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Perceptual identification task points to continuity between implicit memory and recall

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Abstract

Adopting a continuous identification task (CID-R) with embedded questions about prior occurrence, recent research has proposed that implicit and explicit memory are underpinned by a single memory system, since there is a systematic relationship between implicit memory (measured by identification) and explicit memory (measured by subjective report of recognition; for an example, see Berry et al., 2008). We were interested in whether this pattern would extend to recall of information from a study phase (Experiment 1) or recall from semantic memory (Experiment 2). We developed a degraded face identification version of the CID-R task using Gaussian blur. We reproduced previous results regarding the relationship between explicit responses on the recognition task (old/new) and stimuli identification, pointing to a continuity between explicit and implicit memory. Critically, we also found that the strength of the implicit effect (i.e., stimuli identification) was predicted by the accuracy in recall (retrieval of context in Experiment 1 and correct responses to general knowledge questions about the face in Experiment 2). Our results support the idea that memory is unidimensional and related to memory trace strength; both for recall and recognition, and interestingly, for semantic and episodic recall.

KEYWORDS: Explicit memory, implicit memory, face identification, recognition, recall

A critical issue in human memory is whether memory retrieval processes in different tasks rest on one single underlying system, or whether multiple systems exist. This question is particularly critical in examining differences between implicit and explicit memory (e.g. Berry, Henson, & Shanks, 2006). A related question which predates the implicit/explicit distinction is the difference between recall and recognition, the focus of the current paper. Here the critical issue is whether the retrieval of information from memory (often referred to as a search process) and episodic memory decision making (based on the judgement of prior occurrence of a stimulus present in the environment) rely on the same system. This issue has long been a theoretical driver in memory research, with early models and theoretical statements being based on the relative patterns between episodic recall and recognition (e.g. Adams, 1967; Flexser & Tulving, 1978; Brown, 1976).

The main thrust of these early works is that recall and recognition are separable processes, such that, for example, neuropsychological work points to a dissociation between the two, with patients showing impaired recall but intact recognition (e.g. Bastin et al., 2004). Experimental studies have shown additionally that it is possible to fail to recognise recallable words (Tulving & Wiseman, 1975). The recall-recognition dissociation influenced early considerations of the differences between familiarity and recollection processes in recognition memory (Mandler, 2008), and a continued debate is whether recollection and familiarity, like recall and recognition, can be characterized as one process or two (see Yonelinas, 2002 for a review). Whereas behavioural studies point to striking differences between recall and recognition, early computational models suggest that recall and recognition may share a common underlying mechanism (e.g. Gillund & Shiffrin, 1984). Thus, whereas robust experimental differences between recall and recognition are observed, the theoretical distinction between these two as separate processes or systems has constantly been questioned (e.g. Kintsch, 1970; Haist, Shimamura & Squire, 1992; Dunn, 2004; Slotnick & Dodson, 2005). Even those models in which dual processes were posited shared common mechanisms and stores between recall and recognition (e.g. generate-recognise models of recall, e.g. Anderson & Bower, 1974).

A similar somewhat contentious distinction in human memory is between explicit memory (e.g. recognition) and implicit memory (e.g. priming; Richardson-Klavehn & Bjork, 1988; Graf & Schacter, 1985), and recent research into this distinction can also bring to bear on the recall/recognition distinction. It can be argued that implicit and explicit memory are driven by a single-system (Berry, Henson, & Shanks, 2006; Berry, Shanks, & Henson, 2008; Shanks & Berry, 2012). Berry, Shanks, & Henson (2008) developed a computational model in which one continuous memory signal drives recognition and priming. As it assumes that memory processes are uni-dimensional, both familiarity and recollection processes are also part of the same memory trace; only differing in terms of memory strength[1] (i.e. SS model; for the latest version see Berry, Shanks, Speekenbrink, & Henson, 2012). Their simulated data from a single process exhibited priming that is, faster identification for old stimuli in comparison to new items (due to prior exposure). This difference critically occurred

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[1] Here we use 'trace strength accounts' as synonymous with single process theories, but it should be noted that there are a number of different single process theories where memory function varies according to variables other than trace strength per se. These include theories where they key variable is specified as depth of encoding (e.g. Craik and Tulving, 1975), as quality of encoding (e.g. Benjamin, 2010; Curtis & Jamieson, 2018), as learning rate (e.g. Kinder & Shanks, 2003), or as sensitivity to similarity (Nosofsky & Zaki, 1998). Reder, Park, & Kieffaber (2009) propose a single system with two key factors: association and binding.)

according to the explicit response of the participants: judged-old items and judged-new items regardless of the actual state of the stimuli (actually old or actually new). Specifically, Berry et al. (2012) both observed faster identification time for hits compared to omissions and faster identification time for false alarms compared to correct rejections. Therefore, differences in stimuli identification time were predicted according to the explicit response within the same category of stimuli (i.e., actual old and new items).

Berry et al. (2012) used an experimental paradigm measuring both implicit and explicit memory in the same task in order to test their model. In the continuous identification with recognition task (CID-R; Stark & McClelland, 2000), within one trial a stimulus is repeatedly presented very briefly with an increasing presentation time until the participant is able to identify the stimulus. Then, once they have identified the stimulus, the participant has to make a standard recognition memory decision on a trial-by-trial basis. The critical feature of the task is that repetitions of stimuli are embedded in an ongoing recognition task, such that priming (i.e. identification of the briefly presented stimulus) and explicit memory (i.e. reporting whether or not they had already encountered the stimulus or not in the experiment) can be measured within the same task. Thus, the identification time can be compared across the different responses of the participants for the explicit task.

Berry et al. (2012) also conducted an experiment using the Remember/Know (R/K) procedure with the CID-R paradigm in order to evaluate the role of both recollection (‘remembering’) and familiarity (‘knowing’) in the relationship between implicit and explicit memory observed with the CID-R. The R/K procedure is a straightforward paradigm examining the subjective report of the state associated with retrieval: ‘remembering’ and ‘knowing’ (e.g. Gardiner & Parkin, 1990; Gardiner, 1988; Tulving, 1985). According to the SS model, these two processes reflect a difference in terms of strength of evidence in a one-dimensional memory signal and consequently are not independent. As R judgments are associated with a greater strength of memory than K judgments, this model supposes that R judgments would be associated with a faster identification time than K judgments. Conversely, the dual-process theory (Yonelinas, 1994; 2002) predicts that the identification time for the judged-R item should be longer than the identification time for the judged-K item because ‘familiarity is expected to be faster than recollection’ (Yonelinas, 2002, p.446). As predicted by the SS model, R judgments were associated with faster identification time than K judgments.

