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Verbal predicates foster conscious recollection but not familiarity of a task-irrelevant perceptual feature – An ERP study

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ABSTRACT

Research on the effects of perceptual manipulations on recognition memory has suggested that (a) recollection is selectively influenced by task-relevant information and (b) familiarity can be considered perceptually specific. The present experiment tested divergent assumptions that (a) perceptual features can influence conscious object recollection via verbal code despite being task-irrelevant and that (b) perceptual features do not influence object familiarity if study is verbal-conceptual. At study, subjects named objects and their presentation colour; this was followed by an old/new object recognition test. Event-related potentials (ERP) showed that a study-test manipulation of colour impacted selectively on the ERP effect associated with recollection, while a size manipulation showed no effect. It is concluded that (a) verbal predicates generated at study are potent episodic memory agents that modulate recollection even if the recovered feature information is task-irrelevant and (b) commonly found perceptual match effects on familiarity critically depend on perceptual processing at study.

1. Introduction

Recognition memory refers to the ability to remember something previously experienced when it is encountered again. It is widely assumed that at least two distinct processes contribute to recognition memory: familiarity and recollection. Familiarity is usually considered a rather automatic process conveying a general feeling of knowing that something has been encountered before, without allowing conscious access to any specific episodic detail (such as the time and place of the previous encounter, or the name of a familiar person). On the other hand, conscious recollection is usually thought to involve the rather controlled retrieval of such specific spatiotemporal or featural detail associated with a study episode (for reviews, see Diana, Reder, Arndt, & Park, 2006; Ecker, 2007; Yonelinas, 2002; Zimmer, Mecklinger, & Lindenberger, 2006).

Hence, the two processes are associated with different conscious experiences. The process generating the familiarity signal is cognitively impenetrable (Fodor, 1983). Participants have conscious access to the result of this process, that is, the level of familiarity, but they cannot say what the basis of their feeling of familiarity is. In contrast, recollection is at least in part a cognitively penetrable process. Participants have the conscious experience that a stimulus was a member of a specific episode because they can retrieve contextual details, and they can communicate this (cf. Gardiner & Java, 1993).

It is furthermore assumed that a conscious experience at test requires a conscious experience at study. Moscovitch (1992) explicitly formulated this principle in his consciously-in/consciously-out hypothesis. If we apply this to a recognition

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experiment, we should expect that any manipulation that increases conscious processing during study should enhance recollection, simply because it generates possible candidates in memory for later recollection. Many observations of enhanced recognition performances after extended encoding operations could be quoted in support of this assumption. However, the variation of conscious encoding processes should not only influence memory performances, but also the electrophysiological correlates of recognition memory.

The two processes of familiarity and recollection have been associated with distinct and quite consistently found event-related potential (ERP) old–new effects. For example, the two ERP effects show differential sensitivity to depth-of-processing manipulations.[1] Familiarity is associated with an early (ca. 300–500 ms post test stimulus onset) mid-frontocentral ERP old–new effect, while a late (ca. 500–700 ms) left-parietal ERP old–new effect is thought to reflect recollection.

ERP old–new effects vary in amplitude with the quantity and quality of retrieved information (Vilberg, Moosavi, & Rugg, 2006; Vilberg & Rugg, 2007; Wilding, 2000). Hence, the degree of match between the accessed memory representation and the presented test probe will determine the old–new effects. Effect amplitudes are reduced if some information unit is present in both the probe and the reconstructed representation, but with mismatching values (e.g., someone you remember to be John is introduced as Jack). We refer to these kinds of effects as match effects. As will be discussed below, familiarity and recollection are assumed to rely on distinct memory representations. The content of these representations will overlap but they may contain differing information, so there may be a dissociation between match effects in familiarity- and recollection-related ERP components.

Following from the introductory thoughts, the two ERP retrieval effects should be sensitive to the degree of conscious encoding. In the present study, we led subjects to consciously encode a specific perceptual feature of common objects (their colour). In the subsequent old/new recognition test, we changed either the colour or the presentation size of a subset of old items. One general prediction could then be that the recollection-related ERP old–new effect should be reduced for old items with a changed colour, but nor for old items with a changed size.

Before we concretise this prediction, we will first discuss the role of perceptual features for recognition memory, and explain our general experimental approach to its investigation—the study-test manipulation of sensory features.

1.1. Perceptual features in recognition memory

A typical perceptual study-test manipulation is the manipulation of object colour. Subjects study a list of arbitrarily coloured objects (e.g., a blue[2] car, a red balloon, etc.) and are then tested with a mixed list of old-same, old-different, and new items (e.g., a blue car, a green balloon, and a yellow shirt). They can be instructed to ignore the perceptual features and any changes to them, or they can be asked to accept only exact copy cues as 'old' (i.e., studied) items. As discussed above, standard dual-process theories of recognition memory would predict that retrieval of an episodic detail such as object colour would need to rely on conscious recollection.

In contrast, some recent ERP studies from our lab have demonstrated that familiarity can also contribute to recognition memory for featural detail (Ecker & Zimmer, in press; Ecker, Zimmer, & Groh-Bordin, 2007a, 2007b). To be more precise, the study-test manipulation of perceptual object features such as the object's colour seems to affect familiarity, whereas the manipulation of contextual information such as the background's colour selectively affects recollection. That is, identically repeated old items will elicit larger ERP old–new effects than changed ones, and these perceptual match effects will affect familiarity and recollection components depending on whether the feature is intrinsic to the object or part of the extrinsic context.

We have further claimed that this dissociation is asymmetric insofar as contextual features should under no circumstances directly influence familiarity (see in particular Ecker, Zimmer, Groh-Bordin, & Mecklinger, 2007c), whereas intrinsic object features may potentially affect both familiarity and recollection. The reason for this asymmetry lies in the supposed hierarchic structure of representations, such that the higher-level binding of object and context information includes the lower-level binding of object features,[3] so there could be some redundancy in mnemonic feature representation (cf. Johnson & Chalfonte, 1994; for a somewhat similar proposal of different representational formats, see Buchler, Light, & Reder, in press, and especially Reder et al., 2000).

Concerning the mechanism by which intrinsic object features are integrated with perceptual and spatiotemporal context information at a higher level (an operation probably requiring hippocampal binding; Cansino, Maquet, Dolan, & Rugg, 2002; Daselaar, Fleck, & Cabeza, 2006), we have speculated that verbal predicates, such as "oh, blue is a nice colour for that car", may constitute well-integrated memory entries with high levels of conscious accessibility and may hence play a vital role in the recollection of perceptual object properties (cf. Ecker et al., 2004).

