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Fluency in Similarity Judgements

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Abstract

Similarity judgments have traditionally been assumed to arise from an alignment process that seeks correspondences between the objects and relations for two entities. Several recent studies have shown that thematic relationships between items (e.g. bowl and spoon) can influence people's assessments of similarity above and beyond the effect of feature match and mismatch. We suggest that thematic similarity responses can be accounted for in terms of perceived processing fluency. We propose and test a general framework for the role of fluency in similarity that is related to work by Jacoby and Whittlesea. In Study 1, participants assigned higher similarity ratings to word pairs previously encountered in a study list than to new pairs. In Study 2, participants assigned higher similarity ratings to word pairs that comprised familiar noun compounds (e.g. "garbage truck") than to corresponding reverse-ordered pairs ("truck garbage"). In Study 3, lower similarity ratings were observed for word pairs under low-contrast rather than normal viewing condition.

Components of Similarity Judgments

Similarity is arguably the most influential single construct in the history of cognitive science. It informs leading theories of concepts, reasoning and choice (e.g. Medin, Goldstone, & Gentner, 1993). One reason for the prevalence of similarity-based theories of cognition is similarity's explicit availability in a person's metacognitive experience. For example, undergraduate participants in inductive reasoning tasks often use similarity as a justification for inferences (Bailenson, Shum, Atran, Medin, & Coley, 2002).

The prevalence of similarity in cognitive theories raises important related questions about the nature of similarity judgments themselves. Proposals based on spatial representations (Shepard, 1957) and feature-matching (Tversky, 1977) provide computationally straight-forward accounts of judgments with relatively few assumptions. Recent advances in understanding the way relational information plays a role in similarity led theorists to view similarity judgments in terms of structural alignment (Markman, 1996). In this framework, the process of comparison involves the discovery of both relational and object-level commonalities.

Despite important differences between spatial, featural and structural approaches, all theories assume that a similarity judgment is based on an assessment of commonalities (and differences) between two concepts along a set of dimensions. That is, current theories postulate a single process bridging stimulus and judgment. It is, of course, possible that this *unitary* perspective is too narrow and judgments are informed by a set of processes, only one of which being the discovery of commonalities and differences.

More specifically, we believe that it is important to distinguish between comparison and judgments of similarity. Comparison of mental representations gives rise to the commonalities and differences for a set of objects. These commonalities and differences are combined into an assessment of similarity. A final judgment may be affected by a set of additional factors. These processes may come into play before, alongside or after the comparison (Markman & Gentner, 2005).

One important processing component that may affect similarity judgments is the *fluency* of processing a pair of concepts. Roughly speaking, fluency is the perceived ease of processing a pair of items. Obviously, a central factor that affects the feeling of fluency is the success of the comparison process itself. Comparison of a pair of similar items gives rise to a stronger feeling of fluency than does comparing a pair of very dissimilar (nonalignable) items. Here we focus primarily on fluency processes that are not related to alignment per se.

Another factor that may give rise to a feeling of fluent processing is the presence of an association between the concepts being compared. For example, a coffee cup and coffee are commonly found together but share relatively few features. Several studies have shown that such pairings receive higher similarity ratings than would be expected on the basis of matching attributes (Bassok & Medin, 1997; Wisniewski & Bassok, 1999). Interestingly, such *thematic associations* do not extend to generalizations. Gentner and Brem (1999) asked participants to extend a novel linguistic label (e.g. "dax") between a source and a target object. While participants gave high similarity ratings for thematically related concepts, they were unwilling to project the novel label between them. This finding is consistent with the hypothesis that associations and similarity contribute to similarity judgments but not to related cognitive activities, such as inductions.

A central aspect of our proposal is that the source processes that give rise to the feeling of fluency are not immediately available to consciousness. The implication of this assumption is that the feeling of fluency can sometimes be mistaken for structural similarity. For example, when presented with "cup" and "coffee", people will experience activation of the associative system but the source of this activation will not be immediately "known." A person's metacognitive system may thus erroneously attribute that activation to similarity, which would subsequently inflate ratings.