In sum, a series of experiments responding to their SS model, even on amnesic patients (Berry, Kessels, Wester, & Shanks, 2014) and even extending to source memory (Lange, Berry, & Hollins, 2019), suggests that implicit and explicit retrieval rely on one underlying process, and this pattern even extends to recognition decisions based on the familiarity and recollection distinction. Such findings are a continuation of the idea that fluency or ease-of-processing underlies the relationship between the feeling of familiarity and priming (Kelley & Rhodes, 2002; Mandler, 1980). In the context of dual process theories, familiarity is proposed to be an automatic signal detection process (for a review see Yonelinas, Aly, Wang & Koen, 2010). For instance, Lucas, Taylor, Henson and Paller (2012) used the R/K procedure and showed that ‘old’ responses increase for the more fluently processed stimuli. However, the extension of the idea of fluency to recollection is more contentious; Lucas et al. (2012) found that their fluency effect was apparent only for K responses. In the current paper we consider most directly perceptual fluency, but it should noted that a critical distinction would be the difference between conceptual and perceptual fluency. There is some evidence that whereas perceptual fluency (repetition priming) increases K responses, conceptual fluency (semantic priming) increases R responses (Taylor & Henson, 2012).

In their CID-R experiments, Berry and colleagues find a continuity between familiarity and recollection, whereas other studies show that implicit memory and fluency effects pertain to familiarity only, and recollection is not similarly influenced (although it has been argued that R responses may benefit from both familiarity and recollection processes which could enhance the identification time of the stimuli, e.g. Parks & Yonelinas, 2007). From this perspective, R judgments are not a pure measure of the recollection process (which could explain faster identification times for the R-judged item even in the context of the dual processes theory). Thus, although familiarity processes and priming have been linked, the relationship between priming and recollection remains less clear. Whereas dual process accounts suppose that they are independent, Kurilla & Westerman (2008) suggest that they may influence each other. Using a modified version of the R/K procedure in which familiarity and recollection are judged on a 4-point scale for each process, they showed that processing fluency affects both R and K-judgments. Furthermore, studies using Event-Related Potentials (ERPs) have shown that priming can influence conscious recollection

(Komes, Schweinberger, & Wiese, 2014; Park & Donaldson, 2016). Note that all of the foregoing studies place a considerable burden on subjective report: in the majority of experiments, participants themselves classify their experience as ‘remembering’ or ‘knowing’, and in the remainder of the experiments, trace strength is evaluated by a subjective report of post-retrieval confidence. One alternative is to test source memory (as carried out by Lange et al., 2019) because the output is verifiable and source memory is proposed to be less based on familiarity (although exceptions exist - see discussion). Thus, we can examine whether the source is correct or incorrect for a given level of familiarity. However, note that these source decisions are largely binary choices and so can be solved by an evaluation of relative familiarity.

It seems to us that an ideal test of the single system proposal is to test recall: by asking participants to retrieve information once they have solved the identification task. This information is objectively verifiable and not based on a subjective ‘feeling’. This use of recall is the central feature of the experiments presented here. We argue that whereas fluency (derived from solving the identification implicit memory task) may be used as diagnostic information when making a recognition memory decision, or even when discriminating between subjective reports of remembering and knowing, it would be harder to explain in a dual process context, how fluency of identification is related to recall (i.e. reproduction of associated information, such as memory for source or other contextual information).

The main focus of this paper is thus to evaluate the relationship between explicit memory and implicit memory, but with a focus on recall. Specifically we focused on recall of context as our index of recollection (i.e., memory source; Slotnick, 2010). In short, we aimed to extend previous results suggesting that one continuous memory signal drives recognition and priming (e.g., Berry et al., 2012; Berry Kessels, Wester, Shanks, 2014; Berry, Ward, Shanks, 2017) to a task for which familiarity processes are theoretically less relevant. In a first experiment, we used a procedure where we evaluated repetition priming, recognition, and recall of a particular encoding context. To foreshadow our results, finding a systematic relationship between implicit memory and recall of contextual specifics in episodic memory, we then in a second experiment measured recall of semantic attributes, hypothesizing that implicit memory performance should be related to the activation and hence recallability of semantic attributes of a stimulus. Both studies were preregistered on the Open Science Framework (https://osf.io/uz9ua/).

Experiment 1

Method

Participants. Eighty participants (M_{age} = 20.02, SD_{age} = 2.01) including sixty five women were recruited through advertisement in the University Grenoble Alpes. They all reported normal or corrected-to-normal vision. Sample size was estimated using an estimate effect size from a preliminary study conducted with 23 participants (using G*Power software with a power of .99 at the standard .05 alpha error probability). The chosen effect size was the critical analysis of the relationship between recall and identification blur level (the difference between the identification blur level for correct recall and the identification blur level for incorrect recall; d_z = 0.49).

Materials. The stimuli were 60 famous faces including 16 women. These faces were selected from a pre-tested database of 120 famous faces for which we collected data about the familiarity of the presented stimuli. Because one of the tasks was to identify the famous person, the 60 selected items were the most recognized. For the perceptual identification task, each face was degraded in 15 blur levels. Using Photoshop software, a Gaussian blur was applied to the stimuli so that each blur level was twice as blurred as the subsequent one. We created two sets of faces, targets and distractors, which were counterbalanced across participants. Prior to the experiment, targets were randomly associated with a context which did not vary across participants. These contexts were pictures of stereotypical places (e.g., bedroom, kitchen, swimming pool, bar, beach). To select these contexts we pretested 40 pictures where participants had to name the place. Contexts with the highest rate of agreement were included in the study.

Procedure. Participants performed the task individually in a quiet room. The entire procedure included two phases: an encoding phase and a retrieval phase. During the encoding phase, participants studied an association between a famous face and a context. For each trial, they had to say if they knew the presented person and to name the associated context (e.g. ‘beach’). Specifically, participants were asked to say ‘yes’ if the face was identified as a famous person, but they were not asked to name them. This allows a minimal check of the previous knowledge for the famous faces without increasing the between-face variability in encoding. Faces that were reported as not known at encoding were excluded from the analyses for each participant.

