A dissociation between similarity effects in episodic face recognition

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Abstract

Memory similarity, the similarity between a test lure and memory traces, reduces confidence and accuracy in all forms of recognition memory. In contrast, Tulving (1981) showed that, in recognition memory for scenic pictures, accuracy was increased, but confidence was decreased, by choice similarity, that is, similarity between forced-choice test alternatives. We replicated both memory and choice similarity effects, and the dissociation between accuracy and confidence, with pictures of faces. State-trace analysis confirmed the dissociation and identified two dimensions underlying these effects, one associated with choice similarity and another associated with memory-similarity. Further analysis showed that the effect of study-test lag was associated with the memory-similarity dimension.

Unstudied test items that are judged perceptually or conceptually similar to study items produce increased false recognition for a wide range of stimuli (e.g., words, numbers, shapes and pictures). The resulting negative correlation between similarity and accuracy, which we call the *memory similarity* effect[1], is a general regularity in recognition memory tested by either Yes/No or two-alternative forced-choice (2AFC) procedures (e.g., Wickelgren, 1977). A second regularity, a positive correlation between recognition accuracy and retrospective confidence (i.e., confidence judgments given at test), is attributed to memory trace strength being the common basis for both decisions (Hart, 1967); stronger traces cause greater confidence and are associated with more accurate recognition decisions.

Hence, it was doubly surprising when Tulving (1981) reported a reversal of both regularities in 2AFC recognition decisions for scenic pictures followed by a confidence rating. The reversals were caused by *choice similarity,* the similarity between studied (target) and unstudied (lure) test alternatives. In higher choice similarity (*AA'*) pairs both items were halves of the same scenic picture, where one half (*A*) was studied and the other half (*A'*) was not. In lower choice similarity (*BC'*) pairs, the lure (*C'*) was the unstudied half of a studied picture (*C*) that was not similar to the target (*B*). Since the lure in both choice similarity conditions is similar to a studied item, memory similarity was controlled. Tulving found that for picture halves rated as higher in similarity, accuracy was increased but confidence was reduced, for *AA'* compared to *BC'* test pairs. These results are all the more compelling because, in the same experiments, the usual memory similarity effect was obtained when choice similarity was controlled. Accuracy and confidence were greater for lower compared to higher memory similarity pairs. However, for picture halves rated lower in similarity only the choice similarity effect on confidence was reliable.

Despite the surprising nature of Tulving's (1981) results, to our knowledge only one replication has been performed, by Dobbins, Kroll and Liu (1998). They used the same type of stimuli as Tulving, but their choice similarity effect was weaker for both accuracy and confidence, likely because memory similarity was lower for their stimuli. We know of no attempt to determine whether the choice similarity effect, or the dissociation between confidence and accuracy, applies to other types of stimuli. The three experiments reported here investigate whether these phenomena also occur in recognition memory for faces. The experiments differ only in their test procedure. Experiment 1 followed Tulving, with a 2AFC response followed by a confidence rating on a three point scale. In Experiment 2 participants simultaneously indicated their choice and confidence on a six point scale. Experiment 3 followed Dobbins et al. in requiring a "remember-know" response after a simultaneous choice and confidence rating.

Two models of the Tulving (1981) effect have been proposed. Although both were developed on the basis of data collected with scenic images, the mechanisms that they propose might also apply to face stimuli. Clark's (1997) *single-process* model assumes 2AFC is based on a single *evidence* variable equal to the difference in memory strength (i.e., the match between memory and test cues) between test items. Memory strengths for higher choice similarity pairs is positively correlated, facilitating average accuracy, but also making more extreme differences less likely, which reduces average confidence. Dobbins et al. (1998) proposed a *dual-process* model to explain their finding that "remember" responses, and by implication decisions based on recollection, were less common but more accurate when choice similarity was higher. For "know" decisions accuracy was unaffected by choice similarity, whereas confidence was decreased when choice similarity was higher (see

also Voss, Baym & Paller, 2008, for an alternative dual-process account in terms of implicit and explicit memory processes).

Both models explain the confidence-accuracy dissociation in terms of differential effects on two underlying dimensions or latent variables that control either two simple processes or one more complex process. In the dual-process model each dimension is equivalent to a process (familiarity and recollection) each controlled by a single latent variable (mean familiarity and recollection probability). In Clark's (1997) model the single-process is controlled by two latent variables (evidence mean and variance). Rather than directly comparing the models[2], we test their shared assumption that two dimensions are required to explain the confidence-accuracy dissociation.

