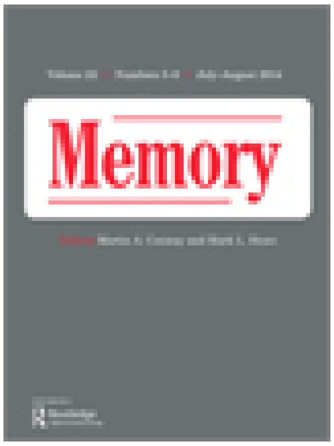

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Effect of retention interval on the simultaneous cognate-noncognate and remember-know mirror effects

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Effect of retention interval on the simultaneous cognate-noncognate and remember-know mirror effects

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Recognition memory for Spanish-Catalan cognate and noncognate words was tested at retention intervals of 30 minutes, 3 days, and 7 days using a remember/know response procedure. We observed a clear mirror effect for the cognate-noncognate stimulus class and a remember-know response categorisation at the immediate retention interval. However, the cognate and noncognate mirror was still observed at 3 and 7 days, whereas the remember-know mirror disappeared at both retention intervals. Also, we ran a repeated testing condition to be able to carry out a sequential item analysis and observe the fate of the original remember and know responses 3 or 7 days later. The analysis supported the idea that there was a loss of contextual information that was at the root of the disappearance of the remember-know mirror effect. These results provide support to the idea that it is the imbalance between recollection and familiarity that is the most likely cause of the mirror effect.

On a recognition test it is quite frequent to find that one class of stimuli gives rise to higher hits and lower false alarms than another. This so-called mirror effect is one of the most important explanatory problems for recognition memory theories because the pattern is difficult to explain in a simple way based on single factor theories of recognition memory (e.g., Gillund & Shiffrin, 1984; Glanzer & Adams, 1990; Hintzman, 1988; Shiffrin & Steyvers, 1997). If we assume, as single process theorists do, that items presented at testing vary simply along a single dimension of familiarity, then the difficulty lies in the need to postulate simultaneously that test items have a high strength when old and a low one when new, given that both have been extracted from the same stimulus class. Some single process theories have postulated that subjects use likelihood ratios (Glanzer & Adams, 1990; Shiffrin & Steyvers, 1997), instead of memory strength, as the basis for their decision. A simpler explanation has been introduced recently in the form of two-process theories (Joordens & Hockley, 2000; Reder, Nhouyvansivong, Schunn, Ayers, Angstadt, & Hiraki, 2000). According to these theories, the higher hit rate in the mirror pattern is due to the fact that the corresponding stimulus class shows more possibilities of recollection (greater distinctiveness), whereas the lower false alarms are due to inferior pre-experimental familiarity.

The two-process theory also offers a straightforward explanation of the results in the remember-know (r-k) literature (Gardiner & Richardson-Klavehn, 2000) and the corresponding mirror (see Reder et al., 2000). The remember-know mirror is defined as the pattern of data in which more remember hits are associated with fewer false alarms than their corresponding know hits and false alarms. If "remember" is associated with greater recollection than know, and vice versa with regard to familiarity, two-process theories could also predict a remember-know mirror.

This seemingly simple explanation has proven to have considerable predictive power. When

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recollection is reduced at testing, the hit advantage is attenuated or reversed, leaving the false alarms untouched. This reduction is also present when the overall results are partitioned as a function of confidence or r-k response categorisation (Hockley, Hemsworth, & Consoli, 1999; Joordens & Hockley, 2000). When pseudowords are not recollectable, due to their novelty, they do not show a mirror pattern. Only after a familiarisation phase does the mirror appear at a later stage in training (Reder, Angstadt, Cary, Erickson, & Ayers, 2002). Furthermore, the administration of midazolam (Hirshman, Fisher, Henthorn, Arndt, & Passannante, 2002)—a substance producing anterograde amnesia that supposedly affects the recollection process—reversed the mirror in favour of high-frequency words. Finally, when age is taken into account, the hit advantage for low-frequency words is diminished, as in Alzheimer's disease patients (Balota, Burgess, Cortese, & Adams, 2002), which is congruent with the well-known fact that there is a very steep decrease in the ''remember'' type of recognition with age (e.g., Parkin & Walter, 1992). In conclusion, the appeal to the dual processes of recollection and familiarity seems to provide a more straightforward explanation of the overall data than a single view does.

