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Eye-Closure & the Retrieval of Item-Specific Information in Recognition Memory.

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Abstract

Two experiments investigated the effect of eye-closure on visual and auditory memory under conditions based on the retrieval of item-specific information. Experiment 1 investigated visual recognition memory for studied, perceptually similar and unrelated items. It was found that intermittent eye-closure increased memory for studied items and decreased memory for related items. This finding was reflected by enhanced item-specific and reduced gist memory. Experiment 2 used the Deese-Roediger-McDermott (DRM) paradigm to assess auditory recognition memory for studied, related and unrelated words that had (vs. had not) been accompanied by pictures during encoding. Pictures but not eye-closure produced a picture superiority effect by enhancing memory for studied items. False memory was reduced by pictures but not eye-closure. Methodological and theoretical considerations are discussed in relation to existing explanations of eye-closure and retrieval strategies.

Keywords

Eye-closure

Perceptual memory

Item-specific memory

False memory

Gist memory

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1. Overview of the current research

Episodic memory is defined as conscious memory for personal experiences and events involving the retrieval of information bound to particular times and situations (Gardiner, 2001; Tulving, 1985, 2002). Typically, these memories are highly detailed and rich in event or item-specific information. At other times such detail is missing and memories are somewhat more general or vague (Gardiner & Richardson-Klavehn, 2000, Yonelinas, 2002). The research presented here is concerned with the effects of eye-closure (EC) on true and false episodic recognition memory accompanied by item-specific details.

1.1. Eye closure and episodic memory

Incoming sensory material can interfere with the retrieval of information from memory. In such situations the competition between retrieval and the monitoring of external inputs impairs cognitive performance and has been likened to that of a dual-task situation (Glenberg, Schroeder, & Robertson, 1998). However, performance can be improved by *instructed* eye-closure. This eliminates the dual-task situation, reduces interference and can enhance retrieval from episodic memory (e.g., Vredeveldt, Hitch, & Baddeley, 2011).

Episodic memory is typically assessed by free-recall, cued recall and recognition of words and pictures. Most research on EC effects has made use of free-recall and cued-recall. For example, Perfect et al. (2008) exposed subjects to a simulated (video) robbery (Experiment 1), a news bulletin (Experiment 2), a television programme (Experiment 3), or a staged event (Experiments 4 & 5) and later tested free and cued-recall under eyes open (vs. closed) conditions. It was found that eye-closure improved memory for both visual and auditory details with both types of test. Eye-closure can also improve episodic memory in ecologically naturalistic conditions, as might occur when retrieving information in a busy outdoor location (Vredeveldt & Penrod, 2012). Eye-closure effects have also been observed with both children (e.g., Mastroberardino, Natali, & Candel, 2012; Mastroberardino & Vredeveldt, 2014; Natali, Marucci, & Mastroberardino, 2012) and older participants (Wais, Martin, & Gazzaley, 2012). Indeed, a range of studies have demonstrated that eye-closure can improve free-recall without increasing recall errors or inducing overconfidence in responses (Vredeveldt & Sauer, 2015). More generally, it has been argued that environmental distraction reduces the fidelity of representations recalled from memory and that EC influences the retrieval of specific recollective details (Wais & Gazzaley, 2014; Wais, et al., 2012).

1.2. Explanations of eye-closure effects

Two prominent cognitive accounts of EC effects are the modality-specific and the resource-general explanations (e.g., Craik, 2014; Perfect, Andrade, & Eagan, 2011). The former describes EC effects as resulting from reduced visual interference and the consequent freeing of visual processing resources. This notion gains broad support from experiments in working memory in which the visuo-spatial component is responsible for the short-term maintenance and manipulation of visual and spatial information and is susceptible to modality-specific interference (e.g., Baddeley & Hitch, 1974; Postle, Idzikowski, Della Sala, Logie, & Baddeley, 2006). From this perspective eye-closure eliminates visual input and provides a basis for more effective imagery-processing and perceptual simulation. This in turn enables the more efficient retrieval of modality congruent representations from long-term memory (Vredeveldt et al., 2011).

The resource-general account can also be conceptualised from within a working-memory framework. In this case, eye-closure is hypothesised to influence domain-*general* processing mechanisms such as the central executive. According to this account, when the eyes are open, environmental scanning is taking place in which a resource-limited attentional pool is constantly monitoring and evaluating external inputs (Glenberg, 1997). Because of capacity limitations, retrieval from memory is compromised and therefore less efficient than it would be if attentional resources were not divided between external monitoring and memory retrieval. Thus, eye-closure frees domain-general processing mechanisms and facilitates memory retrieval. Overall, research has accumulated that is supportive of both explanations and there is no reason to conclude that either is necessarily correct (Vredeveldt, Baddeley, & Hitch, 2012).

Regardless of theoretical points, research indicates eye-closure can increase memory for fine-grained information (e.g., Vredeveldt et al., 2011; Wais et al., 2012; Wais & Gazzaley, 2014), improve the quality of retrieved details, and enhance visualisation (Vredeveldt et al., 2011). These results have potential implications for other research paradigms in which the retrieval of imagistic, distinctive or fine-grained perceptual information can improve memory accuracy. This sets the context for the two experiments presented here. In particular, Experiment 1 employs a paradigm in which targets and distractors are highly similar and it is necessary to retrieve perceptual item-specific information to increase memory accuracy. Experiment 2 makes use of a technique in which the retrieval and use of distinctive-visual information, in the form of word-picture associations, can also be used to increase memory accuracy.

2. Experiment 1: Eye-closure and visual recognition memory

2.1. Background to experiment 1

As noted, most research in EC effects has made use of either free or cued-recall. However, there are a couple of exceptions to this. Vredeveldt, Tredoux, Kempen, and Nortje (2015) found that eye-closure did *not* enhance face recognition in a line-up eyewitness procedure (Experiment 1) or a face recognition test (Experiment 2). It is not clear why EC effects were not found and perhaps part of the reason may have been due to the unusual testing conditions. For instance, Experiment 2 consisted of a series of 20 study-test trials. Each of these started with a 750 ms exposure to a target face, followed by a distractor task for 90 s. After this task, participants mentally rehearsed (pictured) the face with their eyes open or closed. Finally, they were presented with either the studied or a non-studied face for recognition. The null findings were likely not due to the effectiveness of the eye-closure manipulation itself, as eye-closure did increase memory for event information (Experiment 1).

Secondly, Uchiyama and Mitsudo (2019) examined recognition memory for unrelated word lists presented for study either visually or auditorily. During retrieval, participants were required to mentally recall and rehearse the words with their eyes open (vs. closed) prior to a visual recognition test in which all participants kept their eyes open. Like Vredeveldt et al. (2015), no effects of EC were found. A failure to observe EC effects could relate to the timing of the EC phase, which was prior to, rather than during the test of memory. In addition, the memory test involved item recognition. This can be achieved based on overall item familiarity without the recall of precise detailed information (e.g., Westerman, 2001; Yonelinas, 2002). If, as suggested above, EC influences the retrieval of fine-grained or detailed information, then such tests may lack sufficient sensitivity to detect EC effects.