Thus, features can be represented both on a sensory level and a more conceptual verbal level (Engelkamp & Zimmer, 1994; Ikeda & Osaka, 2007; Paivio, 1995, 2007), and this level of representation may well affect the output level at which features affect memory retrieval (i.e., familiarity and/or recollection). Sensory features are part of a visual representation

[1] Concerning the general association of distinct ERP old-new effects and the processes of recollection and familiarity, see Ecker (2007), Friedman and Johnson (2000), or Rugg and Curran (2007) for reviews.

[2] For interpretation of color in Figs. 1 and 5, the reader is referred to the web version of this article.

[3] We have previously used the terms object token and episodic token for the lower-level and higher-level type of representation, respectively (cf. Ecker, 2007; Ecker, Groh-Bordin, & Zimmer, 2004; Ecker et al., 2007a).

of a perceived stimulus and they are not necessarily conscious (hence manipulating the colour of an object may make this less familiar even if the change is not consciously noticed), whereas verbal descriptions are explicit, consciously available predicates of sensory attributes (hence manipulating the colour of an object may lead to weaker recollection because the study colour may not be recollectable if its verbal label is not addressed by the mismatching cue).

These assumptions are based, inter alia, on the following findings: Manipulating left–right orientation, Groh-Bordin, Zimmer, and Mecklinger (2005) found no impact of perceptual match on the recollection ERP effect following incidental study. In contrast, when subjects are instructed to intentionally memorise and integrate an item and a specific (intrinsic) feature, congruency effects on recollection are usually obtained (Curran, 2000; Curran & Cleary, 2003; Ecker et al., 2007a; Groh-Bordin, Zimmer, & Ecker, 2006). Now, it may be assumed that the intention to remember an item should enhance recollection per se (Macken & Hampson, 1993), but the behavioural literature (cf. Craik & Lockhart, 1972; Craik & Tulving, 1975; Hyde & Jenkins, 1969) suggests that it is not primarily the intention to study itself, but rather the type of processing that determines memory performance (and also the level of hippocampal involvement, see Rugg, Fletcher, Frith, Frackowiak, & Dolan, 1997). In this vein, the intention to study will typically lead subjects to integrate the study item with contextual information, so the impact of study intention is indirect. In particular, deliberate encoding may increase the likelihood of generating explicit verbal predicates that foster recollection. Verbalising perceptual stimulus qualities is thus considered a strategy to make these features available to consciousness and hence recollection (cf. Moscovitch, 1992).

1.2. Aims and hypotheses

Immediately following from this, the present study served to directly test the effect of generating basic verbal predicates of perceptual object features at study on later recollection. It is assumed that verbalisation leads to an easily and consciously available object-colour association, which fosters recollection. When the presented test probe matches this representation of the studied item, it will address the full representation, leading to a full-blown reinstantiation, which should yield a large recollection-related ERP effect. In contrast, along the logic presented above, if colour is changed the test probe will not address the full representation and the ERP old–new effect should be reduced.

As indicated above, recollection is considered a controlled process that is modulated selectively by features that are task-relevant (de Chastelaine, Friedman, & Cycowicz, 2007; Ecker et al., 2007a; Wilding, Fraser, & Herron, 2005). In the present case, we instructed participants to ignore perceptual changes—rendering the features colour and size task-irrelevant—, to test if the mnemonic potency of the verbal predicate could override task-irrelevance.

Put simply, if participants verbalise the colour of an object at study, and colour is then (irrelevantly) changed at test, this manipulation should affect recollection. The task-irrelevant manipulation of size, however,—a feature that was not named at study—should not reduce the recollection-related old–new effect. Hence, a perceptual study-test manipulation should only affect recollective processing if a corresponding verbal feature predicate was generated in the prior study phase.

The second aim of the study was concerned with familiarity. As adumbrated above, the calculation of a familiarity signal can rely on varying amounts of perceptual and conceptual processing. The study task determines how an item is encoded into memory in the first place. Consequentially, the influence of a conceptual and sensory match between the study and test item depends heavily on characteristics of the study and/or test task (cf. Ecker & Zimmer, in press). In particular, perceptual features should only influence familiarity if the focus at both study and test is on perceptual processing to a certain degree.

As discussed above, in our previous studies this was the case; subjects were typically instructed to memorise objects together with their perceptual features. Test ERPs suggested an automatic (i.e., independent of task-relevance) influence of perceptual features on familiarity processing. In the present study, however, we asked participants to verbalise (i.e., conceptual processing). This allows us to test whether the familiarity component still depends on perceptual similarity between study and test in the absence of a perceptual focus. That is, would the typically found perceptual match effect on the familiarity-related old–new effect disappear when the study task was made more conceptual?

In the present study, what is memorised should primarily be the verbal (i.e., conceptual) label, not the sensory attribute itself. Therefore, we hypothesised that the impact of the feature manipulation on familiarity and the associated ERP old–new effect should be attenuated so that only a general familiarity old–new effect occurs that is not modulated by the perceptual study-test match (in line with Curran, 2000; Curran & Cleary, 2003).

Such a finding would be evidence for the proposed flexible involvement of perceptual and conceptual processing in the calculation of object familiarity. It would also provide evidence against accounts that consider familiarity a fluency-like process akin to perceptual implicit memory (e.g., Jacoby & Dallas, 1981; Mandler, 1991), in line with recent evidence that perceptual fluency mainly influences guessing, not familiarity (Tunney & Fernie, 2007).

Finally, previous research has shown that irrelevant perceptual changes slow down responses (Cooper, Biederman, & Hummel, 1992; Jolicoeur, 1987; Zimmer & Steiner, 2003; see Engelkamp, Zimmer, & de Vega, 2001, for a review). It is likely that such match effects of irrelevant perceptual manipulations are typically based on reductions in familiarity (Groh-Bordin et al., 2005; Srinivas & Verfaellie, 2000). Following from the above, however, if verbalisation makes perceptual feature information highly accessible via recollection, a colour change but not a size change should slow down reaction times because of the mismatch of the probe and the mnemonic representation.

2. Methods

The experiment was designed to test the indirect influence of a task-irrelevant study-test manipulation of colour on object recognition memory. For this purpose, an inclusion task (i.e., an object old/new recognition task with instructions to accept as old any studied object irrespective of changes in presentation colour or size) was used to assess recognition memory following a colour-oriented naming task at study.

2.1. Participants, materials, and design

Twelve subjects, all students at Saarland University (eight female, mean age 24.8 years, age range 21–29 years), participated in this experiment and were paid for their effort. The experiment took place in an electromagnetically shielded cabin, and participants sat about 80 cm from the screen. Stimuli were fully coloured line drawings of everyday objects. There were six different presentation colours: red, magenta, green, dark blue, turquoise, and yellow. Every object existed in two colour versions and two size versions (max. expansion 300 and 170 pixels, respectively). Fig. 1 shows an item sample.