In the following experiment, we pursue two closely related goals. The first is to replicate the mirror effect with a new stimulus class recently reported in the literature (Algarabel, Gotor, & Pitarque, 2003). The mirror effect has been found for stimuli such as word frequency, concreteness, imagery, meaningfulness, familiarity, pictures versus words (Glanzer & Adams, 1985; Glanzer, Adams, Iverson, & Kim, 1993) or distinctiveness of orthographic features (Malmberg, Steyvers, Stephens, & Shiffrin, 2002), to name but a few stimulus classes. Our idea was to use stimuli from one language with varying similarities to another language, following the suggestion that to get a mirror pattern the stimuli have to differ in recollective capabilities and previous familiarity (see Joordens & Hockley, 2000). In fact, we have found that in a situation in which there were differences in contextual information between two conditions that were equally familiar, the hit advantage for the more recollectable class was present, but the false alarm advantage was not (Pitarque, Algarabel, Gotor, & Luciano, 2003). In our case, we took advantage of the Catalan-Spanish bilingualism, and assumed that cognate (c) words were more familiar but less recollectable than noncognate (nc) ones in the Catalan language. We base this differential recollectability on the fact that Spanish is the dominant and familiar language, whereas Catalan is by contrast more distinctive phonetically and phonologically (see Malmberg et al., 2002; Rajaram, 1996; Rajaram & Geraci, 2000). There is clear evidence in favour of this interpretation (e.g., Reder et al., 2000), although it is not critical for the results that we will be presenting.

Second, and more importantly, we intend to observe simultaneously the c-nc and the r-k mirrors as a function of relatively intermediate retention intervals. We make the novel prediction that an interaction between both types of mirrors and the retention interval should be found if the two-process theory is correct, based on the assumption that both mirrors reflect a different use of recollection and familiarity. Traditionally, the remember-know paradigm is used in the literature under the assumption that both responses reveal a different balance in the use of recollection and familiarity. Our hypothesis is that words included in an experimentally manipulated stimulus class, and defined as noncognate, are less recollectable by definition than those words self-selected by a participant through a remember response. Further, we assume that context has a much lower role than the item in recognition, as the experiments on context change show (e.g., Smith & Vela, 2001). By this account, we expect that recollection suffers more from the effect of delay, and we should expect a greater impact of retention interval on the r-k as compared to the c-nc mirror. Additionally, in the case where context evidence is lost, we should also expect that a higher proportion of remember responses would become know, as originally demonstrated by Knowlton and Squire (1995). If this were the case, the shift would indicate that subjects change their judgement from being more recollective to being more familiarity based. To substantiate this point, we will carry out an item analysis similar to that performed by Knowlton and Squire (1995, Experiment 3), in order to observe the fate of the r-k judgements and the responses given to cognate and non-cognate stimuli between successive tests. In a previous paper, Joordens and Hockley (2000) did not find a significant decrease in hits with very short retention intervals, although the effect was in the correct direction, and they did find an unexpected increase in false alarms. They assumed that remember items were subject to more forgetting than know items, an assumption that we believe is wrong. We also expect to shed light on this point, because the transfer mechanism between the remember and know response categories will also explain why there is an increase in false alarms over time.

As mentioned previously, there are reasons to believe that the context in which the retention interval has been manipulated underestimates forgetting in the know response category because some initially ''remembered'' items become known after the loss of contextual information. The literature investigating the effect of retention interval shows that when participants are asked to categorise their recognition responses as remember or know, the remember response decreases or deteriorates more sharply than the know response (Gardiner & Java, 1991, Mäntylä, 1994), at least within the first week or so (see also Yonelinas, 2002). In fact, some of the reports in the literature (Gardiner & Java, 1991) argue that know responses remain largely stable across a variety of relatively short retention intervals (although see for example Hockley & Consoli, 1999). In any case, one can observe frequently (e.g., Knowlton & Squire, 1995) that although the decrease in both remember and know responses may happen over delays of 1 week, the decrease in d′ is produced for different reasons in each case. Whereas in the case of remember responses there is a pronounced deterioration in the hit part and a modest increase in the false alarm rate, in the case of know responses the pattern is the opposite.