In the context of the forgoing, Experiment 1 addressed the impact of eye-closure on visual recognition by making use of a testing paradigm in which the recall of *precise* visual details is important for maintaining recognition accuracy. In particular, the encoding phase involved study of coloured visual objects (e.g., a shoe). In the test phase three types of stimuli were presented; studied objects, related-unstudied exemplars of studied objects (a different shoe), or new objects not seen during the encoding phase[1]. Thus, related-unstudied exemplars possess the same name and conceptual codes as studied exemplars, but differ in terms of precise visual features and leads to high false recognition of these items (Budson, Daffner, Desikan, & Schacter, 2000; Koutstaal, 2003, 2006; Koutstaal & Cavendish, 2006; Slotnick & Schacter, 2004). True memory can be enhanced, and false recognition reduced, by the retrieval of perceptual item-specific features that differentiate between studied and related-unstudied items (Kim & Yassa, 2013; Koutstaal, 2006; Koutstaal & Cavendish, 2006).

In this paradigm, false recognition of related-unstudied items is based on conceptual information about the object category and due to reliance on gist-based memory (Brainerd & Renya, 2005; Koutstaal & Schacter, 1997; Koutstaal & Cavendish, 2006). This is because *gist*-based memories are abstracted from individual exemplars and lack specific details that characterise such instances. In contrast, accurate memory relies primarily on the retrieval and use of *item-specific* information derived from the encoded experience.

2.2. Outline of experiment 1 and predictions

The first experiment was concerned with whether eye-closure can increase the retrieval of distinctive perceptual information and reduce gist-based false memory. To this end, following the study of a set of exemplars, visual recognition memory was tested with eyes open or closed. Eye closure was manipulated on an intermittent basis such that the participant closed their eyes prior to and following each test item. Recognition responses were then made when the eyes were closed.

If eye-closure enhances the use of visualisation, or the retrieval of visual details (e.g., Vredeveldt et al., 2011), then such closure should reduce gist-based false memory and enhance true memory. In addition to overall recognition, individuals were asked to indicate *how* items were recognised based on the remember-know procedure (Gardiner 2001; Tulving, 1985). This was used to assess the type of information retrieved. For instance, ‘remember’ responses are based on the recall of detailed contextual information about an item, while ‘know’ responses indicate familiarity in the absence of such details (Gardiner 2001; Tulving, 1985). This procedure was employed on an exploratory basis and as an adjunct to the main dependent variables. The details of this procedure and the results can be found in the supplementary information file.

Given that previous experiments have found that EC enhances memory for detail, it was hypothesised that eye closure would increase the hit rate to studied items and reduce the false alarm rate to related-unstudied items.

3. Method

3.1. Design

The design of the experiment was a 2(eye condition during retrieval; open vs. closed) between-subjects by 3(item type on the recognition test; studied vs. related-unstudied vs. unrelated-unstudied) within-subjects mixed factorial. The dependent variables were the item-specific and gist-based signal detection measures of response accuracy and bias (described in the results section), together with proportion measures of ‘yes’ responses to each item-type.

3.2. Participants

A total of 80 individuals[2] recruited from the student population of Manchester Metropolitan University (via opportunity sampling) and the subject pool. The number of participants in each between-subject eye condition was 40. All participation was voluntary and no one reported taking part in any prior similar research.

3.3. Materials & Apparatus

Stimuli were taken from Koutstaal (2003) and consisted of a set of picture/object pairs depicting two different exemplars (versions) of the same object type (e.g., two different pictures of a piano). From the whole set of stimuli, 60 pairs of target images were selected (plus 3 for primacy and recency buffers). Thus, for the first experiment, each stimulus pair consisted of two alternate pictures of the same object and as such, each pair had the same name/label and conceptual codes but differed in their *precise* perceptual details.

From this overall set of pairs of pictures, each pair was randomly allocated into two groups (A and B). Thus each group consisted of 30 *pairs* of pictures. From these two sets, four further ***sub***divisions were created. By this division, group A was separated into subgroups A1 and A2. These subgroups comprised of only 1 image from each pair (decided randomly). Thus if the image pair was of two exemplars of a piano, then one image of the piano was placed in set A1 and the second image in set A2. This division was performed across groups A and B and produced a set of subgroups A1, A2, B1 and B2. Each of these subgroups formed an encoding set each of 30 ***single*** items. Thus, subjects were exposed to subgroup A1 (vs. A2) or (B1, vs. B2). Exposure to the sets was counterbalanced across participants.

Recognition tests were assembled by combining half of one exposed set (e.g., half of A1) with half of the alternate set (e.g., half of A2). For example, if a picture of one pair was selected from A1, then the alternate member of the pair from A2 was ***not*** selected. This produced a set of 30 items of which 15 were the ***same*** (studied exemplar) as those during encoding set and 15 were ***different*** (related-unstudied exemplar) versions of the ones as seen during encoding. To these, a further 15 picture items were selected randomly from the non-exposed set (e.g., set B). This provided the unrelated new items on the recognition test. For these items, only one picture of a pair was used (thus the recognition test did not contain two new items of the same pair).

3.4. Procedure

All participants were tested individually. During recruitment, participants were informed that they were being asked to take part in an experiment investigating cognitive processing and that memory would be tested. No further details were given regarding the manipulations or predictions.

In the experimental session, participants were asked to sign consent forms prior to the experiment itself. The experiment was divided into three phases: encoding, delay and test phases. Allocation to eye conditions was random.

In phase one, participants were asked to attend to a set of pictures displayed on the computer screen at rate of 2 s per picture with an interstimulus interval of 1 sec. The target stimuli were buffered by 3 primacy and 3 recency stimuli that were not recorded in the recognition test. Following the encoding phase, participants were asked to write down the names of any towns and cities in the United Kingdom for 3 minutes as a distractor task.

The test phase was similar for each between-subject condition with small differences to accommodate the eye closure variable. At the start of the test, participants sat in front of a computer screen with the experimenter to one side. On the screen was a central fixation cross to which participants were asked to allocate their attention. Once fixated those in the closed condition were asked to close their eyes whereas those in the open condition were asked to continue to look at the fixation cross. See Figure 1 for an illustration of this procedure.

The research assistant then initiated the sequence of events and the experimental trials unfolded as follows: (i) there was a period of 10 s during which the participants eyes were open or closed depending on the allotted condition. In the centre of the screen was a fixation cross. At the end of this period the computer emitted a beep. (ii) the beep signalled the presentation of a picture in 2.5 s. Those in the open condition continued to look at the cross whereas those in the closed condition opened their eyes to view the cross. (iii) the test picture was presented for 2 s seconds after which it was replaced by a fixation cross. (iv) the appearance of the cross signalled to those in the closed condition to close their eyes. Those in the eyes open condition kept their eyes open.

Following this, the research assistant requested their response (yes/no and remember-know-guess) and this was recorded. The details of the instructions for the remember-know-guess responses can be found in the supplementary information file. The test phase proceeded when participants indicated they understood the instructions. There was no time limit to respond and the experimenter initiated each trial. This cycle was repeated until completion of the experiment. Finally, the participants were debriefed and thanked for their participation.