Following Busey, Tunnicliff, Loftus and Loftus (2000), we use state-trace analysis (Bamber, 1979) to test the dimensionality of the relationship between confidence and accuracy. State-trace analysis uses a plot to test whether one psychological dimension is sufficient to explain the relationship between a pair of dependent variables without making assumptions that have been identified as problematic in other approaches to this question (Dunn & Kirsner, 1988). Results for one dependent variable (e.g., accuracy) are plotted against results for the other dependent variable (e.g., confidence). Points on the plot represent results from experimental conditions. In our case the conditions are the result of a factorial combination of high and low choice and memory similarity manipulations. If all of the points on the state-trace plot can be joined by a single always increasing or always decreasing (i.e., monotonic) curve, the findings can all be explained by a variations on a single underlying psychological dimension. If a monotonic curve does not suffice, more than one dimension is required.

Like us, Busey et al. (2000) studied episodic recognition memory for faces. They found that one dimension explained the relationship between confidence and accuracy (i.e., state-trace plots were monotonic) in two experiments that manipulated only study-related factors; either allowing or not allowing rehearsal combined with stimulus duration (Experiment 1) or luminance (Experiment 2) manipulations. In contrast, more than one dimension was required (i.e., the state-trace plot was non-monotonic) in a third experiment that manipulated luminance and the match between study and test stimulus luminance. Confidence and accuracy dissociated because participant's confidence judgments were less affected than their accuracy by the match between study and test stimuli; they were more confident for bright than dim test stimuli even when those bright test stimuli that were less accurate because they were studied dim. Tulving's (1981) dissociation is analogous; participants were more confident for low than high choice similarity even though accuracy was greater for high then low choice similarity pairs when memory similarity was high.

In our second and third experiments we also examined the effect of the time between study and test (i.e., study-test lag). Arguably the single-process model makes a very constrained prediction: the effect of lag will dissociate with the effect of choice similarity but *not* with the effect of memory similarity. That is, a monotonic curve will join points in a state-trace plot from different memory similarity and lag conditions, but a different curve will be required for high and low choice similarity conditions. If this were the case it would demonstrate that a one-dimensional model is not a straw man in our paradigm in the same way that Busey et al.'s (2000) findings about rehearsal and study duration showed the one-dimensional model was not a straw man in their paradigm.

Our predictions about lag also test of the generality of the mechanisms underlying the single-process model, because they are based on using those mechanisms to extrapolate from an empirical finding about lag effects in another paradigm. Ratcliff, McKoon and Tindall (1994) found an effect of study position on the mean but not the variance of memory evidence. In Clark's (1997) model, memory similarity affects mean evidence and choice similarity affects evidence variance. Hence, only one dimension (mean evidence) is required to predict the joint effects of lag and memory similarity.

Experiments

Face stimuli were classified by gender and race (Black, Asian and White). The experiments used the same 2×2 factorial design crossing higher and lower choice similarity with higher and lower memory similarity as Tulving (1981, Experiment 2). Memory similarity was manipulated using pairs of faces from sets that were rated higher and lower on perceptual similarity (see Figure 1). Higher choice similarity resulted when test alternatives were members of the same pair. Lower choice similarity resulted when test alternatives were from different racial categories. Formation of lower choice similarity pairs from different races was a convenience based on the available stimulus set[3].

Method

Participants

Participants were introductory psychology students at the University of Newcastle, Australia, who received course credit for participation. Thirty-eight participated in Experiment 1, 35 in Experiment 2, and 45 in Experiment 3.

Apparatus and Procedure

Face images (105×120 pixel grayscale bitmaps) from the FERET database (Phillips, Wechsler, Huang & Rauss, 1998) were grouped into 377 generally similar pairs. Pair similarity was rated by 10 first year psychology students using a 5 point

scale (1=*very low* to 5=*very high*). Pairs were rank ordered using average similarity ratings within gender and race categories, and higher and lower similarity sets created by selecting lowest and highest ranked pairs. Table 1 provides the rating results for each category for 240 critical pairs. Four faces appeared before and after the critical faces in study list as untested primacy and recency buffers. Buffer faces, and faces used for an initial practice study-test cycle, were randomly drawn from the remaining 137 face pairs.

Responses were recorded via a six-button array in Experiment 1. The first button on the left, labeled 'GO', was used to initiate study-test cycles. The remaining five buttons were labeled 'L', 'R', '1', '2' and '3' from the left. In all experiments buttons 1-3 were used to make typicality ratings of faces in the study phase (1=*very typical* to 3=*very unusual*). Typicality ratings were elicited to ensure attention to the faces and were not further analyzed. In the test phase buttons 1-3 were used to make confidence ratings (1=*guess* to 3=*sure*). In Experiment 1 the L=*left* and R=*right* buttons were used to indicate which face was the target. An eight button array, consisting of left and right hand clusters of three keys and a central pair of keys, simultaneously recorded confidence and accuracy in Experiments 2 and 3. In Experiment 2 the left and right clusters were labeled 3, 2, 1, 1, 2, 3 from left to right. Buttons in the left and right clusters indicated left and right choices respectively.