In this experiment, the encoding task was to provide the Spanish equivalent of a Catalan word. Two groups of participants were later tested after 3 or 7 days (between subjects) on different words requiring a recognition response and a remember-know judgement in sequence. In order to carry out the item analysis, we ran the same conditions on two additional groups of subjects, but this time they were tested on the same stimuli.

METHOD

Participants

A total of 84 psychology students participated in the experiment for course credit. All of them had a perfect knowledge of Spanish but were knowledgeable of Catalan as a second language to different degrees.

Materials and procedure

We selected 168 Catalan words from Spanish-Catalan norms (Nacher, Gotor, & Algarabel, 1998), half of which were cognates. The study phase of the experiment consisted of a list of 94 words, with the first and last 5 considered as primacy and recency buffers. We constructed two separate lists of the same lengths. Both lists were equated on word frequency (Alameda & Cuetos, 1995) in Spanish and Catalan (Gotor, Borras, & Perea, 1994) and length. Concretely, the specific mean values for the main parameters for both lists were 105 per 2 million (frequency), 5.6 (number of letters), and 0.1 (similarity ratio); and 121, 5.52, and 0.2 for noncognate lists A and B, respectively. For cognates, the respective values were: 131 (frequency), 5.8 (length in letters), and 1 (Similarity ratio) for list A; and 115, 5.86, and 1 for list B.

The test lists were created according to the following procedure. We divided each study list into seven consecutive blocks of 12 words, and from each block we sampled 6 different words for each of the two 42-word test lists. Both lists were completed with another 42 words from the alternate list following the same procedure. The process was carried out independently for each participant, who received a different randomised study list printed in a booklet. Participants were told that their task was to provide the Spanish translation for each Catalan word in the blank space provided to the right of each word, or leave the space blank if they did not know the answer. They were also told that they would be tested with an unspecified memory test at a later point, although they did not know that they were going to be tested twice.

Each word was timed by the experimenter, and every 5 seconds participants were told to advance a word, until the end of the list was reached, at which point the booklet was collected. The first test started 30 minutes after the study phase (n = 84). The second test started 3 days later for one group (n = 22) and 7 days later for the other (n = 19). The two tests were identical except for the differences in retention interval. In addition, two more groups were run and tested twice with the same words, at either 3- (n = 25) or 7-day delays (n = 18). In both cases old words, regardless of their translation status, were randomly mixed with new words from the alternate list in equal proportions. The second test was not announced in advance, and there were no environmental cues suggesting that it was going to take place.

All tests were self-paced and completed quickly. The instructions given to the participants asked for two responses to each stimulus. The first response was a new/old discrimination, the second (only for yes responses), a remember/know/guess. The instructions followed others usually found in the literature (e.g., Rajaram, 1996) with the addition of instructions for ‘‘guess’’. If the initial response was ‘‘old’’, and they were able to bring to mind specific aspects of the previous occurrence like details of the physical appearance, place in the list, or any other image or idea that occurred at the moment of the presentation, they now had to respond ‘‘I remember’’. If they recognised the word as old, but were unable to recollect any other specific event, then they were to say, ‘‘I know’’.

RESULTS

The level of guess responses was low (see Tables 1–3), and they were excluded from further analyses because they were not related to the main hypothesis of the paper. The proportion of noncognate words not translated in the study was 14.07%, although, as will be shown, noncognate words were better recognised. The significance level for all statistical tests was $p < .01$, unless otherwise noted. For clarity we will analyse the stimulus class variable and the remember-know response category independently for each retention interval. We think that this strategy is necessary for simplicity in the description, although we will return to a finer-grain examination in the general discussion.

We took as the dependent variables the discrimination index d′, and then unpartitioned and remember-know proportions in each experimental condition. Tables 1 (immediate retention interval), 2 (non-repeated tests), and 3 (repeated tests) present a complete view of all data on which subsequent analyses are based. Yonelinas and Jacoby (1995) suggested the use of a transformed know measure [Know independent; k = k/(1–R)] to make it independent from the proportion of remember responses. Although this is a debatable point (see for example, Gardiner & Richardson-Klavehn, 2000), we did carry out this analysis here, but this led to similar conclusions, and so for simplicity these analyses are not reported.

