Why It's Easier to Remember Seeing a Face We Already Know Than One We Don't: Pre-existing Memory Representations Facilitate Memory Formation

Reder, L. M.[1*], Victoria, L. W.[1], Manelis, A.[1], Oates, J. M.[2], Dutcher, J. M.[3], Bates, J. T.[4], Cook, S.[5], Aizenstein, H. A.[6], Quinlan, J.[7], Gyulai, F.[7]

[1]Psychology Department, Carnegie Mellon University, Pittsburgh, PA 15213
[2]Psychology Department, American University, Washington, DC, 20016
[3]Psychology Department, University of California, Los Angeles, CA, 90095
[4]Computer Science Department, Purdue University, West Lafayette, IN 47907
[5]Psychology Department, Millersville University, Millersville, PA 17551
[6]Department of Psychiatry, University of Pittsburgh Medical Center, Pittsburgh, PA, 15213
[7]Department of Anesthesiology, University of Pittsburgh Medical Center, Pittsburgh, PA, 15213

*Corresponding Author
Lynne M. Reder
Department of Psychology
Carnegie Mellon University
5000 Forbes Avenue
Pittsburgh, Pennsylvania 15213
Phone: (412) 268-3792
Fax: (412) 268-2844
reder@cmu.edu

Total words: 4251

Abstract

In two experiments, we provide support for the hypothesis that stimuli with pre-existing memory representations (*e.g.*, famous faces) are easier to associate to their encoding context than are stimuli that lack a long-term memory representation (*e.g.*, unknown faces). Subjects viewed faces superimposed on different backgrounds (*e.g.*, Eiffel Tower). Face recognition on a surprise memory test was better when the encoding background was reinstated; however, the reinstatement advantage was modulated by how many faces had been seen with a given background, and reinstatement did not improve recognition for unknown faces. The follow-up experiment added a drug intervention that inhibits the ability to form new associations. In the drug condition, context reinstatement did not improve recognition for famous or unknown faces. The results suggest that it is easier to associate context to faces that have a pre-existing long-term memory representation.

Keywords: pre-existing memory representations, face recognition, familiarity, amnesia, context-associations

Why it's Easier to Remember Seeing a Face We Already Know Than One We Don't: Pre-existing Memory Representations Enable New Memory Formation

Recognition memory for familiar faces is better than for unfamiliar faces (*e.g.*, Bruce & Young, 1986; Ellis, Shepard & Davies, 1979; Hancock, Bruce & Burton, 2000; Johnston & Edmonds, 2009; Leveroni, Seidenberg, Mayer, Mead, Binder & Rao, 2000; Valentine & Bruce, 1986; Voss & Paller, 2006; Voss, Reber, Mesulam, Parrish & Paller, 2008). It has been suggested that semantic knowledge of celebrities facilitates recognition by enhancing elaboration of the encoding episode using associated factual knowledge of famous individuals (Carbon, 2008; Jackson & Raymond, 2008; Voss & Paller, 2006; Zion-Golumbic, Kutas & Bentin, 2010). While there is no doubt that it is easier to elaborate an encoding episode that involves a stimulus we know more about, the goal of this paper is to explore whether there are other factors that moderate this effect.

In this study, we test the hypothesis that the memory advantage of known faces over unknown faces results, in part, from the greater ease of associating known stimuli to their encoding context. It is known that reinstatement of context often helps memory (*e.g.*, Godden & Baddeley, 1975; Smith, Glenberg, Bjork, 1978), including face memory (Kerr & Winograd, 1982). However, the benefit of context reinstatement is modulated by the *fan* of the context (*i.e.*, the number of memories associated with a given context; Diana, Peterson & Reder, 2004; Park, Arndt & Reder, 2006; Reder, Donavos & Erickson, 2002). To test our hypothesis, we manipulate the fan of the background shown with known and unknown faces and whether the background is reinstated at the recognition test. We predict that these manipulations will have greater impact on memory for famous than unknown faces.

To further test our hypothesis, Experiment 2 includes a drug intervention that disrupts the formation of new memories but leaves familiarity-based judgments unaffected. Finally, in both experiments we include an additional test of the hypothesis that the memory advantage for known faces comes from the greater ease of associating context to stimuli that have pre-existing representations in memory: we asked subjects to give a phenomenological report of whether a given "Old" response was based on retrieval of contextual information from the encoding episode or based on item familiarity.