The idea that fluency can be used in cognitive processing is not entirely new. There is evidence in the memory literature demonstrating fluency effects in familiarity judgments. For example, Jacoby and colleagues (Jacoby, Woloshyn, & Kelley, 1989) showed that unfamiliar names that appeared on a study list were significantly more likely to be judged as famous than unfamiliar names that did not appear on the list. Participants may have expected greater ease of processing for famous names than for novel ones. Consequently, the fluency that arose due to a name's appearance on a study list was misattributed to the fluency arising from the name being famous (see Whittlesea & Williams, 2001 for a theory of recognition memory based on the same principle).

In this paper, we explore the generality of fluency effects on similarity judgments. In the first study, we increase the fluency for pairs of items by presenting them on an earlier study list. In the second study we test whether fluency can exert an influence in cases where concepts have a linguistic association but do not typically have any taxonomic of thematic relationships. For example, when judging the similarity of a pair such as "garbage" and "truck", will people be influenced by the fact that the two words frequently occur together in the form of a noun-noun compound "garbage truck"?

In our third study, we introduce a manipulation that lowers the ease of perceptual processing by lowering the contrast of the stimulus display. Making words harder to read presumably should not affect similarity judgments under the unitary view. Alternatively, the low-contrast display may reduce fluency, which, in turn, may lower the judged similarity of the items when compared to normal-contrast display.

Study 1: Fluency from Prior Exposure

In this experiment, we tested whether prior exposure to pairs of words increased their perceived similarity. Thirty-six University of Texas students rated the similarity of 32 pairs of words on a seven-point scale. The pairs were of medium similarity (e.g. "ROSE—PINE TREE"). About 30 minutes *before* the similarity task, participants were presented with a study list for a later memory test. The study list was constructed by randomly assigning pairs in the forthcoming similarity task to two possible study lists, each consisting of 16 pairs. Thus, each participant studied *either* list A or list B, and then rated pairs from both list A and list B.

The study portion of the experiment was presented on a computer. Participants were instructed that study words will be presented in pairs and that they can remember each word by forming its mental image. Participants were not told to associate the words, although the instructions did not preclude this strategy. After the study and the similarity-rating portions of the experiment, participants were given an intervening task, followed by a paper-and-pencil recall test.

Two analyses were of particular interest. First, we predicted that a pair of words would be rated as more similar if they appeared on a study list. Presumably, encoding the words for a later memory test increases their processing fluency when similarity is probed. This heightened fluency should then be misattributed to similarity.

A related question is about the relationship between the recall performance and the magnitude of the fluency effect. Would the fluency effect be stronger or weaker for pairs that were successfully recalled than for those that were not recalled? An intuitive answer might be that there is a positive relationship between the fluency effect and the strength of the memory trace. This view predicts that the stronger the memory, the more likely fluency is to be misattributed to similarity.

Whittlesea's theory is more nuanced, suggesting that once the source of the fluency has been established, it will be discounted. Thus, explicit awareness that words were presented in a study list may in fact get rid of the possible misattribution of fluency for similarity, because the increase in fluency has been (correctly) accounted for. This view predicts that fluency effects should be stronger for not-recalled pairs than for recalled ones.

Results and Discussion

In order to test for a fluency effect on similarity judgments, we computed the mean similarity for list A and list B items for each participant. We then subjected these means to a 2x2 ANOVA with List Source (A or B) as a within-subject factor and Study List (A or B) as a between-subject factor. There was no main effect of List Source, $F(1,34) = .006$, *n.s.*, indicating that pairs from the two lists were equally similar. There was also no main effect of study list, $F(1,34) = .001$, *n.s.*, suggesting that the particular list studied did not impact similarity ratings overall. Importantly, there was a reliable interaction between the list source and the study list, $F(1,34) = 12.82$, $p < .001$. Figure 1a shows the mean similarity ratings as a function of the words tested on (List A or List B) and the words studied (List A or List B). When tested on words from List A, participants who had previously seen words from that list gave higher similarity ratings than participants who saw list B. Analogously, when tested on words from list B, participants who were exposed to list B gave higher ratings than those who studied list A. We interpret this pattern as being consistent with an effect of processing fluency on similarity.