Experiment 3 attempted to replicate the response procedure used by Dobbins et al. (1998). The left and right hand clusters were labeled 1, 2, 3, and 3, 2, 1 from left to right, and both buttons in the central pair were labeled 4, as participants were required to rate their confidence using a 4-point scale. Additionally, the central pair of keys was used to make remember-know judgments. Participants pressed the left button, labeled *remember*, if they remembered seeing the face, or particular elements of the face, and the right button, labeled *familiar*, if the face was familiar but they did not remember the face or any particular elements of the face.

Testing used a PC with a 1168×856 resolution monitor. The experimental session, which lasted 40 to 55 minutes, began with participants reading instructions on

the screen at their own pace. During study, faces were displayed one at a time in the middle of the screen for 2 seconds. After each face appeared, participants were prompted to make a typicality rating. The test phase began immediately after study. In the test phase, face pairs appeared one pair at a time. If no response was made after six seconds, the next pair was displayed.

In each of the 11 study-test cycles (the first being practice) participants studied 32 faces presented in a random order, except that the first and last four were buffer items. Each study list used faces which were all of the same gender, half from one race and half from another (see Figure 1). High choice similarity pairs were created by pairing a studied face with its unstudied pair mate. Low choice-similarity pairs were created by pairing a studied face from one race with an unstudied face from another race (see Figure 2). The order of the 16 test pairs and the side on which the target was presented was randomized.

Results

Eight, four and seven participants in Experiment 1-3 respectively were excluded from analysis either because their accuracy was less than 60% (accuracy for other participants was above 70%) or because they did not follow instructions to use all confidence ratings (i.e., rarely or never using the lowest confidence rating). Integer confidence ratings (r=1-3) were converted to percentages using $100\times(r\text{-}1)/2$. Following Tulving (1981), we calculate confidence based on all responses, both correct and incorrect.

ANOVAs examined accuracy and confidence as a function of experiment and choice and memory similarity factors. Effects with $p<.05$ are described as reliable. Experiment did not reliably interact with any other variables and so Figure 3 shows results averaged over experiments[4]. There was a reliable main effect of choice similarity, $F(1,96)=17.1$, $p<.001$, with the high more accurate than low by 2.3%. The main effect of memory similarity was also reliable, $F(1,96)=51.9$, $p<.001$, with low

more accurate than high by 2.3%. Consistent with the almost identical main effects of each factor, their interaction was not reliable, $F<1$.

For confidence, there were reliable main effects of choice similarity, $F(1,96)=26.0$, $p<.001$, with the low more confident than high by 3.5%, and of memory similarity, $F(1,96)=47.9$, $p<.001$, with low more confident than high by 2%. The interaction between choice and memory similarity was reliable, $F(1,96)=6.7$, $p=.011$, as the difference in confidence due to memory similarity was larger for high (2.8%) than low (1.2%) choice similarity pairs. Note, however, that the effect of choice similarity was reliable in both low, $t(98)=3.23$, $p<.002$, and high, $t(98)=4.1$, $p<.001$, memory similarity conditions.

Figure 4 displays state-trace results. For Experiment 1 (top panel) a two-factor explanation of the confidence-accuracy dissociation is clearly supported. Within each level of choice similarity (i.e., points joined by lines) both confidence and accuracy increase as memory similarity decreases. In contrast, within each level of memory similarity, accuracy increases, but confidence decreases as choice similarity increases. The bottom two panels of Figure 4 show state-trace results for Experiments 2 and 3 broken down by short vs. long lag. The lag factor was created using a median split; the average short and long lags were 16.5 and 29.5 study and test events respectively. For low choice similarity test pairs, lag was calculated using the study position of the unstudied test item's studied pair-mate. Conditions with the same choice similarity and lag are joined by lines. All four lag and memory similarity conditions within each level of choice similarity can be joined by a single monotonic curve (within experimental error). These results indicate that the effects of memory similarity and study-test lag can be explained by a single dimension. In contrast, the curve for higher choice similarity conditions is displaced upward and to the left (i.e., more accurate, less confident) than the function for lower choice similarity, indicating that a second dimension is required to explain the effect of choice similarity.