Why manipulate background fan? The SAC model of memory (*e.g.*, Reder et al., 2002; Diana, Reder, Arndt, & Park, 2006) posits that when an encoding context is associated with many study episodes, the benefit of reinstatement is diminished. This is because the amount of additional activation that is sent to any single episode node from the activation source of the test probe context is shared or distributed among all the competing contextual associations. Therefore, manipulations of contextual fan (such as the number of faces associated with a background) should affect the success of recovering the memory trace associated with that context (Diana et al., 2004; Park et al., 2006; Reder et al., 2002; Rutherford, 2004; Smith & Manzano, 2010). Given the reasonable assumption that it is easier to elaborate the encoding for famous faces (because more is known about them), we want to make sure that any greater reinstatement advantage for famous faces than unknown faces is the result of greater ease of associating the famous person to the encoding context, not elaboration, *per se*. We predict that famous faces will be more affected by background fan when context is reinstated than unknown faces because the former are more likely to have successfully associated the face to the context in the first place. The elaboration explanation for a reinstatement advantage for famous faces should not predict that background fan would affect the reinstatement advantage. Likewise, an elaboration account cannot explain why the recognition benefit of reinstatement of an unusual font or voice used during word encoding is modulated by font or voice fan.

Why introduce a drug intervention? Midazolam, a benzodiazepine that produces temporary anterograde amnesia, has been shown to block the formation of new associations (*e.g.* Hirshman, Fisher, Henthorn, Arndt, & Passannante, 2003; Park, Quinlan, Thornton, & Reder, 2004; Reder, Oates, Thornton, Quinlan, Kaufer, & Sauer, 2006; Reder et al. 2007a) and should only affect stimuli that could otherwise be associated with context. Midazolam is known to not affect retrieval of previously learned (i.e., semantic) knowledge (*e.g.*, Ghoneim, 2004; Hirshman et al., 2003). If the advantage of famous faces is due to a greater ability to bind the stimulus to context, the detriment due to midazolam should be greatest for famous faces that have a reinstated background that is low fan. Conversely, it should have the smallest effect for unknown faces regardless of background manipulation.

Why include Remember/Know judgments? While not all memory theorists agree that recognition judgments can be based on either a recollective or familiarity process (see Diana et al., 2006, for a review), many recognition memory paradigms have employed the "Remember/Know" procedure developed by Tulving (1985) to measure the contributions of recollection and familiarity processes to recognition judgments (*e.g.*, Dudukovic & Knowlton, 2006; Horry, Wright, & Tredoux, 2010; Joordens & Hockley, 2000; Reder, Nhouyvanisvong, Schunn, Ayers, Angstadt, & Hiraki, 2000; Yonelinas, 2002). Reder et al. (2000; 2002) proposed that recollection depends on the ability to access an encoding episode that links the stimulus to the encoding context. From that perspective, if it is difficult to form associations between the stimulus and the encoding context, "Old" judgments should be based on familiarity rather than recollection, yielding few "Remember" responses. If the episodic trace linking a stimulus to its associated context can be retrieved at test, we predict that there should be more recollection-based responding. Therefore, we predict more Remember responses for famous faces with low-fan, reinstated backgrounds provided the subject's ability to form associations was not impaired by the drug. The SAC model of memory posits that recollection (Remember judgments) involves retrieval of the memory trace involving the encoding context and that the fan of the context (*e.g.*, number of other faces associated with a background) affects the ease of retrieval of any one of the associated encoding episodes (Reder et al., 2002).

Experiment 1

Subjects

Thirty-eight undergraduates from Carnegie Mellon University (ages 18-25) participated for partial course credit or $10.

Materials, Design & Procedure.

Stimuli were images collected from the Internet composed of a famous or unknown face superimposed onto the bottom left side of a background (see top panel of Figure 1). There were two different photographs of each face for a total of 384 face pictures. One photograph of a face was used during the encoding phase, while the other was used during the test phase (see bottom panel of Figure 1). The backgrounds were photographs of 20 well-known locations (*e.g.,* the Grand Canyon, the Statue of Liberty, the Eiffel Tower).

During the encoding phase, subjects viewed 96 faces superimposed on backgrounds and rated how likely it was that the person depicted would visit that location (from 1 -“very unlikely” to 5 - “very likely”). After rating all 96 faces, there was a surprise recognition test in which subjects were shown 192 faces, half old and half new, and asked to judge whether the person depicted had been rated during encoding, irrespective of whether the background was the same one shown earlier. After all target and foil faces had been judged, there was a post-test that asked subjects to indicate whether the face was of someone they could identify as famous.