We also performed an analysis of recall data in order to test whether it was predictive of the magnitude of the fluency effect. As discussed above, the recall data can shed light on the extent to which explicit awareness of having studied the words would moderate the fluency effect. Specifically, we expect conscious awareness of having seen the words to allow participants to discount, or "explain away" the source of the additional fluency without it affecting similarity judgments. Consequently, the fluency effect should be stronger for words were not recalled than words that were recalled.

Each participant studied a total of 32 words. The mean recall performance was 15.4 words (48%). The mean number of words recalled for List A and List B did not differ reliably (M_A = 17.0; M_B = 14.2, $t(34) = 1.53$, *n.s.*). Each participant provided similarity ratings associated with a total of 64 words (i.e. 32 pairs). Each word in a similarity comparison received a similarity score derived from that comparison. For example, if a participant gave ROSE—PINE TREE a similarity of 4.0, then the word ROSE and PINE TREE would both be assigned a score of 4.0. For each participant, we computed the mean similarity score for words that were recalled, not recalled, or not seen on a study list at all. Figure 1b presents the mean similarity ratings as a function of whether the words were studied previously, studied without recall, or studied and successfully recalled. Overall, the studied words exhibited higher similarity ratings than those that were not studied. This is consistent with the previous analysis showing an overall effect of having seen a word pair previously. Importantly, this gain in perceived similarity is highest for words that were *not* recalled. The studied-not-recalled mean (3.59) is reliably higher than the studied-recalled mean (3.34), $t(63) = 2.30$, $p < .05$. The studied-not-recalled mean is also reliably higher than the not-studied mean (3.23), $t(63) = 5.12$, $p < .001$. It is also worth noting that the studied-recalled words were not reliably different in their similarity from the not-studied words, suggesting that the fluency effect only manifested itself for words that were not recalled.

This experiment provided direct evidence for the role of fluency in similarity judgments. One possible alternative explanation for the present finding is that presenting people with pairs of words at study allowed for deeper processing of these items, leading to discovery of a greater number of possible commonalities as compared with only seeing the pair during the similarity judgment. For example, while CLASS and GAME may not strike one as similar initially, deeper processing can suggest structural or analogical commonalities that may translate into higher similarity judgments (Goldstone & Medin, 1994). While this possibility is worth considering, it is not consistent with our second finding – that the similarity judgments were higher when the strength of explicit memory was weaker. Presumably, words that are easy to associate would appear more similar than those that are difficult to associate. At the same time, words that are successfully associated should also be more likely to be to be recalled. Contrary to our findings, this predicts a positive relationship between similarity and recall success. It is fair to say that we do not yet know whether the increase in fluency arose due to the

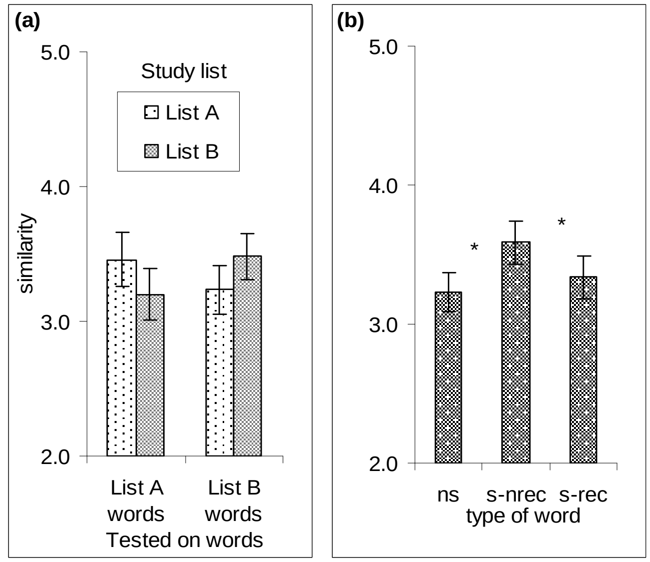

Figure 1: (a) Mean similarity for word pairs as a function of study list in Study 1; (b) Mean similarity (Study 1) as a function of recall performance: **ns** = not studied, **s-nrec** = studied but not recalled, **s-rec** = studied and recalled (* $p < .05$).

association of the words in a pair at study or from the memory activation of individual words in the pair. A study using only single words in the study phase is currently underway.