Discussion

We observed for faces the same confidence-accuracy inversion found by Tulving (1981) and Dobbins et al. (1998) with scenic pictures. Increased choice similarity improved accuracy but decreased confidence when the effect of memory similarity was controlled. Hence, the choice similarity effect appears to occur along a general visual similarity dimension that applies to both scenes and faces. The potentially greater range of variation between halves of scenic pictures than between pairs of faces may explain why our results differed from Tulving's (1981) in two respects: 1) our choice and memory similarity effects were smaller, although highly reliable, and 2) Tulving only obtained a choice similarity effect for his higher memory similarity pairs whereas we found reliable effects for our lower and higher memory similarity pairs. Both differences are likely caused by face pairs sharing a great deal of structural similarity, whereas scenic picture halves can be quite dissimilar. Hence, the difference between stimuli in lower and higher choice and memory similarity pairs is likely to be much greater for scenes than faces, causing larger effects for scenes. In the same vein, our lower memory similarity pairs were likely still sufficiently similar to support a reliable choice similarity effect, whereas Tulving's lower memory similarity pairs were likely not sufficiently similar.

Our findings with 2AFC tests of memory for facial stimuli may have implications in the applied domain of eyewitness identification. Juries tend to assume a positive correlation between confidence and accuracy (Penrod & Cutler, 1995), whereas our results imply they can be negatively correlated. Even though we found a smaller confidence-accuracy dissociation than did Tulving (1981) with natural scenes, the dissociation is likely to be quite pervasive due to the high level of similarity between all faces. Clearly, however, more investigation is needed to explore these implications in more ecologically valid paradigms. For example, although 2AFC tests resemble criminal identification lineups there are also many differences, such as more than two choices and the ability to make no choice in lineups (see Clark, 2003).

We obtained the same choice and memory similarity effects with the response methods used in previous investigations, choice followed by a confidence rating (Tulving, 1981) and a simultaneous choice and confidence response followed by a remember-know classification (Dobbins et al., 1998), as well as with a simultaneous choice and confidence rating alone (our Experiment 2). One of the reasons we ran the latter condition was to check a potential speed-accuracy tradeoff (Reed, 1973) explanation of the choice similarity effect suggested by Tulving's statement that "highly similar test items may induce participants to … examine the evidence more thoroughly" (p.495). Test response times were strongly affected by confidence (higher confidence decisions were quicker), and to a lesser degree by accuracy (correct choices were quicker). However, when the effects of differences in confidence and accuracy between memory and choice similarity conditions were controlled, neither choice nor memory similarity had a reliable effect.[5] Hence, speed-accuracy tradeoff was unlikely to be the cause of the choice similarity effect.

For all response methods, state-trace analysis consistently indicated that at least two psychological dimensions are required to explain the dissociation between choice and memory similarity effects on confidence and accuracy. Study-test lag effects in Experiments 2 and 3 could be explained by the same dimension as memory similarity effects, but both dissociated from choice similarity[6]. Qualitatively the dissociation which we found and the one found by Busey et al. (2000) are similar in that they both relate to differences between conditions that might be evident to participants at test (i.e., brightness and similarity between test alternatives). A potential explanation for both dissociations suggested by Busey et al. is that confidence judgments are affected by erroneous beliefs about the effects of test differences on accuracy. However, differences evident at test may not always be necessary to cause a dissociation. Recently Voss et al. (2008) reported that dividing attention during study of abstract visual stimuli resulted in decreased confidence but increased accuracy in a 2AFC test using high choice-similarity pairs.

The state-trace results also have strong implications for quantitative memory models. In Clark's (1997) single process model the state-trace results are consistent with changes in mean memory evidence underpinning lag and memory similarity effects, and changes in evidence variance underpinning choice similarity effects. In Dobbins et al.'s (1998) dual-process model these results are consistent lag and memory similarity having the same pattern of effect on familiarity and recollection and choice similarity having a different pattern of effect. Given Yonelinas and Levy's (2002) suggestion that study-test lag affects familiarity but not recollection, these results could be used as a basis to extend Dobbin's et al.'s model to address lag and memory similarity effects using a familiarity based mechanism. In general, our results demonstrate the power of state-trace analysis to provide guidance for the development of different process models with requiring a commitment to the detailed assumptions made by any one model.

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Footnotes

[1]We avoided the more commonly used term *target-lure similarity* because that could also apply to the similarity between choices in a two-alternative forced-choice test (i.e., what we call *choice similarity*). The term *memory similarity* emphasizes the relationship between a memory trace and a test lure, which is what our memory similarity manipulation affects while controlling for choice similarity.

[2]We collected remember-know judgments in Experiment 3 to pilot an experiment used to compare the models. For the present purposes Experiment 3 serves as a check on whether making remember-know responses changes choice and accuracy effects (it did not). Lack of space does not allow us to report remember-know results for Experiment 3 here. A model comparison based on remember-know responses is reported elsewhere (Heathcote, Bora & Freeman, submitted).