The factors (old/new, famous/unknown, reinstated/swapped, high/low background fan) did not comprise a full factorial design because the reinstatement/swapped variable was only defined for the old faces but all factors were balanced and randomly permuted for each subject (*e.g.*, for each subject a given background was randomly assigned to be high or low fan, assigned to famous or unknown people, reinstated or swapped for a face). High-fan backgrounds appeared with 12 faces while low-fan backgrounds appeared with three faces. We chose to swap backgrounds rather than replace them with new ones (Murname & Phelps, 1993, 1994) when the context was not reinstated so that global familiarity was independent of contextual reinstatement. We also chose to always replace the photo of the person whether in the swapped or reinstated condition so that the value added of reinstatement could not be attributed to an advantage due to an identical image.

During the encoding phase, the stimuli were displayed for 2 seconds each followed by a prompt for subjects to rate the likelihood that the person depicted would visit that location on the keyboard.[1] During the surprise recognition test phase, half of the faces had not been rated previously. All of the backgrounds seen during the test phase had been part of the first phase rating task, but were seen with different people half of the time. When the original background for a face was not reinstated at test, a different background of the same fan level was substituted (*i.e.*, if the encoding background was high-fan, the test background was also high-fan). Although backgrounds were randomly assigned to famous or unknown faces for each subject, when a background was high-fan all associated faces would be of the same fame status. Likewise, backgrounds would be swapped with the same level of fan and fame (*e.g.*, another high-fan, unknown face).

Subjects were further instructed that when they thought that they recognized the face from the previous rating task (irrespective of background matching or not), they were to indicate the nature of their recognition, using the *Remember* vs. *Know* method developed by Tulving (1985). Subjects were told to respond *Remember* when they could retrieve details regarding the experience of judging the previously viewed face and *Know* when the face seemed *so familiar that it must have been viewed previously* but no encoding details come to mind.[2] The keys “S”, “G,” “K” were covered with stickers labeled with *R*, *K*, and *N* to indicate *Remember*, *Know*, and *New* responses, respectively.

The face identification post-test showed faces without backgrounds and subjects were required to indicate whether or not a face was famous. For famous judgments, subjects were asked to give some sort of identifying information such as name, political office held, or movie in which person appeared.

Results and Discussion

Trials involving “famous” stimuli that were not identified as famous on the post-test were excluded from analysis. On average, subjects could correctly identify 90% of the famous faces and were very accurate at rejecting unknown faces.

The proportion of hits and false alarms are presented in Table 1 as a function of whether the background was reinstated or swapped at test (for targets), whether the background was high or low-fan, and whether the face was famous or unknown. These results are presented both as *Old* responses that reflect the sum of *Remember* and *Know* responses and separately for *Remember* responses, thought to reflect a recollection-based recognition judgment. The results of the signal detection analyses are shown in Figure 2. A one-sample t-test of d' scores showed that, for all conditions, *d′* was significantly above 0 (all p-values <0.001) for both *Old* and *Remember* judgments.

A 2 (fame) x 2 (fan) x 2 (reinstated) repeated-measure ANOVA was performed on hit rates and on *d′* scores for both *Old* and *Remember* responses. Effects that were not significant are not reported. These analyses revealed a significant main effect of fame [*Old* hits: $F(1,37)=132.58$, $p<.001$, partial $\eta^2=.78$; *Remember* hits: $F(1,37)=410.57$, $p<.001$, partial $\eta^2=.92$; *Old d′:* $F(1,37)=105.7$, $p<.001$, partial $\eta^2=.74$; *Remember d′:* $F(1,37)=129.48$, $p<.001$, partial $\eta^2=.78$]. This main effect of fame is consistent with studies that have reported that famous faces are better recognized than non-famous (unknown) faces (Carbon, 2008; Jackson & Raymond, 2008; Voss & Paller, 2006; Zion-Golumbic et al., 2010).

Memory performance was also significantly better when the background was reinstated [*Old* hits: $F(1,37)=14.8$, $p<.001$, partial $\eta^2=.29$; *Remember* hits: $F(1,37)=20.90$, $p<.001$, partial $\eta^2=.36$; Old *d′:* $F(1,37)=17.5$, $p<.001$, partial $\eta^2=.32$; *Remember d′:* $F(1,37)=15.49$, $p<.001$, partial $\eta^2=.3$]. There was an interaction between reinstatement and fame for *Remember* hits [$F(1,37)=23.96$, $p<.001$, partial $\eta^2=.39$] and *Remember d′* [$F(1,37)=12.4$, $p<.005$, partial $\eta^2=.25$], and also a significant three-way interaction of fame x fan x reinstatement for *Remember d′* scores [$F(1,37)=4.8$, $p<.05$, partial $\eta^2=.12$].