Study 2: Fluency from Noun Compounds

Like the previous experiment, this study also examined whether the ease of processing of a pair of concepts affects their judged similarity. We assumed that processing a pair that comprised a familiar noun-noun compound would be easier than processing pairs that did not form a familiar compound. In particular, we contrasted similarity judgments for compounds such as "garbage truck" and "chicken hawk" with their respective reversals (i.e. "truck garbage" and "hawk chicken"). If fluency of processing arising from the familiar association does not play a role in similarity judgments then we should not expect a difference in judged similarity between the target (forward) versions of the compounds and their reverse variants.

Method

Thirty undergraduates at the University of Texas at Austin participated for course credit. Participants rated the similarity of 40 familiar noun-noun compounds and their reverse-ordered counterparts. Some examples of the compounds are: beach/blanket, school/bus, trap/door and home /work[1]. On each trial, a participant was presented with two words positioned horizontally 60mm apart. We used a

[1] The complete set can be obtained at http://homepage.psy.utexas.edu/homepage/staff/Blok/nnstim.txt

seven-point rating scale anchored at 1 ("highly dissimilar") and 7 ("highly similar").

Results and Discussion

As expected, the forward versions of target item pairs received significantly higher mean similarity ratings than their reversed counterparts (M_{FWD} = 3.75; M_{REV} = 3.60; $t(39) = 3.00$, $p < .01$). We interpret this difference as evidence for the role of fluency in similarity judgments. Specifically, participants misattributed the greater ease of processing that comes with familiar compounds to featural similarity. This led them to give higher judgments to the compounds than to their reversed counterparts.

One may notice that the manipulation of word order is conceptually related to a number of earlier studies of symmetry in similarity judgment. For example, Tversky (1977) has shown that participants in the 1970's rated Cuba as more similar to China than China to Cuba (though see Aguilar & Medin, 1999). Tversky accounted for the asymmetries in terms of differences in prominence (salience) between the entities being compared. Low to high salience comparisons should generate higher similarity judgments than high to low comparisons. While "salience" in this context has never been sufficiently specified, we addressed this objection by analyzing frequency information for each word in the stimulus set (Francis & Kucera, 1982). Presumably, word frequency is related positively to conceptual saliency. Each pair was coded as a positive asymmetry difference if the frequency of the second word was higher than the frequency of the first. We should expect a positive relationship between a pair having a positive asymmetry difference and the size of the fluency effect. Results indicated that exactly ½ of our items predicted positive asymmetry, so no word frequency asymmetry bias existed in our stimuli.

Study 3: Fluency from Perceptual Processing

In the previous study, we showed that the feeling of fluency due to a familiar word association was attributed to perceived similarity. In other words, we were able to raise similarity judgments by raising fluency. In the current study, we lower fluency by decreasing the ease with which items are processed perceptually. Oppenheimer (2004) conducted a similar study with exemplar typicality judgments. He showed that exemplars presented in a smaller type font exhibited lower typicality judgments with respect to a super-ordinate category.

In the current experiment, we decreased fluency by lowering the contrast of the word-pair display. If perceptual fluency plays no role in similarity judgments, then we should not see a difference between normal and low-contrast items. If, on the other hand, perceptual fluency is misattributed to similarity, we should see lower similarity judgments for low-contarst than for normal items.

In addition to fluency, we manipulate the overall level of similarity for our items by varying the taxonomic relationship between the objects in the pairs (Rosch & et al., 1976). We examine categories that share a basic level (e.g. robin—sparrow), superordinate level (e.g. robin—wolf) and object-level matches (e.g. robin—shirt). The motivation behind manipulating similarity in this way is to examine the role that expectations about comparability may play in judgment. We assume that people will expect that pairs of objects at the basic level would be easier to compare than those at super-ordinate and object levels (E. Markman, 1986; Rosch et al. 1976).