During the retrieval phase, participants performed a perceptual identification task akin to the CID-R paradigm. Degraded faces (the context was not re-presented) appeared gradually, beginning at the strongest blur level. For each blur level, if participants could not identify the famous face they pressed the “SPACE” key to be presented the face with one less level of blur. They continued this procedure until the famous face was identified. If the face was not identified when the participant reached the final lowest level of blur – corresponding to the unblurred stimuli – the trial was excluded from the analyses. On a trial-by-trial basis, participants also performed a recognition judgement on the same face target. That is, they reported if this face was presented during the encoding phase by pressing the ‘A’ key and when they thought the face was not presented before they pressed the ‘P’ key. For recognition judgements participants immediately responded, and at the same identification blur level at which they had identified the stimulus. Finally, they attempted to recall the name of the associated environment in the encoding stage – if they thought that the stimulus was presented during the encoding phase. The name of the environment was typed using the keyboard and participants pressed ‘ENTER’ to start to the next trial. Participants were instructed that they could choose not to answer the recall question if they did not remember the context. The retrieval stage included 30 previously seen targets (i.e., old items) and 30 distractors (i.e., new items). Targets and distractors were counterbalanced across participants. Figure 1 provides a schematic representation of the procedure.

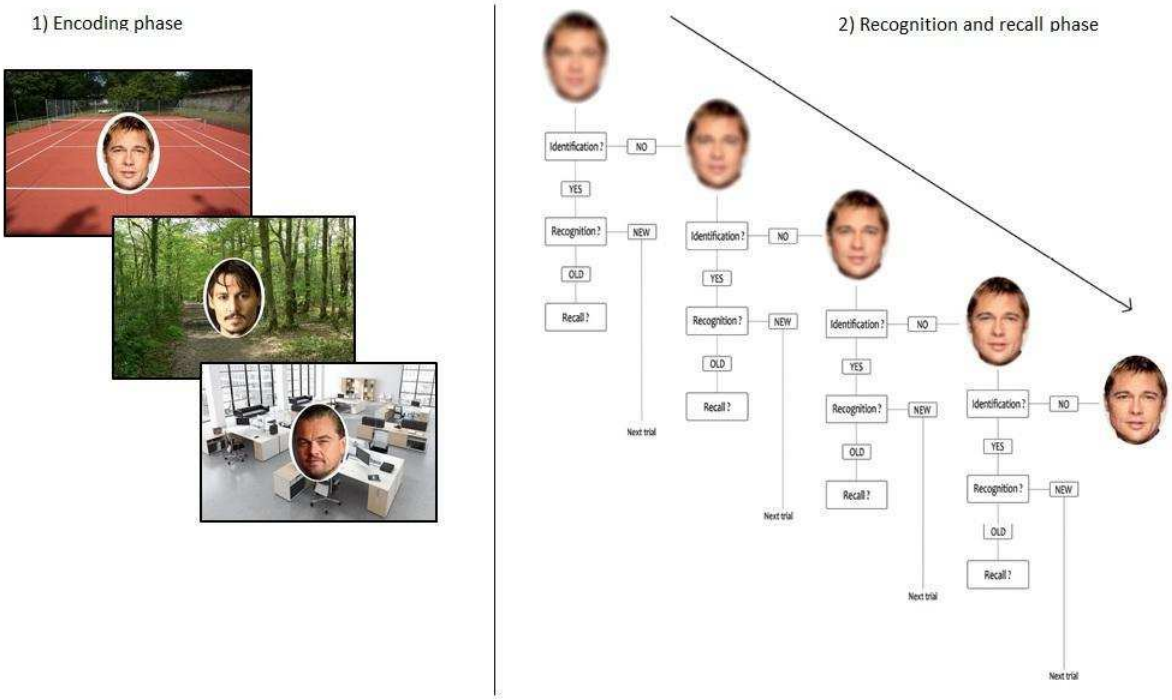

Figure 1. Summary of the procedure. The encoding phase included the presentation of 30 pairs of faces and typical places. The recognition and recall phases included the presentation of 60 faces (30 'old' stimuli and 30 'new' stimuli).

Results and Discussion

As we were interested in the identification of famous faces, we excluded trials for which the famous face was not known to the participant (as identified in the study phase). We had originally determined to exclude participants if they had more than one third of non identified faces; but no participants were excluded according to this criterion. In total, 4.16% of the trials were excluded.

Analyses of task performance are presented according to the three tasks: the priming effect, the recognition task, and the recall task. The priming effect was calculated by the difference between the mean identification blur level for the old items and the mean identification blur level for the new items. Thus, an 'early' blur level corresponds to identification with more blur, suggesting a better identification. Performance on the recognition task was analyzed with d prime. Recall was classified as correct when the environment associated with the face was correctly retrieved. 'Incorrect recall' was when the recall response was the wrong environment; and 'no recall' was when participants did not answer to the recall question. As the recall question was only asked when participants answered 'old' to the recognition question, we kept only 'hits' and 'false alarms' for these analyses. Except for recognition and recall performance analyses, all analyses included linear mixed-effect models computed using 'lmerTest' and 'lme4' packages (Kuznetsova, Brockhoff, & Christensen, 2017) in R software with participants and stimuli as random effects. Because these effects are not the main focus of this paper, we only reported fixed-effects. The number of parameters was estimated by fitting a Principal Components Analysis (PCA) of the random-effects variance-covariance estimates from the 'maximal' mixed-effects model (all possible random effect components included) using the 'RePsychLing' R package (Bates et al., 2015). Therefore, the recognition model included the estimation of an intercept and a slope of the response variable (old vs new) for each participant and each stimulus. The recall model included only an intercept for each participant and each stimulus. When it was necessary, Bonferroni corrections were used.

To calculate effect size, as there is no consensus for mixed-effects models, we decided compute them from the t value for each fixed-effect as for regular t-tests. Therefore, because the design included only within-subject variables, we used the *dz* value calculated as follows (Lakens, 2013): dz=t/N where N is the number of participants.

Task performance analyses. Analysis of the priming effect showed that old items were identified with more blur than new items, priming being different from 0, $t(79) = 3.67$, $p < .001$, $d_z = 0.41$, ($M = 0.57$, $SD = 1.39$). Recognition performance as measured by d' was significantly better than chance (0), $t(79) = 29.44$, $p < .001$, $d_z = 3.29$, ($M = 2.38$, $SD = 0.72$). Proportion of correct recall was calculated for each participant and was also different from 0, $t(79) = 13.22$, $p < .001$, $d_z = 1.48$, ($M = 0.13$, $SD = 0.08$).

Relationship between recognition and identification blur level. We tested whether recognition task responses (actual state of item: target or distracter; response: old or new) predict blur level identification of the faces. This analysis showed a main effect of actual state of item, $t(1175.40) = 2.39$, $p = .012$, $d_z = 0.28$ and also of participant responses, $t(143.70) = 2.07$, $p = .040$, $d_z = 0.23$. Target faces were identified with an earlier blur level (i.e., more degradation) than distracter faces. Similarly, faces given an old response were identified with an earlier blur level compared to faces given a new response. There was also a trend for an interaction between the two factors, $t(2209.00) = -1.93$, $p = .054$, $d_z = -0.22$ (see Figure 2).