We conducted separate 2 (fan) x 2 (reinstatement) ANOVAs for famous and unknown faces. While accuracy for unknown faces was reliably above chance, neither reinstatement of background nor background-fan, nor their interaction affected recognition accuracy. However, when the same comparison of *d′* scores was done for famous faces, there was a main effect of reinstatement for all *Old* responses [$F(1,37)=12.1$, $p<0.005$, partial $\eta^2=.25$], a still stronger main effect for *Remember* responses [$F(1,37)=21.3$, $p<0.001$, partial $\eta^2=.37$], and a fan by reinstatement interaction [$F(1,37)=6.3$, $p<0.05$, partial $\eta^2=.15$] such that memory accuracy for *Remember* responses was better when reinstated backgrounds were low-fan. The follow-up analyses of famous faces revealed that the proportion of *Remember* hits and *Remember d′* scores was greater for reinstated than for swapped trials for both high-fan [hits: $t(37)=2.7$, $p<0.05$; d' : $t(37)=2.1$, $p<0.05$] and low-fan [hits: $t(37)=5.8$, $p<0.001$; d' : $t(37)=5.2$, $p<0.001$] conditions.

These results support the prediction that reinstatement helps more for low-fan backgrounds of famous individuals because it would be easier to access the episodic memory trace when there are few competing associations (Diana et al., 2006; Reder et al., 2002). Neither reinstatement nor background fan matters for unknown faces because the faces are not likely to be bound to the background during encoding. Given that it is difficult to build an episodic memory trace for these stimuli, their *Old* judgments are based on familiarity and there are fewer *Remember* judgments.

Experiment 2

The goal of Experiment 2 was to provide an even stronger test of our hypothesis that faces that are known to the subjects before the experiment are easier to bind to context. We did this by using a drug intervention that affects the ability to create new associations (Evans & Viola-McCabe, 1996; Hirshman, Passannante, & Arndt 1999; Hirshman, Passannante, & Arndt, 2001).

Subjects

Twenty-eight subjects from the campus communities of the University of Pittsburgh and Carnegie Mellon University, who had not participated in Experiment 1, participated in Experiment 2. Subjects were compensated $170 for participating in this experiment and another one in the two sessions.

Materials and Design

Experiment 2 differed from Experiment 1 in that half of the subjects performed the task under midazolam and the post-test was administered at the second session. Midazolam only affects memory formation, not retrieval of information so the post-test performance was unaffected by drug condition at the second session. Experimental procedures began approximately 15 minutes after drug or saline administration.

Results and Discussion

Eight subjects were dropped due to issues with a computer program. As in Experiment 1, trials were eliminated if subjects identified a famous face as unknown during the post-test. Post-test performance was unaffected by drug condition. The saline group's accuracy on the post-test (administered under midazolam) was 92% (SE=0.03) which did not differ from the midazolam group's accuracy 90% (SE=0.02) on the post-test (administered under saline), $t(17)=-0.3$. This finding provides additional evidence that midazolam does not affect retrieval of information from semantic memory. We also examined encoding time (time to decide the appropriateness of the background) as a function of stimulus type and drug condition. Although subjects under midazolam were a bit slower to respond than under saline and although responses for famous faces were bit faster than to unknown faces, these effects were not significant (Midazolam-Famous: 1023.0ms (SE=164.2); Midazolam-Unknown: 1057.9ms (SE=136.2); Saline-Famous: 890.0ms (SE=248.4); Saline-Unknown: 913.8ms (SE=225.7).

Table 2 presents the same information as Table 1 with the added between subjects factor of whether the experiment was performed under midazolam or under saline. Figure 3 illustrates the d' scores for *Old* and *Remember* judgments.

A 2x2x2x2 repeated-measures ANOVA on accuracy (with fame, fan, and background as within-subject variables and drug condition as a between-subject variable) revealed a significant main effect of fame [*Old* hits: $F(1,17)=246.4$, $p<.001$, partial $\eta^2=.94$; *Remember* hits: $F(1,17)=66.5$, $p<.001$, partial $\eta^2=.8$; *Old d'*: $F(1,17)=69.1$, $p<.001$, partial $\eta^2=.8$; *Remember d'*: $F(1,17)=103.0$, $p<.001$, partial $\eta^2=.86$] and reinstatement [*Old* hits: $F(1,17)=6.3$, $p<.05$, partial $\eta^2=.27$; *Remember* hits: $F(1,17)=12.5$, $p<.005$, partial $\eta^2=.42$; *Old d'*: $F(1,17)=7.7$, $p<.05$, partial $\eta^2=.3$; *Remember d'*: $F(1,17)=12.7$, $p<.005$, partial $\eta^2=.43$]. For *Remember* hits, there was a significant main effect of background fan [$F(1,17)=4.8$, $p<.05$, partial $\eta^2=.22$], a fame by reinstatement interaction [$F(1,17)=6.0$, $p<.05$, partial $\eta^2=.26$] and a fame x fan x reinstatement interaction [$F(1,17)=7.2$, $p<.05$, partial $\eta^2=.3$].