4. Results

4.1. Overview of results

Descriptive statistics for all analyses can be found in Table 1. Findings for the remember-know-guess procedure appear in the supplementary file. The analyses presented here pertained to the signal-detection estimates of accuracy and bias, together with overall proportion measures. To supplement the frequentist statistics, Bayesian analyses were performed to assess the Bayes factor (BF_{10}) for main effects, interactions, and any subsequent comparisons. The Bayes factor is a ratio that represents the amount of evidence for competing models of the data (i.e., the alternative model vs. null model Jeffreys, 1935, 1961). Compared to frequentist statistics, the benefit of this approach is that it provides a measure of the relative strength of evidence in favour of the alternative (vs. the null) models. In the current research, the BF_{10} is reported. This represents the numerator (denominator) of the ratio as the alternative (null) hypotheses respectively. Although Bayesian evidence is continuous, the current work makes use of the labels adopted by others. In this, a BF_{10} of 0.3 or less is taken to provide substantial evidence for the null hypothesis. A BF_{10} of 3.0 or above provides evidence in favour of the alternative hypothesis. When the BF_{10} falls in-between this range, the findings are less decisive with the weighting in favour of the experimental or null hypothesis dependent on the closeness of the value to either 0.3 or 3.0 (Dienes, 2011, 2014 Wagenmakers et al. 2018). All Bayesian computations were performed using JASP with default priors (JASP Team, 2018). Finally, unless otherwise stated, the findings from the Bayesian analyses are consistent with those from the frequentist analyses.

4.2. Signal detection and proportion analyses

Signal-detection measures of *d*' (discrimination accuracy) and response bias (β) were calculated according to the methods described by Koustaal and Cavendish (2006). This allowed for the estimation of three different forms of discrimination and response bias that provided measures of item-specific and gist-based responding. The first set of SDT measures were computed in the usual manner using the hit rate to studied items and the false alarm rate to unrelated-unstudied items. Koutstaal and Cavendish (2006) contend that this measure provides an estimate of recognition that is dependent on *both* item-specific information and gist information (as derived from the conceptual basis of the exemplar). This is because recognition decisions can be made based on the retrieval item-specific detail about the presented exemplar or its gist-based meaning (e.g., that a piano was presented in the absence of any particular perceptual detail about the precise visual characteristics of the piano). In this experiment, these are termed *d'* and β overall.

The second set of SDT measures were calculated by using the hit rate to studied exemplars and the false alarm rate to related-unstudied exemplars. Koutstaal and Cavendish (2006) argue that this provides a measure of item-specific processing. This is because correct recognition responses demand the subject discriminate between presented and related-unstudied exemplars that share the same name/conceptual code. Thus, correct responses cannot be made purely based on gist-meaning as this can lead to false recognition errors. In this experiment, this is called *d'* and β item-specific.

Finally, SDT measures were calculated by using the false alarm rate to related-unstudied lures and the false alarm rate to unrelated-unstudied lures. This is considered to provide a measure of gist-based responding. This is because false alarms to related-unstudied items indicates memory for the general class of items (i.e., gist) that were studied. In this instance, the SDT score assesses the ability to discriminate between related vs. unrelated based on gist information (Koutstaal & Cavendish, 2006). Accordingly, the SDT scores are referred to as *d'* and β gist.

The *d*' scores were computed for individual subjects and then placed into a 2(eye condition; open vs. closed) between-subjects by 3(*d*'-type; overall, vs. item-specific vs. gist) within-subjects mixed ANOVA. The descriptive statistics and analyses can be found in Tables 1 and 2. This revealed a significant main effect of *d'* type, eye condition and an interaction. The interaction was assessed by the use of simple main effects at each level of *d*' type. This indicated a significant effect of eye-closure for *d*' overall, $t(78) = 3.45$, $p = .001$, Cohen's $d = 0.76$, $BF_{10} = 33.19$, showing a higher *d*' score for the eye-closure condition. The difference was also significant for item-specific *d'*, $t(78) = 4.88$, $p < .001$, Cohen's $d = 1.09$, $BF_{10} = 2914.59$, and for *d*'gist, $t(78) = 2.454$, $p = .02$, Cohen's $d = 0.54$, $BF_{10} = 3.03$. The former showed an increase with eyes closed and the latter a decrease.

As *d*' is a composite score derived from yes responses to studied and unstudied (related and unrelated) items, a separate analysis was performed on the raw proportion scores to each of the item-types. This comprised a 2(eye condition; open vs. closed) between-subjects by 3(item-type; studied exemplar vs. related-unstudied exemplar vs. unrelated-unstudied exemplar) within-subjects mixed ANOVA. These findings and analyses appear in Tables 1 and 2. Analyses revealed a significant effect of item-type, no effect of eye condition and a significant interaction. This interaction was assessed by the use of simple main effects at each level of item-type. This revealed a significant difference between the eye conditions for both studied and related-unstudied exemplars, $t(78) = 4.64$, $p < .001$, Cohen's $d = 1.08$, $BF_{10} = 1277.98$, and $t(78) = 2.94$, $p = .004$, Cohen's $d = 0.64$, $BF_{10} = 8.85$, respectively. With regard to the studied exemplars, eye-closure increased the hit rate. Regarding related-unstudied exemplars, eye-closure reduced the false alarm rate. There was no effect of eye-closure for the unrelated-unstudied exemplars, $t(78) = 0.51$, $p = .62$, Cohen's $d = 0.09$, $BF_{10} = 0.26$.

The response bias scores β were positively skewed. Thus log transformed scores were used for the analyses. These were placed into a 2(eye condition; open vs. closed) between-subjects by 3(β-type; overall, vs. item-specific vs. gist) within-subjects mixed ANOVA. The descriptive statistics and analyses can be found in Tables 1 and 2. This produced main effects of both eye condition and β-type but no interaction. The main effect of eye condition showed a more conservative response bias with eyes open. Analysis of the main effect of β-type, revealed significant differences between all comparisons (all p's < .001, all BF_{10}'s > 3).

4.3. Discussion of findings

Experiment 1 found that eye-closure improved visual recognition memory by increasing both discrimination accuracy overall and item-specific memory. Eye-closure also reduced gist processing. Examination of the proportion measures indicated that EC increased the hit rate, reduced the related false alarm rate and had no appreciable effect on the unrelated false alarm rate (possibly due to the low levels of unrelated false alarms overall).

The current findings contrast with previous work on EC and recognition memory in which EC has not shown to be beneficial. There are several potential reasons for the differing outcomes. Firstly, the stimuli and task demands were designed to necessitate the retrieval of precise or fine-grained information and thus differs from previous work on recognition memory in this respect. A second reason could relate to the nature of the procedure and timing of the EC phase. Prior work has typically manipulated EC during the retrieval phase and is continuous through this phase. In contrast, eye-closure in Experiment 1 was intermittent and imposed between test stimuli. The implication of this procedural change is deferred until the general discussion. At the present juncture, the point to be noted is that EC can enhance recognition memory accuracy under particular conditions.