Subjects intentionally studied a total of 108 objects presented centrally on a computer screen for 2 s each. They were instructed to speak out loud each object's verbal label and presentation colour (e.g., "a blue kite"; this was controlled by the experimenter). Before the first study phase, there were six practice trials (each colour featured once) to make subjects familiar with the study task. Throughout all test phases, subjects responded by pressing the C and M keys of a standard keyboard. Response-to-key mappings were counterbalanced across subjects to avoid undue EEG lateralisation effects.

There were three study-test blocks, in which subjects' recognition memory was tested with 60 items per test block. In each block, 12 studied items were identically repeated (Same condition), 12 studied items were repeated in a different colour version (Colour-Different condition), 12 studied items were repeated in another size (Size-Different condition), and there were 24 completely new items (New condition). In total this resulted in 36 Same items, 36 Colour-Different items (old item, different colour), 36 Size-Different items (old item, different size), and 72 New items.

Exactly half the items in the study phases and each test condition were presented in their large and small versions, respectively. Also, first and second presentation colours as well as their transitions were counterbalanced within each subject. Most objects had no specific prototypical colour; yet, to preclude an influence of pre-existing semantic knowledge, both colour versions of a specific object were designed to match in terms of semantic appropriateness (e.g., a chilli pepper may have existed in red and green, or in turquoise and dark blue).

2.2. EEG/ERP methods

The EEG was recorded from 63 Ag/AgCl electrodes arranged according to the extended international 10–20 system (Easycap GmbH, Herrsching-Breitbrunn, Germany). Sampling rate was 250 Hz, and signals were amplified with an AC coupled amplifier (Brain Amp MR, Brain Products, Munich; time constant 10 s, analogue low-pass filter 70 Hz, notch filter 50 Hz). A left mastoid reference was used, but signals were re-referenced offline to averaged mastoids. EOG artefacts picked up by four ocular electrodes (two above and below the right eye, and two further electrodes at the outer canthi of both eyes) were corrected offline (Gratton, Coles, & Donchin, 1983). Before averaging, trials containing artefacts (lowest activity in successive 100 ms intervals ±0.5 μV, maximum amplitude in the segment ±100 μV, maximum voltage step between two

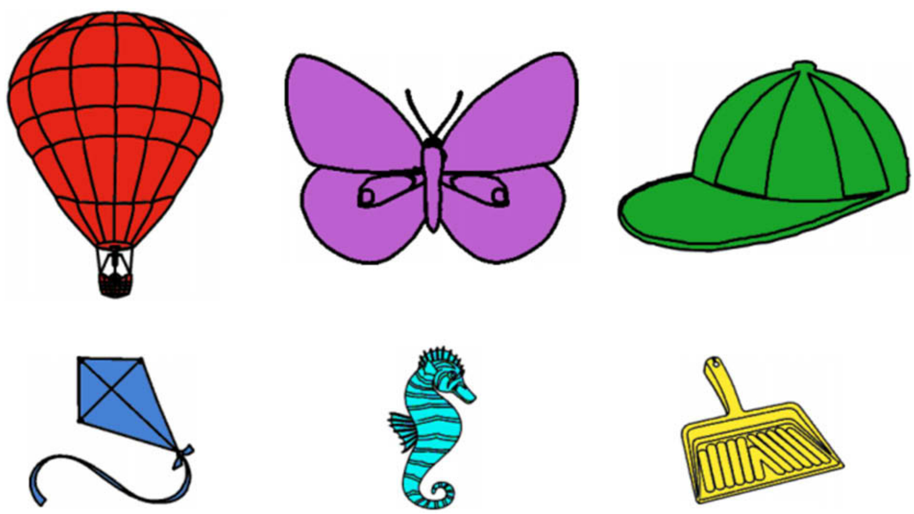

Fig. 1. Examples of items used.

successive sampling points 50 μV, maximum difference between any two sampling points within an epoch 100 μV) were excluded (2.5% of trials). Digital bandpass filtering was applied between 0.2 and 20 Hz.

ERPs were calculated by time-locked signal averaging, using the time window from −200 to 1000 ms relative to stimulus onset. Data were baseline corrected using the 200 ms before stimulus onset. Analysis was based on trials with correct responses, resulting in the following mean trial numbers per condition: New/Same/Colour-Different/Size-Different; 68/34/33/34. The minimum number of trials per condition included in a grand average was 30. Statistical analyses were performed by means of repeated measures ANOVAs on mean voltages in several different time windows (details see Section 3), using the Greenhouse–Geisser correction, and followed up by planned comparisons. Nine regions of interest (ROIs) forming a three-by-three grid were formed by averaging signals from the following electrodes: left-frontal: AF3, F3, F5; mid-frontal: F1, F2, Fz; left-central: C3, C5, TP7; mid-central: C1, C2, Cz; left-posterior: CP3, CP5, P3; mid-posterior: P1, P2, Pz; and the respective right counterparts to left-sided regions and electrodes. The resulting three-level anterior–posterior (AP) and laterality (Lat) factors were used in all ERP analyses.

3. Results

3.1. Behavioural results

Object recognition memory performance is shown in Fig. 2. Subjects showed nearly perfect accuracy, and a repeated measures ANOVA with the sole factor Condition (Same/Colour-Different/Size-Different) on discrimination scores (*Pr* = hit rate–false alarm rate; Snodgrass & Corwin, 1988) yielded no significant effect ($F < 1$).

Response latencies are shown in Fig. 3. A Condition (Same/Colour-Different/Size-Different/New) ANOVA on RTs of correct responses yielded a significant main effect of Condition, $F(3, 33) = 8.19$, $p < .001$. A post-hoc Tukey test confirmed that RTs were higher for New than for Same or Size-Different items (778 ms vs. 722/735 ms, $ps < .01$). The Condition main effect was confirmed in an analysis on hit RTs only, $F(2, 22) = 3.72$, $p = .04$. A Tukey test revealed a significant difference between Same and Colour-Different RTs (722 vs. 753 ms, $p = .03$).

3.2. ERP results

Grand average ERPs of correct responses in the object recognition test at representative ROIs are depicted in Fig. 4, topographic maps are shown in Fig. 5. Waveforms corresponding to old and new items differ from about 250 to 650 ms. The early part of the effect is rather broad and maximal at mid-central electrodes, while the latter part shows a posterior and left-lateralised topography. Based on previous research, the early part of the effect most likely reflects familiarity processing, and the latter part recollection (see Section 1). The latter effect is apparently larger for Same vs. Colour-Different repetitions, especially at the left-posterior ROI.