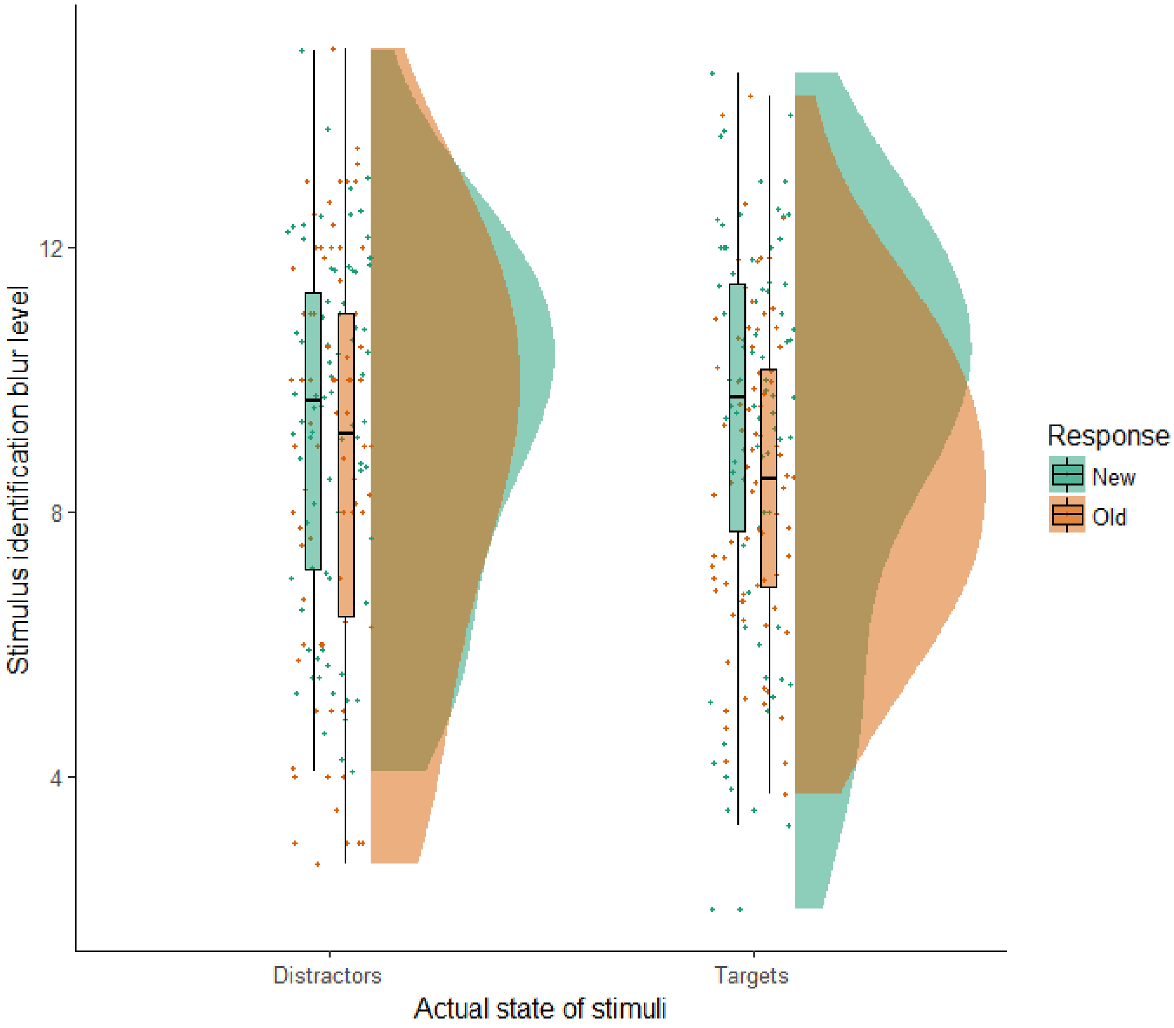

Figure 2. Raincloud plots (Allen et al., 2018) for blur level identification according to the actual state of the stimuli (target vs distracter) and the response (old vs new).

As we were particularly interested in the difference in identification between the explicit response (i.e., judged-old or judged-new) for one type of stimuli (i.e., targets or distracters), we computed two simple effect models. The first one compared identification level for old items (i.e., difference between ‘hits’ and ‘omissions’) and the second compared identification level for new items (i.e., difference between ‘false alarms’ and ‘correct rejections’). As there was no significant interaction, we applied a Bonferroni correction (significant threshold of $\alpha = .025$) for simple effect analyses. Within target stimuli, our analyses revealed that hits (*M* = 8.51, *SD* = 2.34) were identified with an earlier blur level (i.e., more degradation) than omissions (*M* = 9.24, *SD* = 3.05), *t*(178.10) = 3.32, *p* = .001, d_z = 0.37. However, and contrary to our hypothesis, within distracter items, correct rejections (*M* = 9.30, *SD* = 2.59) and false alarms (*M* = 8.83, *SD* = 3.12) did not differ significantly, *t*(401.40) = 0.51, *p* =.609, d_z = 0.06.

Relationship between recall and identification blur level. We compared identification blur level for the three types of recall response: correct, incorrect, and no recall (Figure 3). The analysis revealed that correct recall (*M* = 8.17, *SD* = 2.49) was associated with an earlier identification blur level than incorrect recall (*M* = 8.60; *SD* = 2.67), *t*(1737.60) = 3.28, *p* =.001 d_z = 0.37. Incorrect recall was also associated with an earlier identification blur level than no recall (*M* = 8.83, *SD* = 2.54), *t*(1877.30) = 3.08, *p* =.002 d_z = 0.34.

