., Goodenough, D. R., & Cox, P. W. (1975). Field-dependent and field-independent cognitive styles and their educational implications. ETS Research Bulletin Series, 1975(2), 1–64. doi:10.1002/j.2333-8504.1975.tb01065.x

Witkin, H. A., Olman, P., & Raskin, E. (1971). The Group Embedded Figure Test (GEFT). Mind Garden, Inc.

Yonelinas, A. P. (2001). Components of episodic memory: the contribution of recollection and familiarity. Philosophical Transactions of the Royal Society of London B: Biological Sciences, 356(1413).

Yonelinas, A. P. (2002). The Nature of Recollection and Familiarity: A Review of 30 Years of Research. *Journal of Memory and Language, 46*(3), 441–517. doi:10.1006/jmla.2002.2864