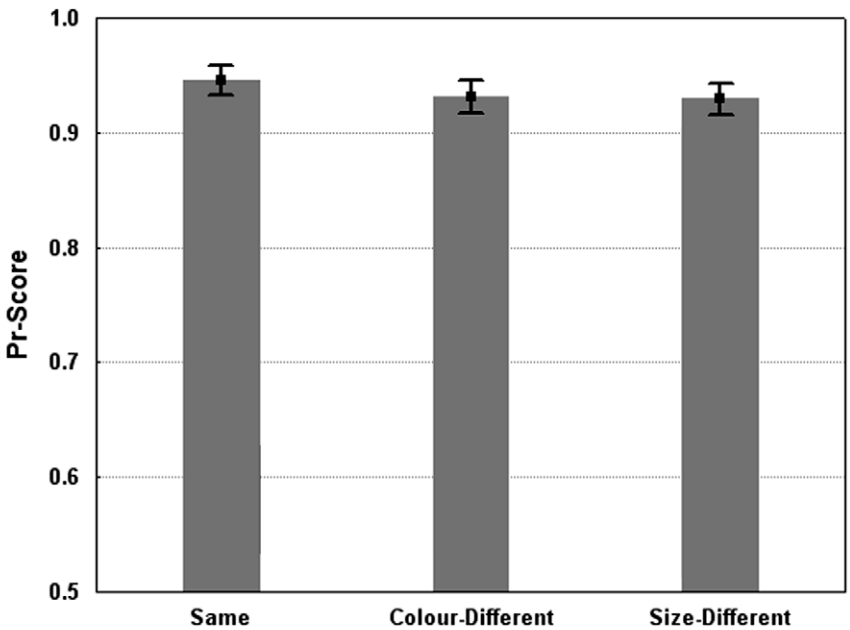

Fig. 2. Object recognition memory performance across study-test conditions. Error bars denote standard errors of the mean.

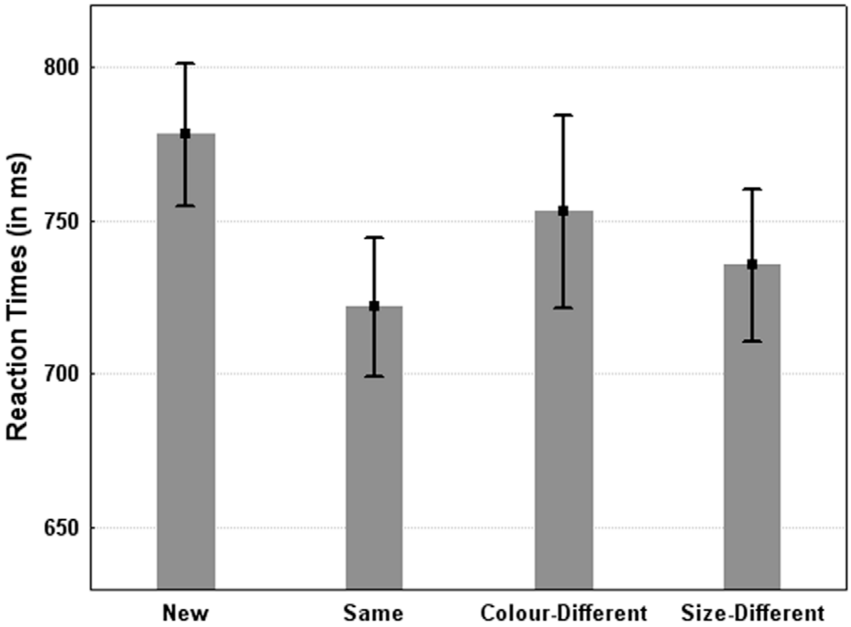

Fig. 3. Mean reaction times of correct responses across study-test conditions. Error bars denote standard errors of the mean.

Based on the literature and visual inspection, time windows for analysis were set to 250–450 and 450–650 ms. It is assumed that the rather simple task and the ease of identification contributed to the fact that effects onset around 50 ms earlier than usual.

In time window 1 (250–450 ms), an AP × Lat × Condition (New/Same/Colour-Different/Size-Different) ANOVA yielded a significant 3-way interaction, $F(12, 132) = 2.67$, $p < .05$. Planned comparisons revealed equivalent mid-frontocentral old–new

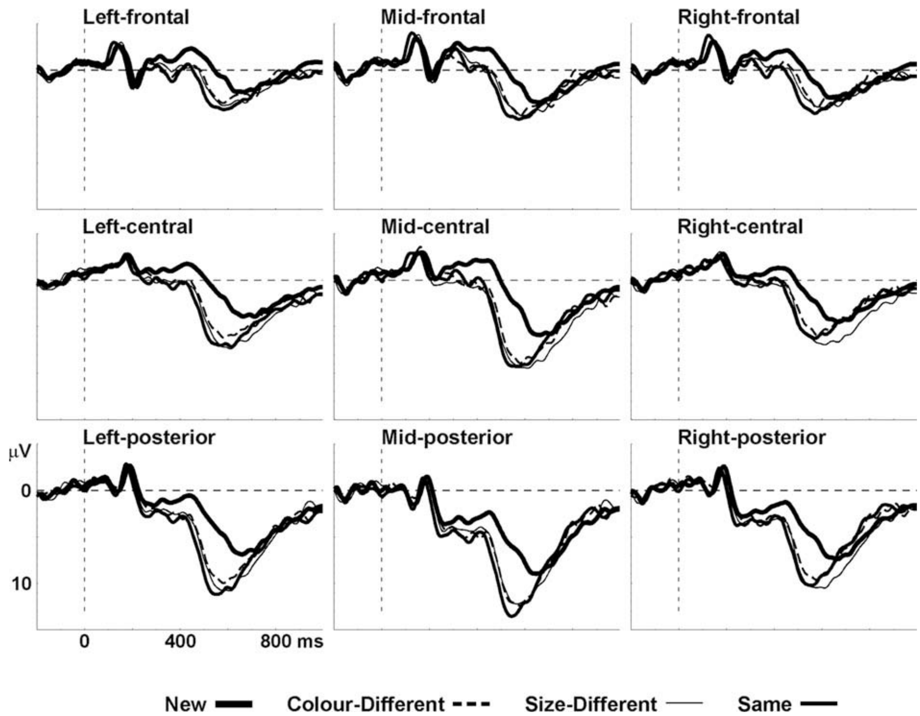

Fig. 4. Topographically arranged (ROI) grand average ERP data.