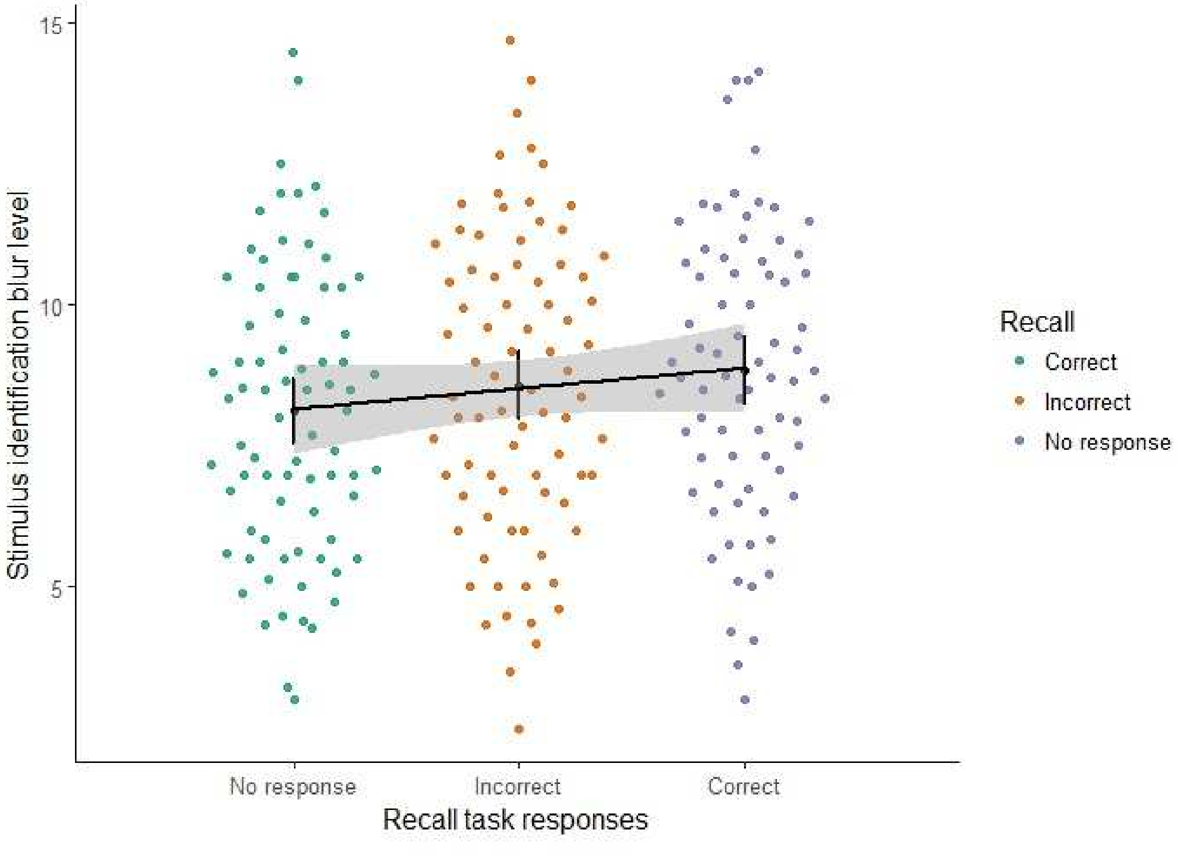

Figure 3. Blur level identification according to the number of correct responses for recall of context (environment). (Points represent individual participant means. Error bars represent the 95% confidence interval. The line shows a linear regression, with the shaded area representing the 95% confidence limits for this trend.)

This experiment provides findings in accordance with the SS model (Berry et al., 2012) in that stimuli identification blur level was earlier for judged-old items within the targets. However, unlike Berry et al., we did not find this same difference according to explicit response within distracters. However, these differences are difficult to interpret since we found only a trend for an interaction. We suggest that this could be due to a low number of false alarms in this experiment (see general discussion). Most importantly, we did find a relationship between recall, a measure of explicit memory less affected by fluency effects, and identification blur level of the stimuli. This novel finding was anticipated by the single system account: the influence of trace strength for an item in recognition extends to the recall of the item's context.

Experiment 2

In this second experiment, we aimed to replicate our first experiment and to examine the unexpected null finding in the distracter items. We also investigated the effect of semantic knowledge on both implicit and explicit memory. In short, we used the same procedure, but rather than contextual information from episodic memory, we asked our participants to recall pre-existing information about the face. Our reasoning was that if trace strength captures both recognition and recall performance as defined in episodic memory (as in Experiment 1), it would also be of interest to see if it extended to semantic retrieval.

Recent research examining retrieval processes using receiver operating characteristics curves has shown similar trace strength and threshold processes are at in play in semantic retrieval as in episodic retrieval, even though it is unusual to describe ‘dual process’ accounts of recognition memory for general knowledge or semantic materials (Kempnich, Urquhart, O’Connor, & Moulin, 2017). Using our procedure, we suggest that retrieval in semantic memory could affect episodic retrieval suggesting a relationship between episodic and semantic memory. A relationship between identification blur level and recall of semantic information would suggest that the single system trace strength account (as shown in Experiment 1 for episodic recall) might actually apply to semantic retrieval as well.

Method

Participants. Eighty-seven participants (M_{age} = 20.36, SD_{age} = 3.25) including seventy-nine women were recruited through advertisement in the University Grenoble Alpes. They all reported normal or corrected-to-normal vision. Contrary to the first experiment, participants were tested in small groups (ranging from 3 to 6). According to the same criterion of the first experiment, we excluded 9 participants who had more than 1/3 of non identified famous faces.

Material and procedure. The procedure was very similar to the first experiment. Participants had to perform the encoding phase with the same set of famous faces, but without the contextual ‘environment’. The retrieval phase was also the same apart from the recall task. Instead of recalling the environment, participants answered general knowledge questions about the celebrity for each face (regardless of the response to the recognition task);

the name and the surname of the person, his or her nationality, and his or her profession. Note that these answers are not immediately apparent from the face presented. In this experiment, therefore, we had a measure of implicit memory (identification blur level), episodic memory (recognition) and semantic memory (recall of general knowledge facts cued by the face).

Results and Discussion

The analyses were performed on 78 participants. Trials with non-identified faces were also excluded (3.69% of all trails). As in the first experiment, we focused on task performance and the relationship between identification blur level and recognition. For each trial, we calculated a semantic recall score according to the number of correct answers to the general knowledge questions about each face (0, 1, 2, or 3; name and surname where scored together). As previously, analyses included linear mixed-effect models and the number of parameters was estimated according to Bates et al. (2015). Therefore, the recognition model included the estimation of an intercept and a slope of the response variable and the actual state of the stimuli variable for each participant and an intercept and a slope of the response variable (old vs new) each stimulus. The semantic recall model included the estimation of an intercept for each participant and each stimulus. Where necessary, Bonferroni corrections were used.

Tasks performance analysis. Analyses of the priming effect showed that target items were identified with more blur (an earlier blur level) than distracter items, priming being different from 0, $t(77) = 18.63$, $p < .001$, $d_z = 2.11$ ($M = 2.29$, $SD = 1.08$). Analysis of recognition performance revealed that participants performed the task correctly as d' was different from 0, $t(77) = 20.71$, $p < .001$, $d_z = 2.34$ ($M = 3.20$, $SD = 1.37$). The mean number of correct semantic recall responses (out of 3) was calculated for each participant and was also different from 0, $t(77) = 70.47$, $p < .001$, $d_z = 7.98$ ($M = 2.50$, $SD = 0.31$).