[3] The use of race does not confound the effects on which we focus due to counterbalancing. Our study format, which mixes races within a study list, is also likely to weaken race effects, which are stronger when race is blocked (Meissner & Brigman, 2001). Consistent with race not affecting our results, the experiment reported by Heathcote, Bora and Freeman (submitted) found the same pattern of results using single-race lists with low choice similarity pairs created by pairing faces with different genders.

[4]A reviewer noted that when lag was included as a factor there were slight deviations from the confidence-accuracy inversion at short lags in Experiment 2 and long lags in Experiment 3. As the interaction with lag was not consistent across experiments, and an ANOVA on the Experiment 2 and 3 data including a lag factor did not produce any reliable interactions, we attribute these deviations to measurement error.

[5]The same was true with the other two response methods for the time to make the first response, and the sum of the times to make both responses. Where two responses were required our participants appeared to make both decisions before making the first response, as the time for the second response was fast and unaffected by choice and memory similarity.

[6]Lag effects for Experiment 1 could not be analysed as we did save information about each test item's study position. Given the similarity of other effects between Experiments 1-3 it seems unlikely that lag effects would differ much between Experiment 1 and the other experiments.

Table

Table 1. Characteristics of the 240 critical experimental face pairs. Female pairs were used to create one Asian-White and three Black-White study lists. Male pairs were used to create three Asian-White and three Black-White study lists.

Gender	Race	Similarity	Mean Rating (%)	Number
Female	Black	Lower	38	18
		Higher	67	18
	Asian	Lower	31	6
		Higher	64	6
	White	Lower	33	24
		Higher	67	24
Male	Black	Lower	33	18
		Higher	63	18
	Asian	Lower	37	18
		Higher	64	18
	White	Lower	34	36
		Higher	71	36

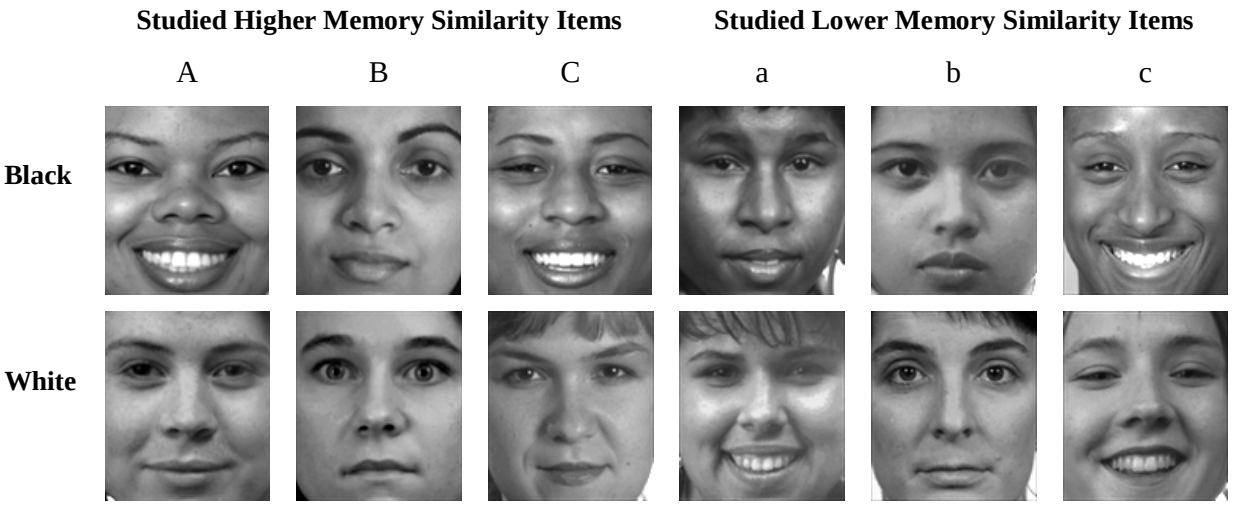
Figure Captions

Figure 1. Study list construction. For each study list 24 critical study items were randomly selected members from 12 high memory similarity pairs and 12 low memory similarity pairs. (a) Example black and white female study list showing half of the actual number of critical items. Examples of higher memory similarity items are designated by upper case letters (A, B, C) and examples of studied lower memory similarity items are designated by lower case letters (a, b, c), and (b) Pair mates for studied faces which were not studied. Examples of unstudied higher memory similarity items are designated by upper case letters with a prime (A', B', C') and examples from lower memory similarity items are designated by lower case letters (a', b', c'). Note that items with the same letter in (a) and (b) (e.g., A and A') are pair-mates.