Attention now turns to whether these findings are limited to one experimental paradigm or can be generalised to others in which the use of perceptual item-specific information can influence recognition memory.

5.0. Experiment 2: Eye-closure and true/false memory in the DRM paradigm

5.1. Background to experiment 2

Experiment 2 extended the first study by use of the Deese-Roediger-McDermott (DRM) paradigm (Deese, 1959; Roediger & McDermott, 1995). This technique involves the presentation of lists of associated words with the meaning of each list converging on an related-unstudied word (the critical lure). The study of associated words leads to false memories for the critical lures and is hypothesised to arise because studied items activate this lure (Gallo, 2010; Roediger, Balota, & Watson, 2001; Roediger & McDermott, 2000) or the overall gist (theme) of the list (Brainerd & Reyna, 2005).

This effect is particularly robust and has been argued to arise because the critical lures lack distinctive qualities that would otherwise allow them to be rejected as non-studied (Gallo, 2010; Gallo & Lampinen, 2015). However, presenting additional item-specific information, such as pictures, alongside each word during study can enhance discrimination between studied items and critical lures and reduce false memory. According to Israel and Schacter (1997), the presence of pictorial information during encoding leads to the expectation that pictorial information will be retrieved during the test. Absence of this information can be used to infer critical lures were not studied (e.g., Israel & Schacter, 1997; Schacter, Israel, & Racine, 1999; Schacter, Cendan, Dodson, & Clifford, 2001). The strategy for inferring critical lures were not studied in this manner has been referred to as the distinctiveness heuristic (Schacter et al., 2001).

Surprisingly, the presence of pictorial information does not typically lead to a picture superiority effect for studied items (e.g., Dodson & Hege, 2005; Schacter et al., 1999) and has been explained by the test being auditory-verbal in nature (Israel & Schacter, 1997). However, words presented auditorily *can* prompt the recall of pictures in a word-picture cued-recall task with non-DRM lists when eyes are closed (Wais et al., 2012). Consequently, Experiment 2 made use of the DRM paradigm to complement the first study as past work has shown the importance of item-specific processing in enhancing memory in the context of a high false alarm rate. Particularly, the second experiment assessed whether EC would increase the retrieval of item-specific information associated with studied items and reduce associative false memory.

5.2. Outline of experiment 2 and predictions

To follow on from the above, in the second experiment, DRM lists were presented either with or without accompanying pictorial information during encoding. During testing with eyes open or closed, studied words, critical lures and unrelated-unstudied items were presented in an auditory yes-no recognition task accompanied with remember-know instructions. As previous research has shown a moderate to high effect size for the reduction in false memory for critical lures in the presence of pictures (e.g., Huff, Bodner, & Fawcett, 2014), it was predicted that such information would reduce false memory by a similar magnitude in the current experiment. It was also predicted that eye closure would enhance the retrieval of pictorial information (even though not requested by test instructions) and bring about a picture superiority effect for studied words.

6.0. Method

6.1. Design

The design was a 2(eye condition during retrieval; open vs. closed) between-subjects by 2(picture condition; present vs absent) between-subjects factorial. The dependent variables were the signal detection measures of accuracy and response bias together with the proportion 'yes' responses to studied words, critical lures and non-critical words (unstudied and unrelated to the presented words).

6.2. Participants

An opportunity sample of 120 individuals[3] recruited from the student population of Manchester Metropolitan University and the subject pool. This produced a total of 60 participants at each level of the independent variables and thus 30 participants per cell. All participation was voluntary and none reported taking part in any prior similar research. The data from one participant was not analysed because of a failure to follow testing instructions.

6.3. Materials

Twenty word/picture lists were taken from Israel and Schacter (1997). Each of the 20 lists comprised of 12 words together with a picture portraying that word. Further, each list had an associated word and picture that were never exposed during the encoding phase (the critical lure). These 20 lists were divided randomly into two sets of 10 lists for the purpose of counterbalancing. During encoding, participants were exposed to only one of these sets; the alternate set was used on the recognition test to create unrelated-unstudied distracters.

The recognition test comprised of (i) the fourth and seventh words from each of the presented lists and these served as studied items (20 words), (ii) the critical non-presented lures from each of the presented lists (10 words) and, (iii) the fourth and seventh words from the unstudied lists, comprising the unstudied-unrelated items (20 words). All items were randomly intermixed for each subject. Within each test booklet, items were presented on the left together followed by response options of 'yes' and 'no' to the right. Further to the right were the response options of ‘remember’, ‘know’ and ‘guess’. As the test was auditory, only the experimenter viewed the test booklet.

6.4. Procedure

All participants were tested individually. In the encoding phase, participants were told that they were to see 10 different lists of stimuli. They were instructed to pay attention to each item, as their memory would be later tested. Each word list was presented separately. For each list, the items were presented individually in decreasing order of associative strength to the critical lure. Each item appeared in the centre of the screen for 2 s with a 1 s interstimulus interval. The words appeared in 48-point Arial font. The pictures were all black and white line drawings with a size of approximately 6 cm by 6 cm.

After the final list had been presented, participants were presented with a sheet of paper and a pen and asked the names of towns and cities in the United Kingdom for 3 minutes as a distractor task.

In the test phase, participants were informed that the research assistant was going to read aloud a list of words for which the participant was asked to indicate whether they recognised each word (by saying ‘yes’ or ‘no’). If the participant responded ‘no’, the researcher read the next word. Following a ‘yes’ response, the researcher asked the participant to say how they remembered each word by indicating ‘remember’, ‘know’ or ‘guess’ response[4]. These instructions were the same as Experiment 1. Once participants indicated that they had understood the instructions, the test began.

7. Results

7.1. Overview of results

Descriptive statistics for all analyses can be found in Tables 3 and 4. Findings for the remember-know-guess procedure in the supplementary information file. The analyses presented pertain to signal-detection estimates of accuracy and bias followed by overall proportion measures. Like Experiment 1, Bayesian analyses were performed alongside the frequentist analyses and are consistent with the latter unless otherwise stated.

7.2. Signal detection and proportion analyses

Signal-detection measures of *d*' (discrimination accuracy) and (β) response bias were calculated for both true and false memory. For the former, hits and false alarms were derived as usual from 'yes' responses to studied and unrelated-unstudied items respectively. For false memory, 'yes' responses to critical lures were treated as "hits" and 'yes' responses to unrelated-unstudied items as false alarms (e.g., Koutstaal & Schacter, 1997; Seamon, Lee, Toner, Wheeler, Goodkind, & Birch, 2002). Higher *d*' scores for false memory indicate greater discrimination between critical lures and unrelated items.

For true memory, the *d*' scores were placed into a set of 2(eye condition; open vs. closed) between-subjects by 2(picture condition; picture vs. no picture) between-subjects ANOVAs. For *d'* true, this produced a non-significant effect of eye condition, a significant effect of picture conditions and an interaction. The interaction was assessed with the use of simple main effects at each level of eye-condition. This showed a non-significant effect of pictures during the open condition, $t(58) = 0.88$, $p = .38$, Cohens's $d = 0.23$, $BF_{10} = 0.36$. However, the difference was significant in the closed condition with pictures producing a higher *d*' score, $t(58) = 4.11$, $p < .001$, Cohens's $d = 1.05$, $BF_{10} = 177.16$. The response bias results for true memory showed no significant effects.