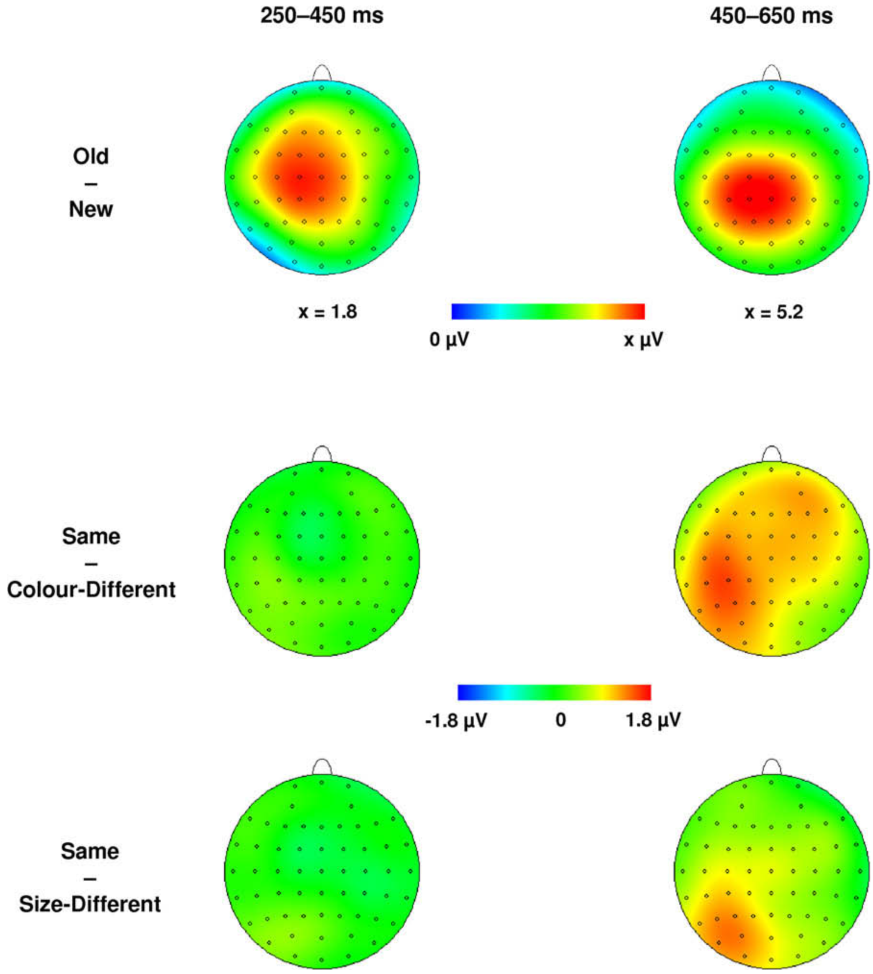

Fig. 5. Topographic maps of old–new effects (top panel) and perceptual match effects (bottom panels).

effects for all three old item conditions (comparisons were calculated at both the mid-central ROI, where effects were most pronounced overall, and the mid-frontal ROI, where old–new effects are typically reported in this time window; see Table 1).

In time window 2 (450–650 ms), the analogue analysis yielded a significant 3-way interaction, $F(12, 132) = 4.66$, $p < .01$. Planned comparisons are summarised in Table 2 and showed that there were reliable left-parietal old–new effects for all three old item conditions. Importantly, however, the effect in the Colour-Different condition was significantly smaller than

Table 1
Planned comparisons at mid-frontal and mid-central ROIs in time window 1 (250–450 ms).

Contrast	*df*	*F*	*p*
Mid-frontal ROI			
New–Same	1,11	10.55	.0078
New–Colour-Different	1,11	11.83	.0055
New–Size-Different	1,11	5.01	.0468
Same–Colour-Different	1,11	<1	
Same–Size-Different	1,11	<1	
Colour-Different–Size-Different	1,11	1.26	.2854
Mid-central ROI			
New–Same	1,11	9.88	.0094
New–Different	1,11	20.64	.0008
New–Size-Different	1,11	33.12	.0001
Same–Colour-Different	1,11	1.97	.1880
Same–Size-Different	1,11	<1	
Colour-Different–Size-Different	1,11	1.03	.3311

Table 2
Planned comparisons at the left-parietal ROI in time window 2 (450–650 ms).

Contrast	*df*	*F*	*p*
Left-parietal ROI			
New–Same	1,11	56.20	<.0001
New–Different	1,11	91.21	<.0001
New–Size-Different	1,11	72.49	<.0001
Same–Colour-Different	1,11	5.52	.0386
Same–Size-Different	1,11	<1	
Colour-Different–Size-Different	1,11	3.64	.0828

the effect in the Same condition and (marginally) the Size-Different condition. Same and Size-Different conditions did not differ from each other (at any ROI).[4]

4. Discussion

Behavioural results were as expected. Performance levels in the object recognition task were high, due to the short lists and the fact that the feature manipulation was not relevant for the task. Reaction time data showed that, overall, copy cues (Same condition) were responded to fastest, likely because they conveyed a match on both the perceptual and the conceptual level. This replicates previous behavioural research (Cooper et al., 1992; Engelkamp et al., 2001; Jolicoeur, 1987; Zimmer & Steiner, 2003). In particular, a change in colour led to slower responses, while a change in size did not; thus the hypothesis of a selective behavioural match effect for colour can be confirmed, suggesting that after colour verbalisation colour but not size information is part of the reconstructed mnemonic representation.

Turning to object recognition ERPs, the results of the colour manipulation on the parietal old–new effect associated with recollection (time window 2) were clear-cut. There was a significantly reduced effect for Colour-Different but not Size-Different items after subjects had made a verbal prediction regarding colour at study. This corroborates our assumption that verbal recoding of the object-feature association is an efficient way how to make perceptual feature information available for later conscious recollection.

To the best of our knowledge, this is the first ERP study to directly examine the impact of this strategy on recollection (vs. familiarity). Our finding is in accord with the generally accepted notion that recollection profits from elaborative processing (rather than shallow processing which is often perceptual in nature) at study relatively more than familiarity (Luo, Hendriks, & Craik, 2007; Rugg & Yonelinas, 2003; Rugg et al., 1998). Importantly and in contrast to the common view (see Section 1), recollection can apparently be influenced by perceptual information even if this information is task-irrelevant. However, the information has to be consciously accessible, and verbal labelling seems to be an efficient way to provide such conscious access, supposedly via hippocampal binding of the verbal label to the object representation (Chalfonte & Johnson, 1996; Davachi & Wagner, 2002).