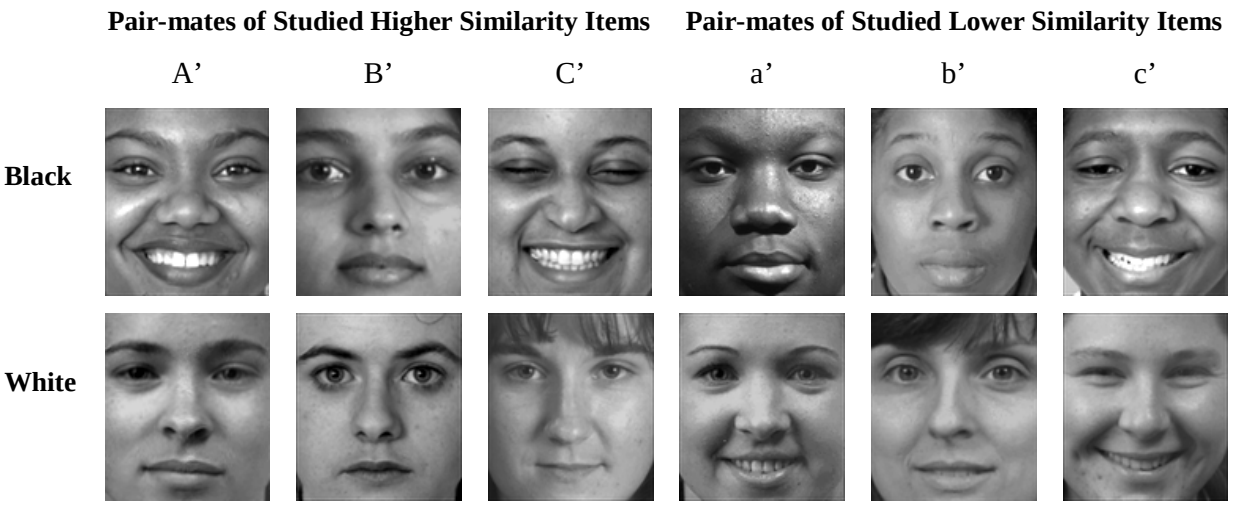
Figure 2. Test list construction. Each test list presented participants with two face pairs from each of the eight race×choice×memory similarity conditions. The figure shows a half-length example test list constructed from studied and unstudied faces shown in Figure 1. For example, the low choice similarity and low memory similarity test pairs (bc') are constructed from studied (b) and unstudied (c') items in Figure 1. Note that members of higher choice similarity test pairs (AA') look similar to each. For higher memory similarity test pairs (BC'), the unstudied pair member (C') looks similar to their studied but not tested pair mate (C) shown in Figure 1.

Figure 3. Confidence and accuracy as a function of choice and memory similarity from Experiments 1 to 3, averaged over experiments. Standard error bars were calculated using Loftus and Masson's (1994) method for a within-subjects design.

Figure 4. State-trace plots of accuracy as a function of confidence as a function of choice and memory-similarity conditions. For Experiments 2 and 3 results were further divided on the lag between study and test. Standard error bars were calculated using Loftus and Masson's (1994) method for a within-subjects design.