There was also a main effect of drug on *Old d'* [$F(1,17)=14.4$, $p<.005$, partial $\eta^2=.46$] and *Remember d'* [$F(1,17)=8.7$, $p<.01$, partial $\eta^2=.34$]. Consistent with our expectations, memory was better for famous than unknown faces but the size of the advantage was significantly smaller under midazolam than saline. There was a significant fame by drug interaction [*Old* hits: $F(1,17)=12.9$, $p<0.005$, partial $\eta^2=.43$; *Remember* hits: $F(1,17)= 9.5$, $p<0.01$, partial $\eta^2=.36$; *Old d'*: $F(1,17)=10.1$, $p<0.005$, partial $\eta^2=.37$; *Remember d'*: $F(1,17)=15.4$, $p<0.005$, partial $\eta^2=.48$].

We conducted separate 2 (fame) x 2(fan) x 2(reinstatement) ANOVAs for saline and midazolam. The saline condition replicated the results of Experiment 1: main effect of fame [*Old* hits: $F(1,8)=203.7$, $p<0.001$, partial $\eta^2=.96$; *Remember* hits: $F(1,8)=142.9$, $p<0.001$, partial $\eta^2=.95$; *Old d'*: $F(1,8)=61.6$, $p<0.001$, partial $\eta^2=.89$; *Remember d'*: $F(1,8)=92.9$, $p<0.001$, partial $\eta^2=.92$] and reinstatement [*Old* hits: $F(1,8)=8.93$, $p<.05$, partial $\eta^2=.53$; *Remember* hits: $F(1,8)=5.6$, $p<.05$, partial $\eta^2=.41$; *Old d'*: $F(1,8)=8.8$, $p<.05$, partial $\eta^2=.52$; *Remember d'*: $F(1,8)=5.5$, $p<.05$, partial $\eta^2=.4$]. There was also a significant fame x fan x reinstatement interaction for *Remember* judgments [hits: $F(1,8)=22.5$, $p<.005$, partial $\eta^2=.74$; *d'*: $F(1,8)=14.7$, *p*<0.01, partial η^2=.65]. Follow-up planned comparisons revealed that for the saline condition, the reinstatement effect on *Remember* judgments was evident for famous low-fan stimuli [*t(*8)=4.1, *p*<.005], but not for famous high-fan or unknown stimuli. In the saline condition, the reinstatement effect was also reliable for *Old* judgments for famous low-fan stimuli (*t*(8)=3.2, *p*<0.05), but not for famous high-fan or unknown stimuli, p>0.1. The *d′* results for *Old* judgments were also reliable for low-fan famous faces, *t*(8)=3.3, *p*<0.05. The *d′* results replicated those for *Remember* responses with the significant reinstatement effect for famous low-fan stimuli, [*t*(8)=3.2, *p*<0.05]. The same 2 (fame) x 2(fan) x 2(reinstatement) ANOVA for midazolam subjects revealed a main effect of fame [*Old* hits: *F*(1,9)=69.2, *p*<.001, partial η^2=.89; *Remember* hits: *F*(1,9)=8.9, *p*<.05, partial η^2=.5; *Old d'*: *F*(1,9)=14.1, *p*<.005, partial η^2=.6; *Remember d'*: *F*(1,9)=20.6, *p* < .005, partial η^2=.7]. There was also a significant effect of reinstatement for *Remember* judgments [hits: *F*(1,9)=11.8, *p*<.01, partial η^2=.57; *d'*: *F*(1,9)=12.8, *p*<.01, partial η^2=.59]. No other effects were reliable.[3]

The fame by drug interaction described above can be understood as reflecting the fact that the hit rate for unknown faces was essentially the same under saline and midazolam. Our interpretation is similar to the one offered by Huppert and Piercy (1976, 1978) in their recognition memory study involving organic amnesic patients. Their patients could recognize pictures well above chance but were unable to indicate whether the picture had been seen a few minutes earlier or on the previous day.[4] We hypothesize that people are generally unable to associate contextual information to faces that lack a pre-existing representation in long-term memory (LTM). Therefore, because recollection is unlikely for unknown faces under saline, midazolam will not hurt performance for those stimuli. This hypothesis also explains why the benefit of reinstatement of a low fan background for famous faces was much greater when those faces were encoded under saline than midazolam. The ability to bind to context was diminished in the drug condition so reinstatement was of little use.