For false memory, a similar ANOVA was used and *d'* showed a non-significant effect of eye condition, the effect of picture condition was significant (lower with pictures) and the interaction just reached significance. This was assessed with simple main effects at each level of the picture condition. When pictures were not presented, the ability to discriminate between critical lures and unrelated-unstudied items was equivalent in both eye conditions,

$t(58) = 0.48$ $p = .63$, Cohen's $d = 0.12$, $BF_{10} = 0.29$. In the presence of pictures, discrimination between the item types was lower when eyes were open $t(57) = 2.92$ $p = .001$, Cohen's $d = 0.75$, $BF_{10} = 8.24$ (that is critical lures and unrelated-unstudied items were treated as being more similar). The response bias for false memory showed only a significant effect of eye condition (lower, more liberal, when eyes were open).

Some points of difference arose with the Bayesian ANOVAs regarding false memory. Particularly, the main effect of picture condition resulted in a BF_{10} of under 3 (albeit very close to 3). Consequently, a degree of caution is needed when interpreting this result. Similarly, the interaction between eye and picture condition was reduced to a BF_{10} of 1.28, suggesting this finding to be equivocal and thus in need of further examination.

For the analyses of the proportion measures for studied items, a main effect of picture condition and interaction were found. The interaction was assessed with the use of simple main effects at each level of eye-condition. This showed a non-significant effect of pictures during the open condition $t(58) = -0.11$, $p = .91$, Cohens's $d = 0.06$, $BF_{10} = 0.26$. However, the difference was significant in the closed condition with pictures producing a higher hit rate, $t(58) = 4.37$, $p < .001$, Cohens's $d = 1.13$, $BF_{10} = 385.49$.

For critical lures, the only significant effect was for the picture condition (lower related false memory when pictures were present). No effects were found for unrelated-unstudied items. The results from the Bayesian analyses for the proportion measures revealed a similar outcome to the traditional analyses.

7.3. Discussion of the findings

Experiment 2 found the presence of pictures increased recognition accuracy by enhancing the hit rate and marginally reducing the unrelated-unstudied false alarm rate. Eye-closure produced a picture superiority effect for true memory that was absent when eyes were open. The lack of a picture superiority effect with eyes open is like that reported in previous experiments (e.g., Dodson & Hege, 2005; Schacter et al., 1999). The present work shows that picture superiority effects can be obtained using the DRM paradigm when the eyes are closed.

Associative false memory was reduced by pictures. Further assessment of this demonstrated that the ability to discriminate between related and unrelated items (*d*' false) was reduced in the eyes open condition when pictorial information was present. However, the interaction effect was small and deemed equivocal when Bayesian analyses were performed.

Despite this, clearer effects were obtained in the proportion analyses in which a reduction in the critical false alarm rate was brought about by the presence of pictorial information during encoding. The finding of more definitive results proportion measures is not without precedent. For example, the effect of pictures (vs. words) has sometimes been detected on proportion scores to critical lures that are masked or reduced to non-significance when *d*' scores are used (e.g., Budson et al., 2000; Schacter et al., 1999). This arises because the latter takes into account responses to both related and unrelated items and represents a measure of discrimination between the two types of item as opposed to associative vs. unrelated false alarms as measured by the proportion scores.

8. General Discussion

8.1. Overview and summary of main findings

Both experiments found eye-closure enhanced true recognition under conditions in which recognition either necessitated the retrieval of item-specific information (Experiment 1) or could be assisted by its retrieval (Experiment 2). In Experiment 1, eye-closure resulted in higher *d*' item-specific scores (indicating an enhanced ability to discriminate studied from related pictures). In Experiment 2, eye-closure brought about a picture superiority effect; memory was higher for words studied alongside pictures.

False memory was reliably reduced by eye-closure in the first experiment for proportion scores for related-unstudied items and gist-based memory (*d*’ gist). In Experiment 2, the presence of pictures reduced false memory but eye-closure did not. However, there was a marginal interaction in which discrimination between related-unstudied and unrelated-unstudied lures was poorest with eyes open in the presence of pictures.

8.2. Theoretical foundations of EC effects in the current experiments

The introduction outlined two explanations of eye-closure effects; a general resource account and a modality-specific account (e.g., Craik, 2014; Perfect et al., 2011). These are considered in relation to the findings of Experiments 1 and 2.

Retrieval from long-term memory requires top-down control when cues are insufficient to directly reactivate stored information (Dudukovic & Kuhl, 2017). In situations like these, retrieval is dependent on frontal-executive processes that perform controlled searches and monitor the products of retrieval attempts (Unsworth, Brewer, & Spillers, 2013). In this context, the increase in item-specific recognition with eye-closure is of importance. In the first experiment, this amounted to an increased hit rate to studied items and decreased false alarm rate to related-unstudied items. Following the presentation of a test-item, eye-closure enables the freeing of resources to engage several cognitive activities such as search and monitoring processes. In relation to recognition memory, the search process might be obviated, when *studied* items are presented as compared to unstudied items, they are more likely to directly cue recall of the stimulus (Moscovitch, 1992; Uzer & Brown, 2017). However, given the nature of the target-lure relationship (high conceptual and perceptual similarity), retrieval may require more resource demanding processes to ascertain the study status of the test item (Bowman & Dennis, 2015; Peters, Jelicic, Verbeek, & Merckelbach, 2007). If so, manipulations that enable such processes to occur efficiently (such as eye-closure) should improve memory. In addition, if direct retrieval cannot be accomplished, then more attentionally demanding processes will be required for the search process itself (Moscovitch, 1992; Unsworth et al., 2013). Thus, studied items are more likely to be recognised and related lures rejected because eye-closure frees resources and enables more effective search operations that allow features of studied items to be identified. For related-unstudied items, eye-closure could facilitate the recall of studied information in order to correctly reject unstudied-related items.

Similar arguments could be made for the findings of Experiment 2. Namely, eye-closure could result in the freeing of attentional resources in order to use presented cues to recall not only the studied words, but additional pictorial information (Wais et al., 2012). The difference in the second experiment was that reduced false memory of critical lures was uninfluenced by eye-closure (only the presence of pictures). This suggests that true and false memory are mediated by different mechanisms.

The modality-specific processing account can also be used to explain some of the current results. Previous research has shown that the recall of visual information can lead to the *re*activation of sensory cortices (Slotnick, & Schacter, 2004, 2006; Stokes, Thompson, Cusack, & Duncan, 2009; Thakral, Slotnick, & Schacter, 2013), and interference with such activations reduces memory accuracy (Waldhauser, Braun, & Hanslmayr, 2016). These findings are useful in explaining the results of eye-closure on true memory in both experiments reported here. Particularly, enhancing memory through freeing visual processing resources from interfering visual input and allowing the more effective regeneration of pictorial information pertaining to the studied objects (Experiment 1) or associated with studied words (Experiment 2).