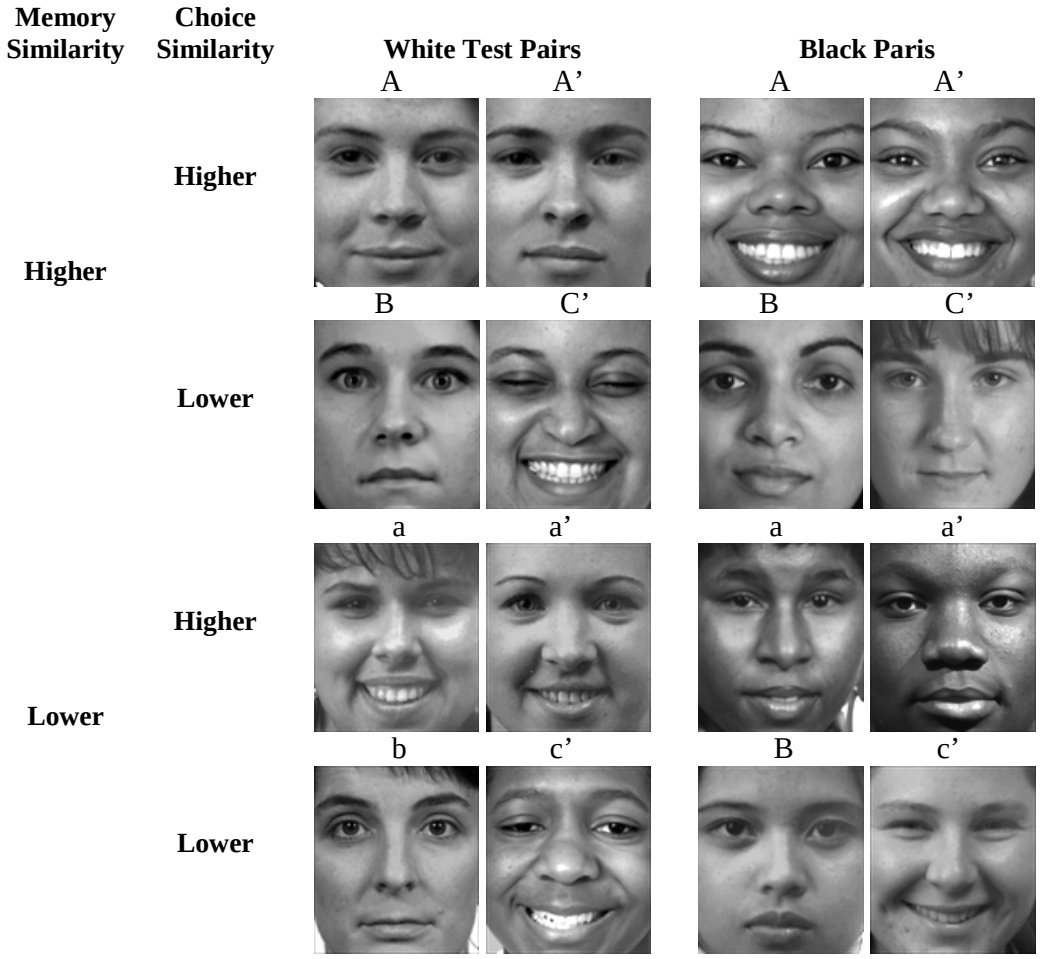

Studied Higher Memory Similarity Items
Studied Lower Memory Similarity Items
A
B
C
a
b
c
Black
White

(a)


Pair-mates of Studied Higher Similarity Items
Pair-mates of Studied Lower Similarity Items
A’
B’
C’
a’
b’
c’
Black
White

(b)

Figure 1


Memory Similarity
Choice Similarity
White Test Pairs
Black Paris
A
A'
A
A'
Higher
Higher
B
C'
B
C'
Lower
a
a'
a
a'
Higher
Lower
b
c'
B
c'
Lower

(c)

Figure 2

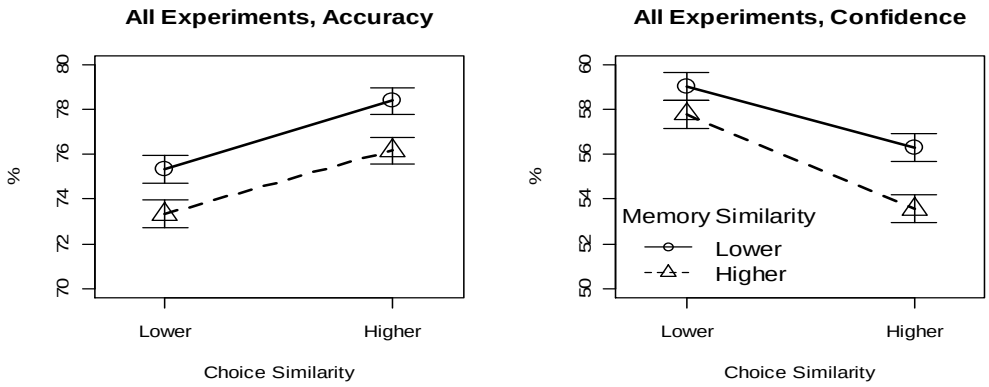

All Experiments, Accuracy
%
70
72
74
76
78
80
Lower
Higher
Choice Similarity
All Experiments, Confidence
%
50
52
54
56
58
60
Memory Similarity
Lower
Higher
Lower
Higher
Choice Similarity