Given that midazolam affects the ability to bind stimuli to encoding context, the drug effect should be most pronounced for *Remember* responses. *Remember* responses are given when contextual information can be retrieved. Indeed, planned comparisons showed that in the low-fan reinstated background condition subjects under midazolam had significantly fewer *Remember* hits than subjects in the saline condition, [$t(17)=-3.0$, $p< 0.01$].

General Discussion

A number of variables affect the ability to associate the encoding context to the presented stimulus, including available working memory resources. When there are insufficient working memory resources, sometimes with older adults (Buchler, Faunce, Light, Gottfredson &Reder, 2010) or in a dual task setting (Castel & Craik, 2003), it is more difficult to associate context with a stimulus. In that case, memory performance relies more heavily on familiarity than recollection. The two experiments reported here demonstrate that another variable that also affects the ease of associating a stimulus to its encoding context is stimulus familiarity. The value added of context reinstatement for recognition memory is much greater when the stimuli have pre-existing memory representations (*e.g.,* famous faces) than when they are unknown (*e.g.,* faces of strangers). Furthermore, the benefit of reinstatement is modulated by the fan of the context. We hypothesized that stimuli with an LTM representation require less working memory resources than unfamiliar stimuli and therefore are easier to bind (see Reder, Paynter, Diana, Ngiam &Dickison, 2007b).

Additional support for our interpretation of these results comes from some of the converging findings in these experiments. First, the advantage of fame and the context reinstatement was more pronounced for *Remember* responses, that is, the recognition judgments that are based on recollection. Second, the fact that the memory advantage for reinstatement was greater when the background was shown with only a few faces supports the interpretation that the benefit of reinstatement involves the prior formation of an association.

Third, Experiment 2 used a drug intervention that specifically impairs the ability to form new associations (Hirshman et al., 1999; Hirshman et al., 2001; Park et al., 2004; Reder et al., 2006; Reder et al., 2007a). Retrieval of contextual associations enables recollection (*Remember* responses). There were far fewer *Remember* responses under midazolam than under saline. Recognition judgments for unknown faces were not affected by the drug intervention because these stimuli would be recognized on the basis of familiarity in any case.

Alternative accounts.

There are several alternative accounts for why famous faces are better remembered than unknown faces. One is that it is easier to generate an elaboration involving a face for which more is known (*e.g.*, Kerr & Winograd, 1982; Voss & Paller, 2006; Zion-Golumbic et al., 2010). Extending this account, one could argue that re-instatement of background should aid memory when the subject has generated an elaboration that involves the background because there would be more features to match the original memory trace. This account (devoid of an assumption of associating the target to a context), however, does not explain why sharing a background with other faces should reduce the advantage of reinstatement.

Another possibility is that it is easier to generate a label (*e.g.*, the person's name) for a famous face than an unknown face and that having a label will facilitate binding to LTM. While we agree that part of the advantage for famous faces is that each face affords a label, we do not believe that merely providing a name for an unfamiliar face will facilitate recognition for unknown faces, with or without a background. Part of the advantage (not the entire advantage) of an item with a pre-existing representation is that encoding the stimulus is more efficient by virtue of the label. That is, when there is a label, the stimulus is a known chunk, rather than a set of features to be described. In our view, ability to bind a stimulus to context requires working memory resources and these resources would be diverted from binding the stimulus to context when trying to represent a previously unknown stimulus. In other words, if a stimulus is easily labeled, it consumes less working memory and is therefore easier to bind to context (Reder, et al., 2007b). This view is also consistent with findings of Lupyan, Rakison & McClelland (2007). What if we were to provide the unknown faces with a name or profession? Would that make learning with the background as easy as famous faces? Just as it is not easy to bind an unfamiliar face to an encoding context, it will not be easy to learn the labels to those faces in a single trial. If we have to train those unknown faces until those labels are easily retrieved, then those (previously) unknown stimuli, would no longer be "unknown."

Another possible explanation for these findings is that subjects spent more time encoding famous faces because the task of rating the appropriateness of the face to the background seemed more sensible since they knew something about the person. If they spent more time encoding them, that could explain the memory advantage. We examined whether subjects spent more time encoding famous than unknown faces. While the encoding times for the two stimulus types did not differ reliably, the mean times went in the opposite direction (as reported in the results section of Exp. 2).

In summary, we have provided evidence that memory is better for stimuli that already have an existing representation in semantic memory because they are easier to associate to encoding context. We showed that the benefit of contextual reinstatement is not observed for face stimuli that were previously unknown to the subject. The likelihood of a recollection response is affected by the ease of retrieval of the encoding context, which in turn is affected by whether the encoding background is reinstated, and if so, whether the background fan is low (relatively unique). These factors did not matter for unknown faces because the formation of an association to context was unlikely to occur for unknown faces. When subjects were under the influence of midazolam, a drug that blocks the formation of new bindings, these effects were greatly diminished, providing additional support for our explanation of the memorial advantage of famous over unknown faces.