There may be other ways to provide conscious access to perceptual information. As discussed in Section 1, any encoding task that draws attention to a perceptual feature could lead to enhanced recollection of that feature. However, previous research has suggested that recollection is typically only influenced by features that are task-relevant, while in the present study, a task-irrelevant feature was influential. Hence we propose that verbalisation is a particularly powerful means to provide conscious access to perceptual information.

Our results are further in line with some recent behavioural research showing that the generation of verbal predicates at study can enhance memory performance and recollection in particular (Brown & Lloyd-Jones, 2006). However, our results are by no means trivial. They contrast with other studies showing that verbalisation of studied material actually tends to impair subsequent memory, a process that has been labelled "verbal overshadowing" (Schooler & Engstler-Schooler, 1990; for reviews see Meissner & Memon, 2002; Schooler, 2002).

Several mechanisms of verbal overshadowing have been proposed (cf. Chin & Schooler, 2008). Firstly, verbal descriptions of perceptual information may be partially inadequate or concerned with irrelevant features to begin with. Second, if perceptually encoded information is later conceptually recoded, interference between competing perceptual and conceptual representations may arise. Alternatively, recoding may lead to a processing shift at test ("transfer-inappropriate processing") or a change in response criterion (cf. Dodson, Johnson, & Schooler, 1997; Schooler, 2002; also Clare & Lewandowsky, 2004).

[4] There are good reasons to select and group electrodes into regions of interest (e.g., counteracting the inflation of degrees of freedom with high-density recordings, collapsing covarying data to account for variance that would otherwise be treated as error variance, increasing interpretability, cf. Dien & Santuzzi, 2005), but grouping can reduce statistical power and lead to Type II error. In the present case, this is relevant for our claim that the three old conditions do not differ in time window 1, and that Same and Size-Different conditions do not differ in time window 2. Hence, we repeated the respective analyses using data from all 58 head electrodes. Results were in line with ROI-based results: In all cases, the Condition main effect and the critical Condition by Electrode interaction were nonsignificant, all Fs < 4.06, all ps > .05.

Brandimonte and colleagues (Brandimonte, Hitch, & Bishop, 1992; Brandimonte, Schooler, & Gabbino, 1997; Hitch, Brandimonte, & Walker, 1995) found that articulatory suppression at study enhanced the representation of perceptual features and hence led to perceptual match effects in a later memory test. They speculated that verbal encoding fosters the retrieval of abstract stimulus characteristics and decreases retrieval of surface features. However, they found that instructions to name a perceptual feature of study figures improved later performance in an imagery task that required accurate perceptual retrieval. This result can be taken as evidence that leading subjects at study to verbalise a perceptual attribute can counteract the negative effects of conceptual verbalisation in terms of overshadowing. Hence, in line with previous research our study suggests that whether verbalisation overshadows or facilitates subsequent memory performance seems to be a function of the appropriateness of study-test processing transfer.

Furthermore, this study provides corroborative evidence that the calculation of a familiarity signal is based on a variable and task-dependent ratio of perceptual and conceptual processing. In previous studies, we had used the same or similar stimuli and perceptual manipulations and had consistently found a perceptual match effect in the early ERP effect associated with familiarity (Ecker et al., 2007a, 2007b; Groh-Bordin et al., 2005, 2006). As predicted, the more verbal-conceptual study task in the present study led to the disappearance of this effect (time window 1).

In all of these previous studies, subjects were asked to memorise the study objects in their specific perceptual layout. In contrast, subjects in the present study were asked to verbalise the object label and one specific perceptual attribute. This encoding strategy seemingly led subjects to adopt a conceptual perspective and lay down a verbal-semantic representation at study. As much effort was made to ensure that a study-test change of colour did not introduce a significant conceptual change, both Same and Colour-Different items would be expected to be similarly familiar on a conceptual level, hence the lack of a perceptual match effect.

It can furthermore be assumed that in object identification, the basic level concept itself (‘‘a car”) is accessed prior to subordinate features, such as colour (Biederman, Subramaniam, Bar, Kalocsai, & Fiser, 1999; Hoffmann, 1982; Hoffmann & Zießler, 1986; Kosslyn & Schwartz, 1978; Zimmer, 1983).[5] Thus, if discrimination of Same and Different items in recognition memory is based on a conceptual representation, it may need to rely on the slower process of recollection.

As noted before, familiarity may not always be perceptually specific, but perceptual match effects seem to depend on a certain amount of perceptual processing at encoding. The present finding therefore suggests that the impact of perceptual features on object familiarity is only automatic (i.e., occurring despite the task-irrelevance of the features) if study processing is perceptual in nature (for further constraints on familiarity automaticity, see Ecker & Zimmer, in press). In this vein, the present results are in line with results reported by Curran and Cleary (2003), who had used copy cues and mirror-reversed images at test and found comparable familiarity-related ERP old–new effects for the two conditions. In contrast, Groh-Bordin et al. (2005) used items that were perceptually hard to identify, fostering perceptual processing at study, and in this study there was only a familiarity old–new effect for copy cues; perceptually changed items did not cause familiarity effects. That is, the degree to which perceptual and conceptual attributes contribute to familiarity calculation at test will depend on study processing and the resulting integration of perceptual and conceptual attributes into the mnemonic representation on which familiarity is based.

Taken together, the behavioural and electrophysiological data are in good correspondence. Colour-Different items showed evidence of impaired test processing in both behavioural and electrophysiological data (i.e., longer latencies and diminished ERP old–new effects) as compared to copy cues or size-manipulated items. This correspondence indicates that the ERP match effect mirrors a genuine memory advantage concerning conscious access to colour information via recollection.

Previous research on perceptual fan effects suggests that the verbal predicate strategy may only effectively foster recollection at rather short intervals, while being prone to interference at longer intervals. Reder and colleagues (Park, Arndt, & Reder, 2006; Reder, Donavos, & Erickson, 2002) have argued that the test reinstatement of specific cues (such as the object colour in the present case) may enhance recognition memory, but that this effect is diminished if the specific version of the cue (e.g., the specific colour) is shared with other items. In accordance with present findings, Park et al. have shown that this fan or interference effect acts selectively on recollection.

To conclude, this study demonstrates that the mnemonic representation subserving episodic recollection can comprise intrinsic perceptual feature information if the feature was verbalised during study. We assume that explicit verbalisation of a feature generates consciously available predicates, like ‘‘Concept X has feature Y”, and this makes a sensory feature easily available to conscious recollection. If the specific object-feature combination is not verbalised, however, feature information may generally not be well accessible via recollection. In contrast, if predicates of sensory features are part of the memory trace after verbalisation, the match or mismatch of this predicate modulates recollection even if the recovered information is irrelevant to the task.