Immediate retention interval

As expected, the difference in d′ for the c-nc distinction was significant in a within-subject analysis of variance, $F(1, 83) = 82.69$, $MSe = .032$, indicating clearly that noncognate words were better recognised than the cognate ones. With regard to the mirror effect, we analysed first the c-nc, followed by the r-k mirrors. A within-subjects analysis of variance on the proportion of hits showed that noncognate hits were superior to the cognate ones, $F(1, 83) = 52.59$, $MSe = .016$. The equivalent analysis on false alarms showed the opposite pattern, $F(1, 83) = 21.81$, $MSe = .004$. The same type of analysis showed a mirror effect for the remember-know response categorisation, $F(1, 83) = 40.21$, $MSe = .055$, and $F(1, 83) = 14.85$, $MSe = .002$. This analysis is carried out on a variable that

TABLE 1
Immediate retention interval

	Hits			False alarms		
	NC	*C*	*Total*	*NC*	*C*	*Total*
Unpartitioned	0.86	0.73	0.79	0.05	0.12	0.09
Remember	0.62	0.37	0.49	0.01	0.02	0.02
Know	0.22	0.32	0.27	0.03	0.07	0.05
Guess	0.02	0.04	0.03	0.01	0.03	0.02
d′	2.77	1.97				

Mean proportions of remember and know responses to old and new test words as a function of linguistic status (noncognates, NC, and cognates, C), for the immediate retention interval. The discrimination values (d′) for cognates and noncognates are also shown.

TABLE 2
Nonrepeated tests

		Hits			False alarms		
Interval		*NC*	*C*	*Total*	*NC*	*C*	*Total*
3 Days	Unpartitioned	0.67	0.49	0.58	0.09	0.22	0.16
	Remember	0.36	0.14	0.25	0.03	0.04	0.04
	Know	0.28	0.29	0.29	0.04	0.14	0.09
	Guess	0.03	0.06	0.05	0.02	0.04	0.03
	d′	1.88	0.95				
7 Days	Unpartitioned	0.58	0.41	0.51	0.19	0.27	0.23
	Remember	0.23	0.08	0.16	0.03	0.04	0.03
	Know	0.30	0.27	0.29	0.12	0.17	0.16
	Guess	0.05	0.06	0.06	0.04	0.06	0.04
	d′	1.27	0.57				

Mean proportions of remember and know responses to old and new test words as a function of linguistic status (noncognates, NC, and cognates, C), and retention interval (3 days, 7 days) for nonrepeated tests. The values for discrimination indices are also shown by interval repetition.

violates the independence assumption of the analysis of variance (see Joordens & Hockley, 2000). We retain this analysis for reasons of clarity, but later we will show convergent evidence with a different approach.

Non-repeated condition

At 3 days, the difference in d' for the c-nc distinction was significant and in favour of the nc stimuli, $F(1,21) = 34.228$, $MSe = .028$. To be brief, we again obtained a mirror effect for the c-nc stimulus class for hits, $F(1,21) = 24.324$, $MSe = .014$, and false alarms, $F(1,21) = 10.41$, $MSe = .032$, but the remember-know mirror became non-significant due to the hit side of the pattern of effects. Statistically, $F(1,21) < 1$, $MSe = .026$, ns, for hits (with means in the opposite direction, 0.25 vs. 0.29), and false alarms, $F(1,21) = 6.24$, $MSe = .005$, $p < .05$.

At 7 days, noncognates were more discriminable than cognates, $F(1,17) = 17.36$, $MSe = .237$. The c-nc mirror followed a pattern similar to that of the immediate condition, although the false alarm rate failed to reach significance. However, now the r-k mirror disappeared because the hit side showed a reversed pattern. Noncognate hits were superior to cognates, $F(1,18) = 15.17$, $MSe = .013$, and the opposite was true for false alarms, $F(1,18) = 5.38$, $MSe = .006$, $p < .05$. However, the r-k pattern was reversed on the hit side, $F(1,18) = 10.334$, MSe = .015, but not for false alarms, $F(1,18) = 15.84$, $MSe = .007$.