Figure 3

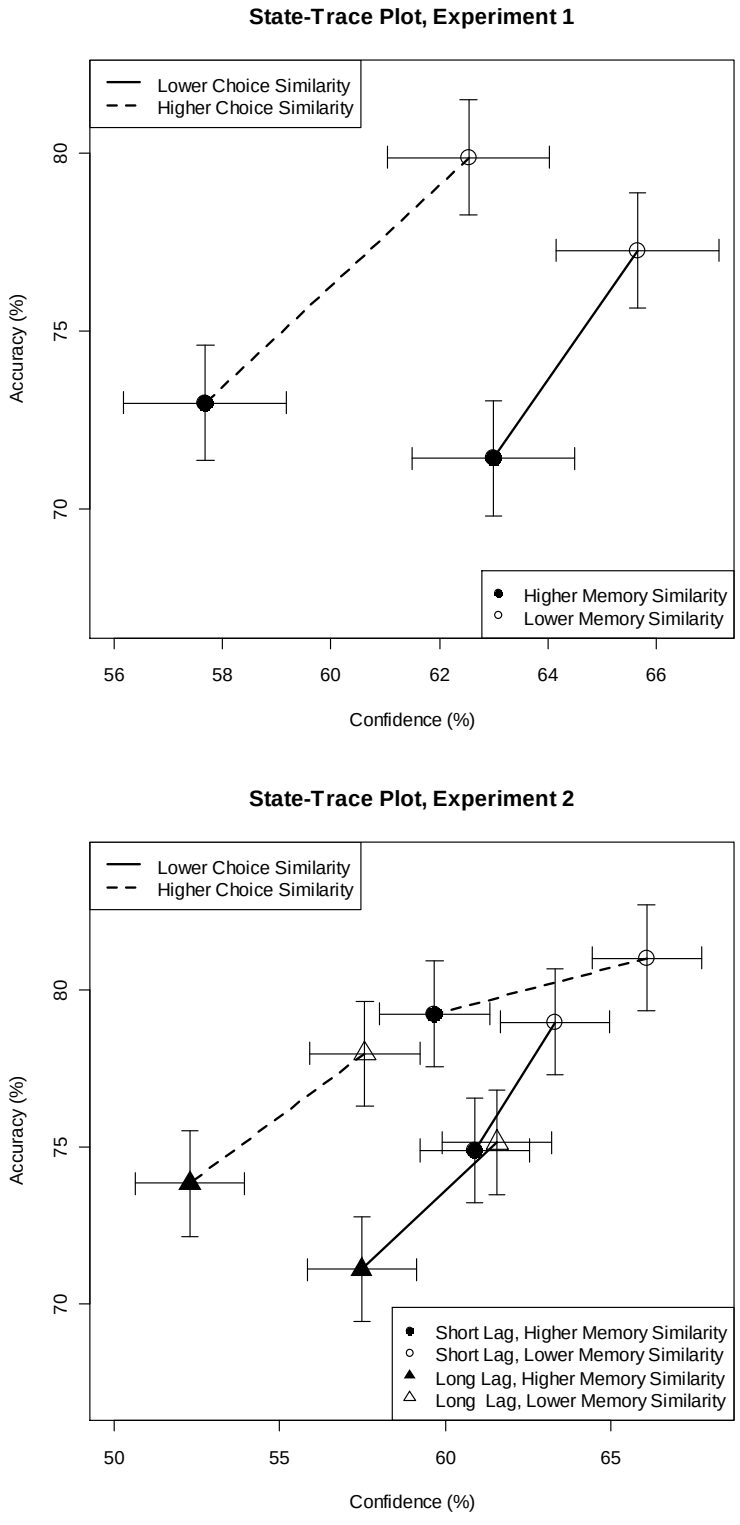


Figure 4 (continues next page)

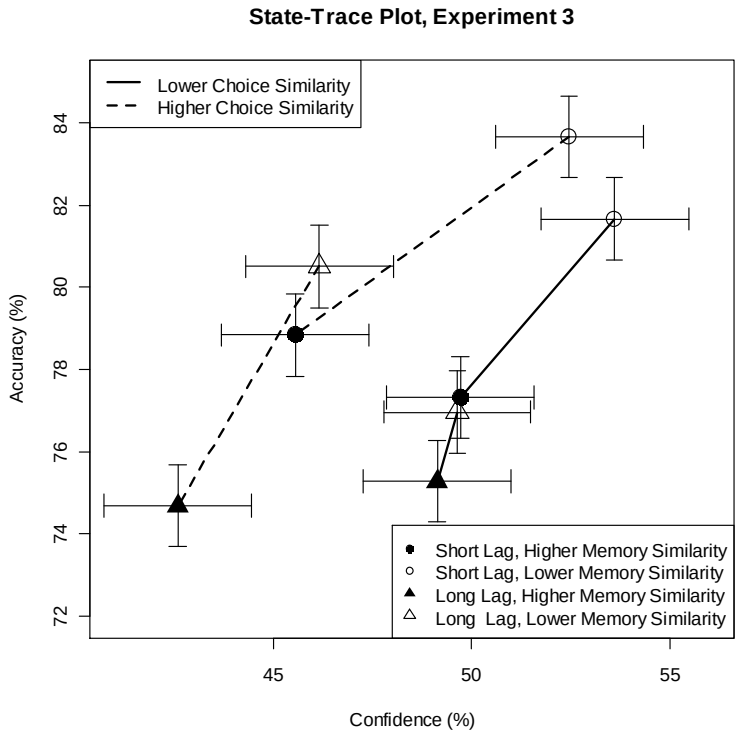


Figure 4 (continued from last page)