Relationship between recognition and identification blur level. As in the first experiment, we tested whether the recognition task response (actual state of the item: distracter or target; response: old or new) predicts blur level identification of the faces. As with the first experiment, this showed main effects of actual state of the item, $t(51.80) = 8.99$, $p < .001$, $d_z = 1.02$ and participant responses, $t(70.20) = 6.10$, $p < .001$, $d_z = 0.69$. Target faces were identified with an earlier blur level than distracter faces. Similarly, faces with an old response were identified with an earlier blur level compared to faces with a new response. There was again no significant interaction between the two factors, $t(857.60) = -0.84$, $p = .402$, $d_z = -0.09$ (see Figure 4).

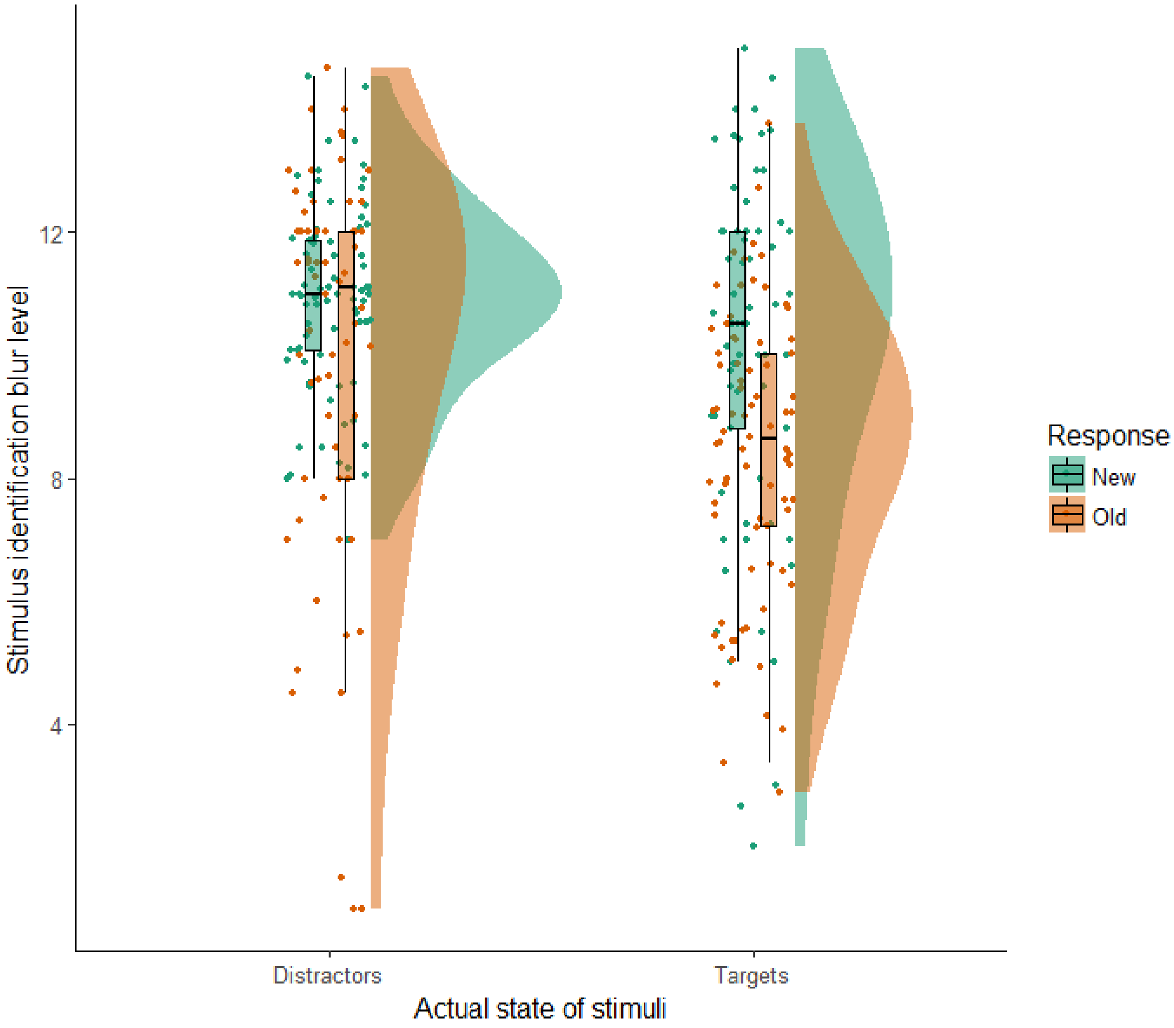

Figure 4. Raincloud plots (Allen et al., 2018) for blur level identification according to the actual state of the stimuli (target vs distracter) and the response (old vs new).

As there was no significant interaction, we applied a Bonferroni correction (significance threshold of α = .025) for simple effect analyses because these differences are of interest. Within target stimuli, our analyses revealed that old responses (hits; *M* = 8.41, *SD* = 2.29) were identified with an earlier blur level (i.e., more degradation) than omissions (*M* = 10.08, *SD* = 2.98), *t*(131.50) = 5.51, *p* < .001, d_z = 0.62. This time, within distractor stimuli, false alarms (*M* = 9.94; *SD* = 3.23) were identified with a significantly lower blur level than ‘correct rejection’ (*M* = 10.90; *SD* = 1.53), *t*(119.30) = 4.60, *p* < .001, d_z = 0.52.

Relationship between semantic knowledge and identification blur level. To have a direct comparison of Experiment 1 and Experiment 2, they key analysis of this section (as preregistered) was to compare identification blur level for the four types of semantic response (from 0 to 3) for targets only. However, we suggest that a comparison with distractors is relevant here and therefore we performed the same analyses with adding the target/distractor variable in the model (Figure 5). The analysis revealed a main linear effect, with identification blur level being greater (i.e., faces being identified with more blur) with more semantic knowledge, $t(71.00) = -6.48$, $p < .001$, $d_z = -0.73$. Consistent with the recognition analysis we also found a main effect of target/distractors, target being identified with more blur, $t(4117.00) = 15.51$, $p < .001$, $d_z = 1.76$. Crucially, there was a significant interaction between the two factors: although linear effects were significant for both targets, $t(114.00) = 7.58$, $p < .001$, $d_z = 0.86$, and distractors, $t(103.00) = 3.87$, $p < .001$, $d_z = 0.43$, the effect was larger for targets, $t(4148.00) = 4.36$, $p < .001$, $d_z = 0.49$.