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[5] Objects with prototypical colours may be an exemption from this rule, as for these items, colour can be diagnostic for identification (cf. Joseph & Proffitt, 1996; Tanaka & Presnell, 1999).

References

Biederman, I., Subramaniam, S., Bar, M., Kalocsai, P., & Fiser, J. (1999). Subordinate-level object classification reexamined. *Psychological Research, 62*, 131–153.

Brandimonte, M. A., Hitch, G. J., & Bishop, D. V. (1992). Verbal recoding of visual stimuli impairs mental image transformations. *Memory & Cognition, 20*, 449–455.

Brandimonte, M. A., Schooler, J. W., & Gabbino, P. (1997). Attenuating verbal overshadowing through color retrieval cues. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 23*, 915–931.

Brown, C., & Lloyd-Jones, T. J. (2006). Beneficial effects of verbalization and visual distinctiveness on remembering and knowing faces. *Memory & Cognition, 34*, 277–286.

Buchler, N. E. G., Light, L. L., & Reder, L. M. (in press). Memory for items and associations: Distinct representations and processes in associative recognition. *Journal of Memory and Language*.

Cansino, S., Maquet, P., Dolan, R. J., & Rugg, M. D. (2002). Brain activity underlying encoding and retrieval of source memory. *Cerebral Cortex, 12*, 1048–1056.

Chalfonte, B. L., & Johnson, M. K. (1996). Feature memory and binding in young and older adults. *Memory & Cognition, 24*, 403–416.

Chin, J. M., & Schooler, J. W. (2008). Why do words hurt? Content, process, and criterion shift accounts of verbal overshadowing. *European Journal of Cognitive Psychology, 20*, 396–413.

Clare, J., & Lewandowsky, S. (2004). Verbalizing facial memory: Criterion effects in verbal overshadowing. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 30*, 739–755.

Cooper, E. E., Biederman, I., & Hummel, J. E. (1992). Metric invariance in object recognition: A review and further evidence. *Canadian Journal of Psychology, 46*, 191–214.

Craik, F. I. M., & Lockhart, R. S. (1972). Levels of processing: A framework for memory research. *Journal of Verbal Learning and Verbal Behavior, 11*, 671–684.

Craik, F. I. M., & Tulving, E. (1975). Depth of processing and the retention of words in episodic memory. *Journal of Experimental Psychology: General, 104*, 268–294.

Curran, T. (2000). Brain potentials of recollection and familiarity. *Memory & Cognition, 28*, 923–938.

Curran, T., & Cleary, A. M. (2003). Using ERPs to dissociate recollection from familiarity in picture recognition. *Cognitive Brain Research, 15*, 191–205.

Daselaar, S. M., Fleck, M. S., & Cabeza, R. (2006). Triple dissociation in the medial temporal lobes: Recollection, familiarity, and novelty. *Journal of Neurophysiology, 96*, 1902–1911.

Davachi, L., & Wagner, A. D. (2002). Hippocampal contributions to episodic encoding: Insights from relational and item-based learning. *Journal of Neurophysiology, 88*, 982–990.

de Chastelaine, M., Friedman, D., & Cycowicz, Y. M. (2007). The development of control processes supporting source memory discrimination as revealed by event-related potentials. *Journal of Cognitive Neuroscience, 19*, 1286–1301.

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 and Review, 13*, 1–21.

Dien, J., & Santuzzi, A. M. (2005). Application of repeated measures ANOVA to high-density ERP datasets: A review and tutorial. In T. C. Handy (Ed.), *Event-related potentials: A methods handbook* (pp. 33–56). Cambridge, MA: MIT Press.

Dodson, C. S., Johnson, M. K., & Schooler, J. W. (1997). The verbal overshadowing effect: Why descriptions impair face recognition. *Memory & Cognition, 25*, 129–139.

Ecker, U. K. H. (2007). *Objects in context. The neurocognitive representation, binding, and processing of object and context features in recognition memory – An electrophysiological approach*. Saarbrücken, Germany: VDM.

Ecker, U. K. H., & Zimmer, H. D. (in press). ERP evidence for flexible adjustment of retrieval orientation and its influence on familiarity. *Journal of Cognitive Neuroscience*.

Ecker, U. K. H., Groh-Bordin, C., & Zimmer, H. D. (2004). Electrophysiological correlates of specific feature binding in remembering – Introducing a neurocognitive model of human memory. In A. Mecklinger, H. D. Zimmer, & U. Lindenberger (Eds.), *Bound in memory – Insights from behavioral and neuropsychological studies* (pp. 159–193). Aachen, Germany: Shaker.

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

Ecker, U. K. H., 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.

Ecker, U. K. H., Zimmer, H. D., Groh-Bordin, C., & Mecklinger, A. (2007c). Context effects on familiarity are familiarity effects of context – An electrophysiological study. *International Journal of Psychophysiology, 64*, 146–156.

Engelkamp, J., & Zimmer, H. D. (1994). *The human memory: A multimodal approach*. Seattle, WA: Hogrefe.

Engelkamp, J., Zimmer, H. D., & de Vega, M. (2001). Pictures and words in memory: The role of visual-imaginal information. In M. Denis, C. Cornoldi, R. H. Logie, M. de Vega, & J. Engelkamp (Eds.), *Imagery, language and visuo-spatial thinking* (pp. 59–80). Hove, UK: Psychology Press.

Fodor, A. (1983). *The modularity of mind*. Cambridge: MIT Press.

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

Gardiner, J. M., & Java, R. I. (1993). Recognising and remembering. In A. F. Collins, S. E. Gathercole, M. A. Conway, & P. E. Morris (Eds.), *Theories of memory* (pp. 163–188). Hillsdale: Lawrence Erlbaum.

Gratton, G., Coles, M. G. H., & Donchin, E. (1983). A new method for off-line removal of ocular artifact. *Electroencephalography and Clinical Neurophysiology, 55*, 468–484.

Groh-Bordin, C., Zimmer, H. D., & Ecker, U. K. H. (2006). Has the butcher on the bus dyed his hair? When colour changes modulate ERP correlates of familiarity and recollection. *NeuroImage, 32*, 1879–1890.

Groh-Bordin, C., Zimmer, H. D., & Mecklinger, A. (2005). Feature binding in perceptual priming and in episodic object recognition: Evidence from event-related brain potentials. *Cognitive Brain Research, 24*, 556–567.

Hitch, G. J., Brandimonte, M. A., & Walker, P. (1995). Two types of representation in visual memory: Evidence from the effects of stimulus contrast on image combination. *Memory & Cognition, 23*, 147–154.