Of additional importance, the reactivation of perceptual information can be used to *suppress* memory for familiar (but non-presented) information and reduce false memory (Bowman & Dennis, 2015). In terms of the modality-specific account of eye-closure effects, eliminating perceptual input enables more effective visualisation and recall of studied perceptual information and the rejection of related stimuli as found in Experiment 1. In relation to Experiment 2, eye-closure did not result in reduced false memory. One explanation for this could be that the use of a recall-like mechanism is not as efficient for rejecting non-studied lures in the DRM paradigm.

8.5. Issues arising & future work

In contrast to the current work, no effects of EC on recognition memory were found in two previous papers (Uchiyama & Mitsudo, 2019; Vredeveldt et al., 2015). Direct comparisons between these experiments and the current studies are difficult because of differences between the materials and tasks. However, some points of difference can be highlighted that could prove to be of importance when both assessing the current findings and in planning future research.

In relation to Experiment 1, responses were made during EC after the presentation of the test item. In past work on visual recognition, the EC phase was prior to the test item and instructions provided to mentally recall and rehearse studied items. Future work might want to compare directly pre and post-test EC phases in a similar design to Experiment 1 to assess the relative effectiveness of these on recognition.

Further work might also alter the timing parameters to evaluate the influence of variations in the amount of time the eyes are closed and the intervals between item presentation and eye closure. This is because recognition memory has been theorised to be the outcome of both automatic and controlled processing activities (e.g., Jacoby, 1991; Yonelinas, 2002). Automatic processing is less likely to be influenced by competing attentional demands (e.g., Gruppuso, Lindsay, & Kelley, 1997; Hasher & Zacks, 1979), and thus should benefit less from EC. In addition, recognition that is the result of the recall of item-specific details is slower compared to automatic forms of recognition based on familiarity (e.g., Gronlund, Edwards, & Ohrt, 1997; Hintzman, Caulton, & Levin, 1998). Consequently, variations in the timing parameters of the recognition test, for example by use of a response-deadline procedure, should have implications for detecting EC effects. To the extent EC effects result from the retrieval of item-specific details, then speeded responding should reduce such effects.

In relation to both experiments, intentional learning instructions were provided during encoding. Consequently, participants were free to decide for themselves the most appropriate encoding strategies. For example, on being presented with a picture of an object, they could have engaged in some form of elaborative processing (e.g., Craik & Watkins, 1973). Previous work on EC has made use of both intentional (Rae & Perfect, 2014) and incidental (Vredeveldt, & Penrod, 2012) encoding instructions. Similarly, work on associative false memories has made use of intentional and incidental encoding instructions (e.g., Schacter et al., 1999; Koutstaal, 2003). Future work should control for particular encoding strategies by the use of orienting tasks that focus attention on specific stimulus dimensions (e.g., conceptual vs. perceptual). This could establish whether the effects found here (or indeed in other EC experiments), are moderated by the type of information encoded.

8.7. Summary and conclusions

Eye-closure was found to influence recognition memory when the materials and retrieval instruction required or allowed for the retrieval of detailed pictorial information and under particular testing environments in which recognition responses were made with eyes closed. This contrasts to previous work in which such constraints were not met (Uchiyama & Mitsudo, 2019; Vredeveldt et al., 2015). Future work needs to extend the present findings to other materials and test-schedules to assess further the conditions under which EC is beneficial to improving recognition memory.

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Footnotes

1. Memory for perceptual item-specific information can be assessed in numerous ways. For example, one procedure could involve the use of identical pictures presented in one of two different colours. The paradigm selected here was selected based on previous research for which well-tested stimulus sets existed and that had examined aspects of false perceptual memory as its focal topic.
2. Sample size was determined by the consideration of past research on eye-closure effects at the time of designing and initiating the present research (early 2014). A review of past work encompassing 18 separate experiments indicated a between-participants, per-condition (eyes closed vs. eyes open) size of 24.44 (mean) and 24.50 (median). That is, the average number of participants in each condition (open vs. closed) was approximately 25.
3. In Experiment 2, the manipulation of picture condition (picture present vs. absent) was, following past work, manipulated between-participants. Accordingly, a review of past experiments similar to Experiment 2 were used to determine sample size. Across a range of 16 experiments (published before 2015), the between-participants, per condition (pictures present vs. absent) were 18.37 (mean), 18 (median).
4. The research assistants were provided with specific instructions about reading aloud the test items. Prior to data collection each, experimenter was “piloted” to ensure they were able to follow these instructions and the procedure for the experiment. The experimenters were not aware of the specific hypotheses under test, and did not have knowledge of the particulars of the stimulus sets.

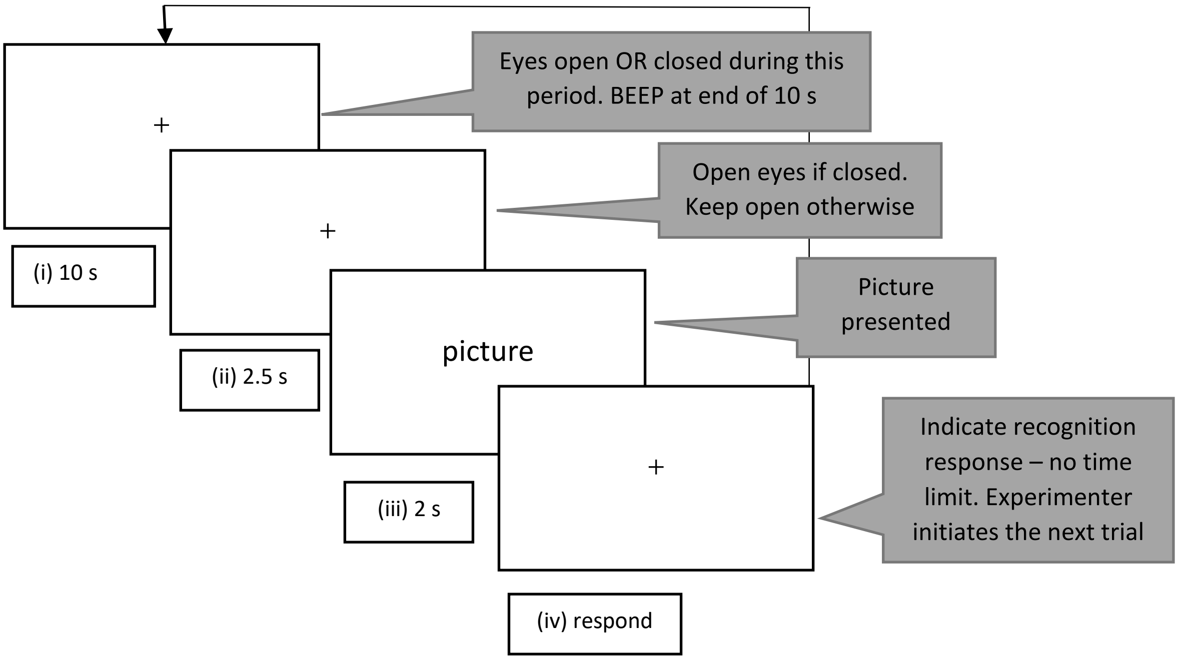

Figure 1. Outline of the test procedure used in Experiment 1. See procedure for details.