TABLE 3
Repeated tests

Interval		Hits NC	Hits C	Hits Total	False alarms NC	False alarms C	False alarms Total
3 Days	Unpartitioned	0.85	0.66	0.76	0.10	0.20	0.15
	Remember	0.60	0.30	0.45	0.04	0.04	0.04
	Know	0.22	0.29	0.25	0.04	0.11	0.08
	Guess	0.03	0.07	0.05	0.02	0.04	0.03
	d′	2.31	1.44				
7 Days	Unpartitioned	0.76	0.58	0.67	0.25	0.33	0.29
	Remember	0.35	0.21	0.28	0.07	0.10	0.09
	Know	0.33	0.28	0.30	0.14	0.17	0.16
	Guess	0.08	0.09	0.09	0.04	0.06	0.05
	d′	1.37	0.70				

Mean proportions of remember and know responses to old and new test words as a function of linguistic status (noncognates, NC, and cognates, C), retention interval (3 days, 7 days) for repeated tests (3 and 7 days later). The values for discrimination indices are also shown by interval and repetition.

Repeated condition

The pattern of the repeated condition at 3 days was identical to that of the immediate test. Briefly, noncognates were significantly better discriminated, $F(1,24) = 45.235$, $MSe = .207$. The nc-c mirror was present: for hits, $F(1,24) = 23.72$, $MSe = .018$, and false alarms, $F(1,24) = 21.42$, $MSe = .003$, as was the r-k mirror: for hits, $F(1,24) = 7.72$, $MSe = .061$, and false alarms, $F(1,24) = 5.07$, $MSe = .005$, $p < .05$.

At 7 days, noncognates were more discriminable than cognates, $F(1,17) = 17.36$, $MSe = .237$. The c-nc mirror followed the same pattern as in the non-repeated condition described earlier: for d′, $F(1,17) = 17.36$, $MSe = .237$, and noncognate hits, $F(1,17) = 13.78$, $MSe = .015$, and false alarms, $F(1,17) = 1.54$, $MSe = .016$, *ns*; for r-k, hits, $F(1,17) < 1$, $MSe = .025$, *ns*, and false alarms, $F(1,17) = 4.026$, $MSe = .01$, $p = .061$.

As we indicated previously, the presence of the r-k mirror was verified by an analysis of variance on a variable with dependent levels. An alternative way of reaching the same conclusion is to analyse separately the effect of delay on hits or false alarms for remember and for know for all conditions (repeated and non-repeated). The analysis should show an effect on remember hits, $F(2,165) = 32.95$, $MSe = .032$, but not on know hits, $F(1,80) < 1$, $MSe = .027$, *ns*, and the usual pattern in false alarms for remember, $F(1,80) = 6.41$, $MSe = .004$, and for know, $F(2,165) = 22.99$, $MSe = .006$. There is an additional prediction that can be made from some of the two factor models (Reder et al., 2000, pp. 296–297); a superior know response level for both old and new responses because their level of familiarity is higher in both cases. In the present experiment, only on the immediate test did the prediction hold; for hits, $F(2,165) = 7.92$, $MSe = .014$, and for false alarms, $F(2,165) = 2.96$, $MSe = .005$, $p = .05$. This is consistent with the presence of the r-k mirror effect only at the immediate retention interval.

Conditional item analysis

Before doing a conditional item analysis, we assessed the effect of repetition with the hope that it would be as low as possible. We carried out a between-subject analysis of variance of interval

TABLE 4
Immediate and second tests

		Delayed test							
		3 Days				7 Days			
		R	K	M	G	R	K	M	G
		Cognates							
Immediate test	R	0.25	0.11	0.06	0.03	0.11	0.12	0.07	0.02
	K	0.04	0.14	0.08	0.02	0.08	0.12	0.12	0.04
	M	0.01	0.02	0.15	0.02	0.01	0.03	0.17	0.03
	G	0.01	0.01	0.02	0.02	0.01	0.01	0.03	0.03
		Noncognates							
	R	0.50	0.13	0.07	0.02	0.27	0.15	0.08	0.04
	K	0.09	0.07	0.02	0.01	0.07	0.06	0.06	0.03
	M	0.01	0.02	0.05	0.01	0.01	0.02	0.08	0.01
	G	0.01	0.01	0.00	0.00	0.00	0.01	0.02	0.01

Mean proportion of changes over the total number of responses in a session, among response states (M = miss, R = remember, K = know, G = guess) from the immediate test to the second test taking place at 3 or 7 days.