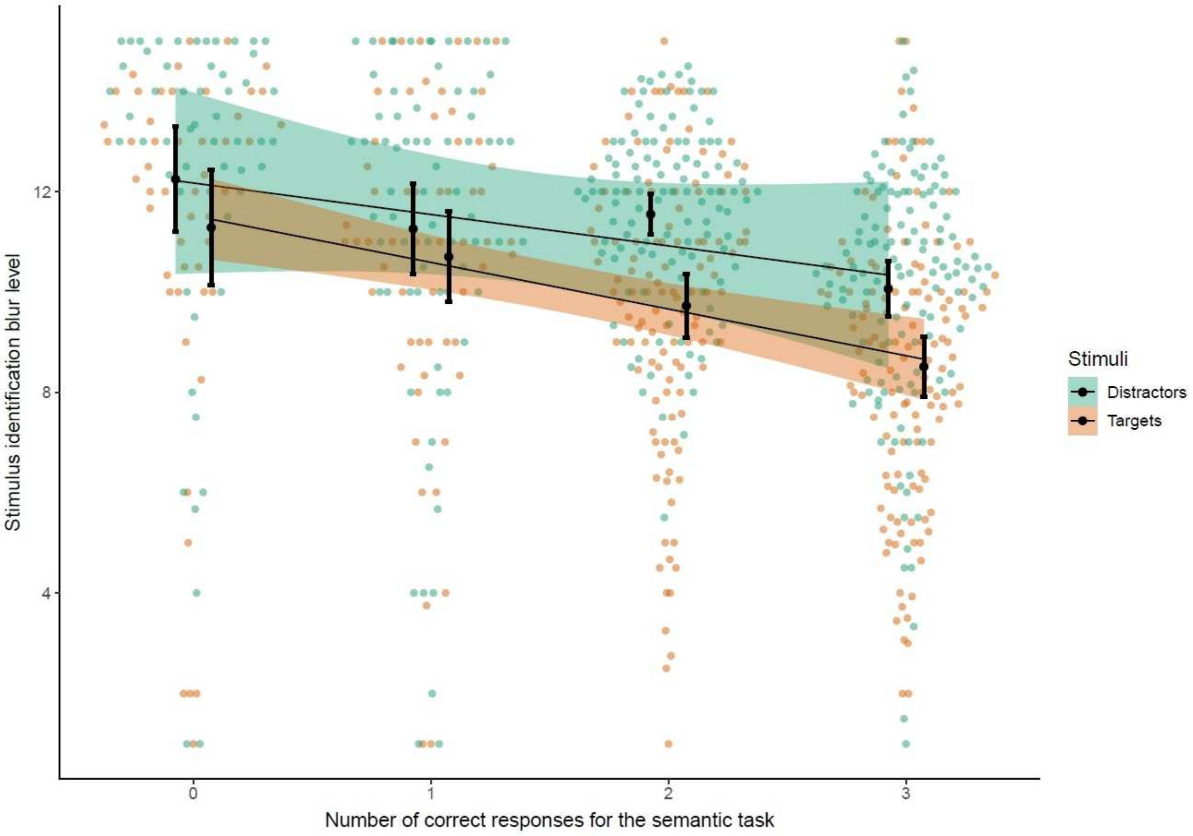

Figure 5. Blur level identification according to the number of correct responses for semantic questions. (Points represent individual participant means. Error bars represent the 95% confidence interval. The line shows a linear regression, with the shaded area representing the 95% confidence limits for this trend.)

In this second experiment, we reproduced Berry et al.'s (2012) results (this time finding differences between false positives and correct rejections) and also our first experiment's results. We found that stimuli identification blur levels were greater for judged-old item within the actual old item on the one hand and within the actual new item on the other hand. Moreover, we found that the more semantic information that was retrieved by the famous face, the greater the blur identification level.

General discussion

The current paper proposes an extension of previous research evaluating the relationship between explicit memory and implicit memory. Whilst prior studies focused on recognition and priming (e.g., Berry et al., 2012; Berry et al., 2014; Berry et al., 2017), we added a measure of recall in order to measure recollection in a more objective manner compared to subjective reports of remembering (R/K procedure), and without the possible interpretation that familiarity responding had ‘bled into’ the recollection decisions.

Our results reproduce previous research regarding the relationship between priming and recognition, but using a novel task. We found a lower level of identification for judged-old items (i.e., hits and false alarms) compared to judged-new items (i.e., omissions and correct) suggesting that participants identify stimuli differently according to the level of the explicit response for the same stimuli category (target and distractor items). A subjective report of prior occurrence predicts a face identification with more degradation even in the case of false alarms. However, an important feature of our findings is that we found lower identification blur level for false alarms compared to correct rejections only in the second (semantic recall) experiment. We discuss this unexpected difference below.

Crucially, our results support the idea that the amount of retrieved information is related to the ability to identify the stimuli early both when the recalled information is contextual information from encoding (Experiment 1; episodic memory) and pre-existing knowledge about the face (Experiment 2; semantic memory). These results support the idea of a single-system account for implicit and explicit memory (e.g., Berry et al., 2012; Lange et al., 2019), which extends even into the amount of semantic information that is available. Our finding is striking in that many conceptualisations of human memory posit critical differences between an assessment of fluency and familiarity of a stimulus in the environment (recognition), and the reproduction or retrieval of information (recall). According to such a dual process view, a high degree of familiarity with a cue is no guarantee of successful recall, and indeed in the 'butcher on the bus' phenomenon (e.g. Mandler, 2008), the very lack of recall leads to a high level of familiarity (e.g. Whittlesea, 1993). Our results contradict this dissociation, since the recognition memory decision and reproduction of information from memory both show a relationship with the perceptual identification task. We here make some suggestions about the organization of the human memory system given that our results point to a generalized enhancement of activation in memory regardless of test (recall/recognition) or type of information (episodic/semantic).

The predominant view of human memory as being based on multiple systems is derived largely from dissociations (recall-recognition/episodic-semantic) particularly in amnesic patients (but see also Graham et al., 2010, below). However, recent work has simulated similar dissociations of memory impairment in the context of a single-system (Curtis & Jamieson, 2018, and see also Kinder and Shanks, 2003). Moreover, a relationship between priming and recognition (such as that we have presented here) has also been found in amnesic patients (Berry et al., 2014). Here, our findings add another element toward this view in finding an association between priming and recall for the first time.

One possible explanation for the relationship between priming and recognition is related to the structure of the CID-R task: participants are more likely to use fluency in the recognition task (e.g., Jacoby & Dallas, 1981). Hence, the overlap between implicit and explicit processes could be exaggerated in the CID-R, since participants may adopt a metacognitive strategy to their explicit memory decisions: if the item is identified easily, with a high level of blur, the participant may interpret the item as being old. In short, according to this view, the dual process account can be sustained if we assume that familiarity 'spills over' into recollection processes, or more simply an assessment of the ease of identification of the stimulus fluency is used to make judgements both about who the face is and whether it has been seen before. However, because recall involves a reproduction of retrieved information, this fluency account is less easy to sustain. Although all our stimuli may be pre-learned and in that sense 'familiar', it is not enough to use an assessment of this familiarity to retrieve contextual or semantic information. As such our results support a single system account.