TABLE 1
Experiment 1: Mean (SE) SDT measures and process estimates as a function of eye condition, measure and responses type

	Eye Condition	
Response Type	Open	Closed
Signal Detection Measures – Accuracy		
d' gist + item-specific (*studied vs. unrelated-unstudied*)	2.42 (0.11)	3.04 (0.14)
d' item-specific (*studied vs. related-unstudied*)	1.12 (0.08)	2.04 (0.16)
d' *gist* (*related-unstudied vs. unrelated-unstudied*)	1.31 (0.09)	0.99 (0.09)
Signal Detection Measures - Response Bias		
Log β gist + item-specific (*studied vs. unrelated-unstudied*)	0.86 (0.11)	0.36 (0.08)
Log β item-specific (*studied vs. related-unstudied*)	-0.34 (0.06)	-0.67 (0.10)
Log β *gist* (*related-unstudied vs. unrelated-unstudied*)	1.20 (0.10)	1.03 (0.09)
Proportion Measures		
Item Type		
Studied	.79 (.02)	.90 (.01)
Related-unstudied	.41 (.03)	.28 (.03)
Unrelated-unstudied	.09 (.02)	.08 (.02)

TABLE 2
Experiment 1. Summary of ANOVA results for SDT, proportion and process measures

Response Type & Source of Effect	*df*	*F*	*p*	η_p^2	BF_{10}
SDT Measure Analyses					
Accuracy *d*'					
Main Effect Eye Condition	1, 78	11.92	.001	.13	10.86
Main Effect *d*' type	2, 156	129.33	< .001	.62	5.49×10^{28}
Interaction*	1, 156	19.86	< .001	.20	8.09×10^{5}
Response Bias Log β					
Main Effect Eye Condition	1, 78	13.56	< .001	.15	4.27
Main Effect β type	2, 156	203.69	< .001	.72	1.31×10^{45}
Interaction*	2, 156	2.01	.14	.02	0.53
Proportion Analyses					
Proportion Scores					
Main Effect Eye Condition	1, 78	0.36	.55	.005	0.16
Main Effect Item-Type	2, 156	596.03	< .001	.88	3.83×10^{89}
Interaction*	2, 156	12.92	< .001	.14	1.65×10^{4}

*NOTE. The interaction value for the Bayesian analyses is the BF_{10} for the *inclusion* of a model containing the unique contribution of the interaction compared to a model that incorporates the main effects. Thus, values > 3 are taken to indicate evidence in favour of a model in which the interaction term is incorporated.

TABLE 3
Experiment 2: Mean (SE) SDT, proportion and process estimates as a function of eye condition, response type and picture condition

Response Type & Picture Condition	Eye Condition: Open	Eye Condition: Closed
Signal Detection Measures		
d'True		
Picture	1.23 (.06)	1.75 (.16)
No Picture	1.05 (.17)	0.89 (.12)
d' False		
Picture	0.07 (.09)	0.45 (.09)
No Picture	0.58 (.15)	0.48 (.12)
Log β True		
Picture	0.48 (.16)	0.41 (.15)
No Picture	0.37 (.14)	0.41 (.12)
Log β False		
Picture	-0.01 (.04)	0.36 (.08)
No Picture	0.16 (.12)	0.28 (.10)
Proportion Measures		
Studied		
Picture	.58 (.03)	.71 (.03)
No Picture	.58 (.03)	.51 (.03)
Related-Unstudied (Critical lure)		
Picture	.35 (.03)	.36 (.03)
No Picture	.50 (.04)	.46 (.03)
Unrelated-Unstudied		
Picture	.23 (.02)	.19 (.03)
No Picture	.27 (.03)	.25 (.03)

TABLE 4
Experiment 2. Summary of ANOVA results for SDT and process measures

Response Type & Source of Effect	*df*	*F*	*p*	η_p^2	BF_{10}
Signal Detection Measures – Accuracy Analyses					
d' True					
Main Effect Eye Condition	1, 115	1.63	.20	.01	0.42
Main Effect Picture Condition	1, 115	12.73	.001	.10	28.15
Interaction*	1, 115	5.47	.02	.04	3.36
d' False					
Main Effect Eye Condition	1, 115	1.50	.22	.01	0.44
Main Effect Picture Condition	1, 115	5.11	.03	.04	2.97
Interaction*	1, 115	4.09	.05	.03	1.28
Signal Detection Measures - Response Bias Analyses					
Log β True					
Main Effect Eye Condition	1, 115	0.01	.91	< .001	0.20
Main Effect Picture Condition	1, 115	0.17	.68	.001	0.21
Interaction*	1, 115	0.19	.67	.002	0.34
Log β False					
Main Effect Eye Condition	1, 115	7.79	.006	.06	6.17
Main Effect Picture Condition	1, 115	0.32	.57	.003	0.25
Interaction*	1, 115	2.26	.14	.02	0.71
Proportion Analyses					
Studied					
Main Effect Eye Condition	1, 115	0.41	.52	<.001	0.22
Main Effect Picture Condition	1, 115	9.31	.003	.07	8.31
Interaction*	1, 115	10.31	.002	.08	20.22
Critical Lure					
Main Effect Eye Condition	1, 115	0.16	.69	.001	0.21
Main Effect Picture Condition	1, 115	12.29	.001	.10	44.82
Interaction*	1, 115	0.69	.41	.006	0.35
Unstudied					
Main Effect Eye Condition	1, 115	1.57	.21	.01	0.38
Main Effect Picture Condition	1, 115	4.32	.04	.04	1.32
Interaction*	1, 115	0.09	.77	.001	1.00

*NOTE. The interaction value for the Bayesian analyses is the BF_{10} for the *inclusion* of a model containing the unique contribution of the interaction compared to a model that incorporates the main effects. Thus, values > 3 are taken to indicate evidence in favour of a model in which the interaction term is incorporated.

Supplementary Material: Further Details of Process Calculations and Analyses in the Main Report:
"Eye-Closure & the Retrieval of Item-Specific Information in Recognition Memory"

By
Andrew Parker* & Neil Dagnall

The information presented below extends some of the coverage of the main report by providing additional information on the RKG procedure and the proportion RKG responses including descriptive statistics and analyses. They are presented here because of the more exploratory nature of the use of this procedure in the current experiments.

Method

Instructions used for the remember-know guess procedure for Experiments 1 and 2.

The instructions for the remember-know task were modelled on previous work (e.g., Gardiner & Richardson-Klavehn, 2000). The definitions provided were as follows: (i) remember responses were described as those that involved the conscious recollection of a studied item or experience that could include the way the item appeared or was presented. (ii) know responses were described as those in which an item was recognised because of its familiarity in the context of the experiment but which lacks associated recollective details. (iii) guess responses were indicated to be those in which the subject felt they were just presuming the item had been studied and was neither associated with recollection or familiarity.