References

Bruce, V., & Young, A. (1986). Understanding face perception. *British Journal of Psychology, 77*(3), 305-327.

Buchler, N. G., Faunce, P. A., Light, L. L., Gottfredson, N., & Reder, L. M. (2010). Effects of repetition on associative recognition in young and older Adults: Item and associative strengthening. *Psychology and Aging, 22*(1), 104-121.

Carbon, C. C. (2008). Famous faces as icons: The illusion of being an expert in the recognition of famous faces. *Perception, 37*(5), 801-806.

Castel, A. D., & Craik, F. I. M. (2003). The effects of aging and divided attention on memory for item and associative information. *Psychology and Aging, 18,* 873– 885.

Diana, R., Peterson, M. J., & Reder, L. M. (2004). The role of spurious feature familiarity in recognition memory. *Psychonomic Bulletin & Review, 11*(1), 150-156.

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

Dudukovic, N. M. & Knowlton, B. J. (2006). Remember–Know judgments and retrieval of contextual details. *Acta Psychologia, 122*(2), 160-173.

Ellis, H. D., Shepherd, J. W., & Davies, G. M. (1979) Identification of familiar and unfamiliar faces from internal and external features: some implications for theories of face recognition. *Perception, 8*(4), 431 – 439.

Evans, M. S., & Viola-McCabe, K. E. (1996). Midazolam inhibits long-term potentiation through modulation of $GABA_A$ receptors. *Neuropharmacology, 35*(3), 347-357.

Ghoneim, M. M. (2004). Drugs and human memory (part 2). Clinical, theoretical, and methodologic issues. Anesthesiology, 100, 1277-1297.

Godden, D. R., & Baddeley, A. D. (1975). Context-dependent memory in two natural environments: on land and underwater. *British Journal of Psychology, 66*(3), 325-331.

Hancock, P. J. B., Bruce, V., & Burton, A. M. (2000). Recognition of unfamiliar faces. *Trends in Cognitive Science, 4*(9), 330-337.

Hirshman, E.; Fisher, J.; Henthorn, T.; Arndt, J., & Passannante, A. (2003). Midazolam amnesia and retrieval from semantic memory: Developing methods to test theories of implicit memory. *Brain and Cognition, 53*, 427-432.

Hirshman, E., Passannante, A., & Arndt, J. (1999). The effect of midazolam on the modality-match effect in implicit memory. *Cognitive Brain Research, 7*, 473-479.

Hirshman, E., Passannante, A., & Arndt, J. (2001). Midazolam amnesia and conceptual processing in implicit memory. *Journal of Experimental Psychology: General, 130*, 453-465.

Horry, R., Wright, D. B., & Tredoux, C. G. (2010). Recognition and context memory for faces from own and other ethnic groups: A remember–know investigation. *Memory & Cognition, 38*(2), 134-141.

Huppert, F. A., & Piercy, M. (1976). Recognition memory in amnesic patients: Effect of temporal context and familiarity of material. *Cortex*, *12*, 3–20.

Huppert, F. A., & Piercy, M. (1978). The role of trace strength in recency and frequency judgments by amnesic and control subjects. *Quarterly Journal of Experimental Psychology, 30*, 347–354.

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

Johnston, R., & Edmonds, A. (2009). Familiar and unfamiliar face recognition: A review.

Memory, 17(5), 577-596.

Joordens, S., & Hockley W. E. (2000). Recollection and familiarity through the looking glass: When old does not mirror new. *Journal of Experimental Psychology: Learning, Memory, & Cognition, 26*(6), 1534-1555.

Kerr, N. H., & Winograd, E. (1982). Effects of contextual elaboration on face recognition. *Memory and Cognition, 10*(6), 603-609.

Leveroni, C. L., Seidenberg, M., Mayer, A. R., Mead, L. A., Binder, J. R., & Rao, S. M. (2000). Neural systems underlying the recognition of familiar and newly learned faces. *The Journal of Neuroscience, 20*(2), 878-886.

Lupyan, G., Rakison, D. H., & McClelland, J. L. (2007). Language is not just for talking: labels facilitate learning of novel categories. *Psychological Science* 18(12), 1077-1083.