Another possible explanation is that the identification task was 'contaminated' by explicit strategies (e.g. Mckone, & Slee, 1997). That is, due to the recognition task, participants might expect previously seen stimuli therefore modifying their perceptual identification (as expectations affect perception, e.g., de Lange, Heilbron, & Kok, 2018). This could also explain the relationship between the implicit task and recall, especially the difference in identification blur level between incorrect recall and no response in the recall task in Experiment 1. As such, subjective report of whether participants can recall the contextual environment, even if the answer is incorrect (i.e. false positives), affects perceptual identification. Incorrect recall of contextual information is related to enhanced perceptual identification, compared to no recall of any information.

A similar issue is raised by Yonelinas (1999) where he describes situations in which familiarity processes are indicative of an item's source - and context. These are interesting cases in human memory because there is the usual dissociation between recollection (source) and familiarity (item memory). As an example, consider a task with two separate lists studied a week a part. In such a case, the familiarity for the latter list will be indicative of source, since the participant can logically reason that items with a lower familiarity were studied at a more distant point in time. To illustrate separable familiarity and source functions using ROCs, one actually has to develop tasks where the familiarity information is not predictive of source (e.g. male or female voice). Whilst this example seems directly comparable to our task, where some familiarity index is bringing to bear on an explicit decision, it is less easy to see directly how the participant can extrapolate from familiarity to recollection processes in such a straightforward manner. Moreover, the existing evidence about familiarity and source all derives from recognition tasks, and not recall, as we have used here. In short, using familiarity (or perceptual fluency) to recall rather than recognise a stimulus does not yield an elegant intuitive explanation as used by Yonelinas, 1999.

Such alternative explanations point to the idea that our findings would also be consistent with a multi-systems account of memory which would be highly interrelated. Moreover, Experiment 2 suggests that semantic knowledge is also related to perceptual identification. With the CID-R design, the relationship between priming and recognition has been exclusively found for stimuli allowing conceptual identification (e.g., words, Berry et al., 2012; object pictures, Berry et al., 2014; famous faces in the current paper). One point to discuss is whether semantic information related to the stimuli allows a deeper level of processing at encoding (e.g. Craik & Lockhart, 1972) which could favour the relationship between priming, recognition, and recall. Thus, a deficit in conceptual implicit memory has been found in patients with explicit memory deficit (e.g., in amnesic mild cognitive impairment patients, Gong et al., 2018; Alzheimer's disease, Fleischman et al., 2005). However, it should be noted that previous work has, again, found dissociations between these factors (e.g. Jacoby, 1993), whereby the task carried out at encoding can selectively change either perceptual or conceptual priming, even producing patterns whereby recognition is improved with a decrease in priming. A further interpretation of our data would be that pre-existing differences in the stimuli (i.e. familiarity) affect all our variables: more familiar famous faces are more easily identified and recognised, plus more can be recalled about them.

Returning to the difference in false alarms and correct rejection identification levels in the two experiments, we suggest that this occurred because participants' recognition was more conservative in the first experiment due to the embedded episodic recall questions. That is, our questions about contextual information may have prompted participants to use additional information during the recognition decision; altering the relationship between hits and false positives; recollected information would serve to reduce false positive responding, because a studied context cannot be retrieved for an item that is falsely familiar. During the second experiment, participants were not prompted to use these cues as the recall test was related to general knowledge and not episodic information. Moreover, we asked participants about general knowledge, regardless of their response on the recognition part of the task; they would not have been as likely to interpret this information as a justification as they would have done in the first experiment. To explore this post hoc hypothesis, we computed a t-test on the number of false alarms between the two experiments. It revealed that Experiment 2 ($M = 4.02$, $SD = 3.11$) had a higher number of false alarms $t(134) = 3.04$, $p = .003$, compared to Experiment 1 ($M = 2.57$, $SD = 1.81$). Therefore, we suggest that the low proportion of false alarms is due to a lower tendency to report ‘old’ responses in Experiment 1, and this could explain the difference between the two experiments.

Thus far, we have mostly discussed the results with reference to the single process-multiple process account of memory. Whilst we do not have the space to discuss in detail the complexity of findings from neuroimaging and classical neuropsychology, one clear possibility is that this all-or-nothing approach does not allow for a nuanced interpretation of our results. Our results, for instance, are entirely consistent with approaches that consider multiple types of processing on one key representation, and which side-step classical modular conceptions of memory, notably the Emergent Memory Account (Graham, Barense, & Lee, 2010). According to this proposition, memory is dependent upon the activation of distributed representations, including complex conjunctive object and scene representations; memory decision making emerges from the hierarchical processing of perceptual information. Whilst designed to addressed the single system account and in particular, recall, our data which shows that perceptual identification is related to a higher order decisional process is entirely consistent with this proposition, especially since our recall performance data is not merely limited to episodic representations. All forms of information linked to the core perceptual stimulus appears to be preferentially activated: whether the specific context at encoding (Experiment 1), or pre-existing factual information about the representation (Experiment 2). Accordingly, information and processes that are relevant for the perceptual decision are used in memory decision making. Whilst it is relatively straightforward to generate familiarity-fluency accounts for the recognition task, it is less easy to generate constituent higher order processes which bring to bear on both perceptual identification and recall. Although one possibility is that participants create a top-down representation which acts like a context for the perceptual decision making: i.e. the ongoing recall task activates perceptual representations.

To conclude, the present experiments support a single-system account of memory. We extended to recall previous results which found that priming and recognition are underpinned by the same memory strength system. Therefore, we argue that the relationship between implicit and explicit memory is not easily explained simply by ease-of-processing and/or the feeling of fluency, since perceptual fluency is less relevant in the recall tasks used here.

Future work should address the issues of episodic contamination and stimulus familiarity in more detail. Using ‘familiar’ celebrities is somewhat an inherent part of our design, since the perceptual identification task is to identify the face rather than another kind of memory judgement, but it would be of interest to see whether, in future experiments, an identification task with unknown, novel stimuli produce the same effects - effectively removing the issue of prior experience on the identifiability of the face and the degree of information related to it. In sum, either top-down recall processes penetrate down to even the lowest level perceptual decisions about a face, or trace-strength-like activations of a previously seen face percolate up through the system to effect even the retrieval of contextual specifics or related semantic information.

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