(3–7 days) and repetition condition (repeated-nonrepeated). Although there was an effect for retention interval that is of little interest here, we found a repetition effect for the hits proportions, $F(1,17) = 18.48$, $MSe = .026$, but not for false alarms, $F(1,80) = 1.25$, $MSe = .015$, *ns*. The interactions were not significant for hits, $F(1,80) < 1$, $MSe = .026$, or for false alarms, $F(1,80) = 1.65$, $MSe = .015$, *ns*.

Table 4 presents the fates of the different categories of responses from the immediate test to either 3 or 7 days.[1] The scores represent the proportions of items over the total number of responses (R+K+M+G) that begin in one state and stay in the same one or change to a different one.

The point that we want to make here is that the number of responses shifting from remember to know is greater than the number shifting from know to remember. The statistical analysis supports this statement, $F(1,44) = 8.81$, $MSe = .007$. Moreover, this result is independent of the starting level of r or k responses because, at the same time, the proportion of responses going from know or remember to misses is more or less equal, $F(1,44) < 1$, $MSe = .004$, *ns*. Finally, there is a marginally significant interaction, indicating that the proportion of changes is greater for noncognates than for cognates, $F(1,41) = 3.09$, $MSe = .01$, $p = .08$.

DISCUSSION

The current experiment shows a very clear mirror effect for the c-nc stimulus class for all retention intervals, together with a general trend towards a decrease in hits and an increase in false alarms over the delay period (concentring; Glanzer et al., 1993). However, the heuristic value of this observed mirror finds its place in the light of two other partitions made with the same data. If we take into account the cognate-noncognate division independently for remember and know, we see that there is no mirror for these two new slices of data for opposite reasons. Whereas the hit advantage for noncognates is present in the remember part, the false alarm advantage for

[1] As indicated in the introduction, Knowlton and Squire (1995, p. 706) originally carried out an item analysis with a similar purpose. However, we would like to point out a difference in the way they computed the state changes. They took as denominator of their calculated percentages changes, the number of responses in the original state (10-minute test condition). Their results, considered as final states R (remember), K (know), and M (miss), were: state changes from Remember: 35.9, 28.5, 35.8, respectively; from Know: 10.1, 28.1, 61.6, respectively; and from Miss: 4.7, 9.8, 85.5, respectively. Each of these series of changes adds up to 100%. In our case, the denominator is composed of all responses in a session (R+K+M+G), and the whole session adds up to a proportion of 1. We have adopted this measure because it fits our purposes better, and makes our proportions independent of the particular number of responses of the starting state. Otherwise, and besides the fact that our proportions are lower, the conclusions would be similar adopting either calculation procedure.

cognates is present in the know slice of the data. This dissociation of the data, according to the subjective response categorisation, is clear evidence in favour of the distinct weights of the recollection and familiarity processes and, on the other hand, of the validity in this context of the remember-know procedure.

The results are more valuable in light of the disappearance of the remember-know mirror at 3- and 7-day delays. The reason is very obvious, and it is easily observed in Table 1. It is the change in the balance between the remember and know proportions that is producing this dissociation. Whereas the predominance of remember responses in the noncognate class persists at all retention intervals, it reverses when one looks at the remember-know mirror. Presumably, and there is very strong evidence in its favour, it is the balance between recollection and familiarity that is producing this shift in the pattern of data. The final item analysis supports this view in line with the idea that item and context information are independent sources of information, at least within the present experimental conditions. Forgetting contextual information causes a remember response to become a know response. This is also the reason why sometimes (Gardiner & Java, 1991) forgetting may not seem to affect know responses. We think that part of the loss in know responses is compensated by previous remember responses that became know responses due to loss of contextual information. We hoped to have had a small or nonexistent repetition effect in order to observe an accurate estimation of the remember-to-know transfer, but this turned out to be unfounded. Therefore, there is an underestimation of the real r>k transfer, given that repetition affected only the remember hit rate.

Many previous authors have pointed out the difficulty or impossibility of completely rejecting a theory based on an isolated set of data. However, these results have a very natural interpretation based on the two-factor theories (Joordens & Hockley, 2000; Reder et al., 2000), which appeal to the interplay of recollection and familiarity as the underlying cause of the experimental evidence described in the literature and, particularly, of the dissociations implying the mirror effect.

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