Hoffmann, J. (1982). *Das aktive Gedächtnis*. Berlin: VEB.

Hoffmann, J., & Zießler, M. (1986). The integration of visual and functional classifications in concept formation. *Psychological Research, 48*, 69–78.

Hyde, T. S., & Jenkins, J. J. (1969). Differential effects of incidental tasks on the organization of recall of a list of highly associated words. *Journal of Experimental Psychology, 82*, 472–481.

Ikeda, T., & Osaka, N. (2007). How are colors memorized in working memory? A functional magnetic resonance imaging study. *Neuroreport, 18*, 111–114.

Jacoby, L. L., & Dallas, M. (1981). On the relationship between autobiographical memory and perceptual learning. *Journal of Experimental Psychology: General, 110*, 306–340.

Johnson, M. K., & Chalfonte, B. L. (1994). Binding complex memories: The role of reactivation and the hippocampus. In D. L. Schacter & E. Tulving (Eds.), *Memory systems 1994* (pp. 311–350). Cambridge, MA: MIT Press.

Jolicoeur, P. (1987). A size congruency effect in memory for visual shape. *Memory & Cognition, 15*, 531–543.

Joseph, J. E., & Proffitt, D. R. (1996). Semantic versus perceptual influences of color in object recognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 22*, 407–429.

Kosslyn, S. M., & Schwartz, S. P. (1978). Visual images as spatial representations in active memory. In E. M. Rieseman & A. R. Hanson (Eds.), *Computer vision systems* (pp. 223–241). New York: Academic Press.
Luo, L., Hendriks, T., & Craik, F. I. M. (2007). Age differences in recollection: Three patterns of enhanced encoding. *Psychology and Aging, 22*, 269–280.
Macken, W. J., & Hampson, P. (1993). Integration, elaboration and recollective experience. *Irish Journal of Psychology, 14*, 270–285.
Mandler, G. (1991). Your face looks familiar but I can't remember your name: A review of dual process theory. In W. E. Hockley & S. Lewandowsky (Eds.), *Relating theory and data: Essays on human memory in honor of Bennet B. Murdock* (pp. 207–225). Hillsdale, NJ: Erlbaum.
Meissner, C. A., & Memon, A. (2002). Verbal overshadowing: A special issue exploring theoretical and applied issues. *Applied Cognitive Psychology, 16*, 869–872.
Moscovitch, M. (1992). Memory and working-with-memory: A component process model based on modules and central systems. *Journal of Cognitive Neuroscience, 4*, 257–267.
Paivio, A. (1995). Imagery and memory. In M. S. Gazzanigga (Ed.), *The Cognitive neurosciences* (pp. 977–986). Cambridge, MA: MIT Press.
Paivio, A. (2007). *Mind and its evolution: A dual coding theoretical approach*. Mahwah, NJ: Lawrence Erlbaum Associates Publishers.
Park, H., Arndt, J., & Reder, L. M. (2006). A contextual interference account of distinctiveness effects in recognition. *Memory & Cognition, 34*, 743–751.
Reder, L. M., Donavos, D. K., & Erickson, M. A. (2002). Perceptual match effects in direct tests of memory: The role of contextual fan. *Memory & Cognition, 30*, 312–323.
Reder, L. M., Nhouyvanisvong, A., Schunn, C. D., Ayers, M. S., Angstadt, P., & Hiraki, K. (2000). A mechanistic account of the mirror effect for word frequency: A computational model of remember-know judgments in a continuous recognition paradigm. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 26*, 294–320.
Rugg, M. D., & Curran, T. (2007). Event-related potentials and recognition memory. *Trends in Cognitive Sciences, 11*, 251–257.
Rugg, M. D., Fletcher, P. C., Frith, C. D., Frackowiak, R. S. J., & Dolan, R. J. (1997). Brain regions supporting intentional and incidental memory: A PET study. *Neuroreport, 8*, 1283–1287.
Rugg, M. D., Walla, P., Schloerscheidt, A. M., Fletcher, P. C., Frith, C. D., & Dolan, R. J. (1998). Neural correlates of depth of processing effects on recollection: Evidence from brain potentials and positron emission tomography. *Experimental Brain Research, 123*, 18–23.
Rugg, M. D., & Yonelinas, A. P. (2003). Human recognition memory: A cognitive neuroscience perspective. *Trends in Cognitive Sciences, 7*, 313–319.
Schooler, J. W. (2002). Verbalization produces a transfer inappropriate processing shift. *Applied Cognitive Psychology, 16*, 989–997.
Schooler, J. W., & Engstler-Schooler, T. Y. (1990). Verbal overshadowing of visual memories: Some things are better left unsaid. *Cognitive Psychology, 22*, 36–71.
Snodgrass, J. G., & Corwin, J. (1988). Pragmatics of measuring recognition memory: Applications to dementia and amnesia. *Journal of Experimental Psychology: General, 117*, 34–50.
Srinivas, K., & Verfaellie, M. (2000). Orientation effects in amnesics' recognition memory: Familiarity-based access to object attributes. *Journal of Memory and Language, 43*, 274–290.
Tanaka, J. W., & Presnell, L. M. (1999). Color diagnosticity in object recognition. *Perception and Psychophysics, 61*, 1140–1153.
Tunney, R. J., & Fernie, G. (2007). Repetition priming affects guessing not familiarity. *Behavioral and Brain Functions, 3*, 40–46.
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*, 161–170.
Vilberg, K. L., & Rugg, M. D. (2007). Dissociation of the neural correlates of recognition memory according to familiarity, recollection, and amount of recollected information. *Neuropsychologia, 45*, 2216–2225.
Wilding, E. L. (2000). In what way does the parietal ERP old/new effect index recollection? *International Journal of Psychophysiology, 35*, 81–87.
Wilding, E. L., Fraser, C. S., & Herron, J. E. (2005). Indexing strategic retrieval of colour information with event-related potentials. *Cognitive Brain Research, 25*, 19–32.
Yonelinas, A. P. (2002). The nature of recollection and familiarity: A review of 30 years of research. *Journal of Memory and Language, 46*, 441–517.
Zimmer, H. D. (1983). *Sprache und Bildwahrnehmung*. Frankfurt am Main, Germany: Haag & Herchen.
Zimmer, H. D., & Steiner, A. (2003). Color specificity in episodic and in object recognition with enhanced color impact. *European Journal of Experimental Psychology, 15*, 349–370.
Zimmer, H. D., Mecklinger, A., & Lindenberger, U. (Eds.). (2006). *Handbook of binding and memory: Perspectives from cognitive neuroscience*. Oxford: Oxford University Press.