Experiment 1

Results

The means (SEs) for the raw proportion scores for remember, know and guess responses can be seen in Table S1 and the ANOVA findings in Table S2. The analyses were 2(eye condition; open vs. closed) between-subjects by 3(item type; studied vs. related vs. unrelated) within-subjects mixed ANOVAs. Separate analyses were performed for the remember, know and guess responses.

TABLE S1

Experiment 1. Mean (SE) proportion scores, as a function of eye condition, item type and response

Item Type & Response	Eye Condition: Open	Eye Condition: Closed
Studied		
Remember	.35 (.04)	.34 (.04)
Know	.38 (.04)	.52 (.05)
Guess	.07 (.02)	.05 (.01)
Related		
Remember	.20 (.02)	.13 (.02)
Know	.13 (.01)	.07 (.01)
Guess	.08 (.01)	.09 (.01)
Unrelated		
Remember	.04 (.01)	.02 (.01)
Know	.01 (.01)	.01 (.01)
Guess	.02 (.01)	.02 (.01)

TABLE S2

Experiment 1. Summary of ANOVA results for proportion measures

Response Type & Source of Effect	*df*	*F*	*p*	η_p^2
Remember				
Main Effect Eye Condition	1, 78	1.14	.29	.01
Main Effect Item-Type	2, 156	76.72	< .001	.50
Interaction	2, 156	0.93	.40	.01
Know				
Main Effect Eye Condition	1, 78	1.35	0.25	.02
Main Effect Item-Type	2, 156	128.93	< .001	.62
Interaction	2, 156	6.60	.002	.08
Guess				
Main Effect Eye Condition	1, 78	0.04	.84	< .001
Main Effect Item-Type	2, 156	16.96	< .001	.18
Interaction	2, 156	1.25	.29	.02

The interaction for 'know' responses was significant. This was assessed by the use of simple main effects at each level of item-type. This indicated a significant difference between the eye conditions for studied and related exemplars, $t(78) = 2.15$, $p = .03$, Cohen's $d = 0.47$, and $t(78) = 2.92$, $p = .005$, Cohen's $d = 0.64$, respectively. The difference between the eye condition was not significant for unrelated exemplars, $t(78) = 0.55$, $p = .58$, Cohen's $d = < 0.001$. With regard to the significant effects, know responses to studied exemplars was *higher* when eyes were closed. For related exemplars, this difference was reversed and know responses were lower when eyes were closed.

Continued Overleaf

Experiment 2

Results

The means (SEs) for the raw proportion scores for remember, know and guess responses can be seen in Table S3 and the ANOVA findings in Table S4. The analyses were 2(eye condition) between-subjects by 2(picture condition; picture vs. no picture) between-subjects ANOVAs. Separate analyses were performed for each type of item and for the remember, know and guess responses.

TABLE S3

Experiment 2. Mean (SE) proportion scores for tested items as a function of eye condition, response type and picture condition

Response Type & Picture Condition	Eye Condition: Open	Eye Condition: Closed
Studied Items – True Memory		
Remember		
Picture	.42 (.04)	.51 (.04)
No Picture	.43 (.03)	.39 (.03)
Know		
Picture	.12 (.02)	.13 (.02)
No Picture	.11 (.02)	.07 (.01)
Guess		
Picture	.04 (.01)	.04 (.01)
No Picture	.04 (.01)	.05 (.01)
Critical Lures – Associative False Memory		
Remember		
Picture	.15 (.03)	.19 (.02)
No Picture	.32 (.04)	.28 (.03)
Know		
Picture	.12 (.02)	.12 (.02)
No Picture	.13 (.03)	.11 (.03)
Guess		
Picture	.08 (.02)	.05 (.02)
No Picture	.05 (.01)	.07 (.02)
Unrelated Lures – Unrelated False Memory		
Remember		
Picture	.08 (.01)	.05 (.01)
No Picture	.10 (.02)	.13 (.02)
Know		
Picture	.09 (.01)	.05 (.01)
No Picture	.09 (.01)	.07 (.01)
Guess		
Picture	.06 (.01)	.08 (.01)
No Picture	.08 (.01)	.04 (.01)

TABLE S4
Experiment 2. Summary of ANOVA results for proportion measures

Response Type & Source of Effect	*df*	*F*	*p*	η_p^2
Studied Items – True Memory Analyses				
Remember				
Main Effect Eye Condition	1, 115	1.27	.26	.01
Main Effect Picture Condition	1, 115	4.37	0.04	.04
Interaction	1, 115	6.68	.01	.06
Know				
Main Effect Eye Condition	1, 115	0.97	.33	.008
Main Effect Picture Condition	1, 115	3.12	.08	.03
Interaction	1, 115	1.48	.23	.01
Guess				
Main Effect Eye Condition	1, 115	.01	.96	< .001
Main Effect Picture Condition	1, 115	0.14	.71	.001
Interaction	1, 115	0.26	.68	.002
Critical Lures – Associative False Memory Analyses				
Remember				
Main Effect Eye Condition	1, 115	0.01	.92	< .001
Main Effect Picture Condition	1, 115	14.32	< .001	.11
Interaction	1, 115	1.41	0.24	.01
Know				
Main Effect Eye Condition	1, 115	0.06	.81	.001
Main Effect Picture Condition	1, 115	0.01	.98	< .001
Interaction	1, 115	0.28	.59	.002
Guess				
Main Effect Eye Condition	1, 115	0.05	.82	< .001
Main Effect Picture Condition	1, 115	0.02	.89	< .001
Interaction	1, 115	1.69	.20	.01
Unstudied Lure – Unrelated False Memory Analyses				
Remember				
Main Effect Eye Condition	1, 115	0.11	.74	.001

	Main Effect Picture Condition	1, 115	10.70	.001	.08
	Interaction	1, 115	3.05	.08	.03
Know					
	Main Effect Eye Condition	1, 115	6.09	.01	.05
	Main Effect Picture Condition	1, 115	1.23	.27	.01
	Interaction	1, 115	0.32	.57	.003
Guess					
	Main Effect Eye Condition	1, 115	0.45	.52	.004
	Main Effect Picture Condition	1, 115	0.96	.33	.008
	Interaction	1, 115	4.45	.04	.03

The interaction for ‘remember’ responses to studied items was significant. This was assessed by the use of simple main effects at each level of picture condition. This indicated a significant difference between the picture conditions when eyes were closed, $t(57) = 3.38$, $p = .001$, Cohen’s $d = 0.86$, but not when eyes were open, $t(58) = 0.35$, $p = .73$, Cohen’s $d = 0.05$. Thus, when eyes were closed, the presence of pictures increased remember responses.

The interaction for ‘guess’ responses to unrelated items was significant. This was assessed by the use of simple main effects at each level of picture condition. This indicated no significant difference between the picture conditions when eyes were open, $t(58) = .77$, $p = .44$, Cohen’s $d = 0.28$, but a significant difference when eyes were closed, $t(57) = 2.27$, $p = .02$, Cohen’s $d = 0.61$. Thus, when eyes were closed, the presence of pictures increased guess responses.