Murnane, K., & Phelps, M. P. (1993). A global activation approach to the effect of changes in environmental context on recognition. *Journal of Experimental Psychology: Learning, Memory and Cognition, 19, 882-894.*

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

Park, H., Arndt, J., & Reder, L. M. (2006). A contextual interference account of distinctiveness effects in recognition. *Memory & Cognition, 34*, 743-751.

Park, H., Quinlan, J. J., Thornton, E., & Reder, L. M. (2004). The effect of midazolam on visual search: Implication for understanding amnesia. *Proceeding of the National Academy of Sciences, 101*, 17879- 17883.

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, 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 & Cognition*, *26*, 294-320.

Reder, L. M., Oates, J. M., Thornton, E. R., Quinlan, J. J., Kaufer, A., & Sauer, J. (2006). Drug induced amnesia hurts recognition, but only for memories that can be unitized. *Psychological Science*, *17*(7), 562-567.

Reder, L. M., Oates, J. M., Dickison, D., Anderson, J. R., Gyulai, F., & Quinlan, J. J., Ferris, J. L., Dulik, M., & Jefferson, B. (2007a). Retrograde facilitation under midazolam: The role of general specific interference. *Psychonomic Bulletin & Review*, *14*(2), 261-269.

Reder, L. M., Paynter, C., Diana, R. A., Ngiam, J., & Dickison, D. (2007b). Experience is a double-edged sword: A computational model of the encoding/retrieval tradeoff with familiarity. In Ross, B. & Benjamin, A.S. (Eds.), *The Psychology of Learning and Motivation*, Academic Press, 271-312.

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

Smith, S. M., Glenberg, A. M., & Bjork, R. A. (1978). Environmental context and human memory. *Memory & Cognition*, *6*, 342-353.

Smith, S. M., & Manzano, I. (2010). Video context-dependent recall. *Behavior Research Methods*, *42(1)*, 292-301.

Tulving E. (1985). Memory and consciousness. *Canadian Psychologist*, *26*, 1–22.

Valentine, T., & Bruce, V. (1986). Recognizing familiar faces: The role of distinctiveness and familiarity. *Canadian Journal of Psychology, 40*(3), 300-305.

Voss, J. L., & Paller, K. A. (2006). Fluent conceptual processing and explicit memory for faces are electrophysiologically distinct. *The Journal of Neuroscience, 26*(3), 926-933.

Voss, J. L., Reber, P. J., Mesulam, M. M., Parrish, T. B., & Paller, K. A. (2008). Familiarity and conceptual priming engage distinct cortical networks. *Cerebral Cortex, 18(7),* 1712-1719.

Yonelinas, A.P. (2002). The nature of recollection and familiarity: A review of 30 years of research. *Journal of Memory and Language, 46*(3), 441-517.

Zion-Golumbic, E., Kutas, M., & Bentin, S. (2010). Neural dynamics associated with semantic and episodic memory for faces: Evidence from multiple frequency bands. *Journal of Cognitive Neuroscience, 22*(2), 263-277.

Footnotes

[1] We chose an incidental learning task in order to assess how easily associations are formed when there is no requirement to do so.

[2] As part of the instructions, we made sure that subjects understood the distinction between “Remember” and “Know” and did not think that this was merely a confidence difference but rather reflected remembering some detail or aspect of the actual encoding event. We have also used the method of asking first for old/new judgments followed by R/K discrimination for old responses (*e.g.*, Reder, et al., 2000). We found no difference in performance in any meaningful way. This procedure seemed faster and less likely to encourage subjects to respond new (because there were fewer buttons to press).

[3] There are more Remember hits and false alarms for unknown faces under midazolam than saline. We attribute this pattern to a more relaxed criterion for Remember responses under midazolam. Unlike Yonelinas (2002), we do not assume a high threshold model, but a normally distributed activation value and criterion both for the representation that enables familiarity judgments and separate ones for the representation that enables recollection (*e.g.*, Reder et al., 2000).

[4] Both drug induced amnesiacs and organic amnesiacs are able to recognize stimuli when a familiarity process will suffice but not when accurate discrimination of targets from foils requires a person to recollect the contextual information. Huppert and Piercy's data suggest that low frequency words and pictures are sufficiently unfamiliar that a recent exposure makes them much more familiar than foils (non-presented items) from the same stimulus class.

Author Notes

This work was supported by the National Institutes of Health grants 5R01MH052808 and T32MH019983 as well as the NIH/NCRR/CTSA Grant UL1 RR024153 of the CTSI of UPMC that provided a skilled nursing research facility for conducting Experiment 2. We thank John Bauman and David Klionsky for help with programming, Brent Fiore and Jessica Henke for help with data collection, Alexandra Tsarenko for help with stimulus preparation, and Michael Griffin and Isaac Shamie for comments on the manuscript.