What role do expectations about similarity play in judgments? One possibility is that expected comparability does not affect judgments. In this case, we should observe just a main effect of fluency, without interaction with item similarity. The difficulty due to a low-contrast display may simply subtract from the fluency across items leading to lower similarity judgments. A more sophisticated possibility is based on the logic of models by Jacoby and Whittlesea, discussed in the introduction. When presented with a pair of objects to compare, people will use the difference between expected and actual processing difficulty in their assessment of similarity. For items which are difficult to compare (i.e. those containing pairs from distant categories), there is an expectation of low fluency. Consequently, reducing fluency experimentally should not have an effect on judgments. By contrast, for items that are easy to compare (those that come from related categories), expected fluency should be high. In this case, artificially reducing fluency should lead to a lower perceived similarity. This predicts an interaction between the size of the fluency effect and the overall similarity of the items, such that the fluency effect should be larger for related items than for unrelated items.

Method

Twenty-four members of the University of Texas community were paid for participating. On each trial, a pair of words was presented followed by a similarity rating scale ranging between 0 ("not at all similar") and 1 ("virtually identical"). The participant moved the slider to indicate a two-digit decimal value. After selecting a value, the participant advanced the trial. The design consisted of all pairwise judgments for the set of objects in Table 1. The design generated 24 judgments at the basic level, 32 at the superordinate and 64 object-level matches. The direction of comparison was randomized for each item and participant. All trials were randomly ordered.

Table 1: Stimuli used in Study 3

Bluebird, Eagle, Tiger, Car, Airplane, Jacket, Sandal, Wolf, Robin, Lion, Fox, Motorcycle, Shirt, Shoe, Hawk, Helicopter

Each participant received the same 120 stimuli under normal and degraded viewing conditions. The degraded stimuli were generated by reducing the contrast of the words (but not the similarity scale). Participants reported that the resulting words were readable but with some effort.

Results and Discussion

We performed an analysis of the results by creating similarity bins from the data under normal viewing condition. We categorized a pair as having low, medium or high similarity if the mean judgment in the normal condition fell within the first, middle or upper thirds of the rating scale, respectively. We then plotted mean similarity ratings within these categories as a function of viewing condition (see Figure 2). The highest similarity level (.66 to 1.00) exhibited a strong effect of the contrast manipulation (M_{NORMAL} = .81; $M_{LOW\ CONTRAST}$ = .72, $t(23) = 3.80$, $p < .001$). The middle level (.33 to .66) showed a moderate effect (M_{NORMAL} = .53; $M_{LOW\ CONTRAST}$ = .49, $t(23) = 2.58$, $p < .05$) while the lowest level showed a slight reversal (M_{NORMAL} = .10; $M_{LOW\ CONTRAST}$ = .14, $t(23) = 3.55$, $p < .01$). It is worth noting that the numbers of observations in each bin were unequal, and we can only make comparisons with caution.

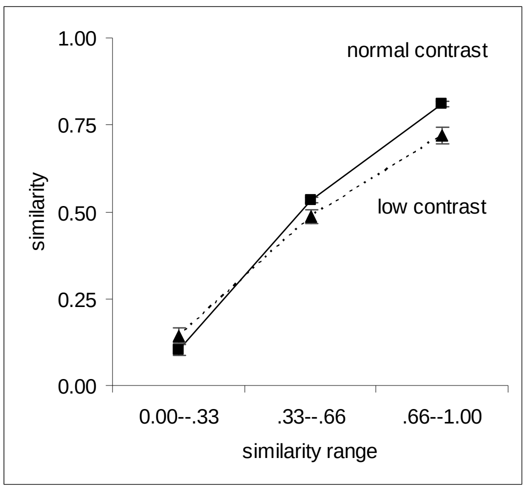

Figure 2: Similarity as a function of viewing condition. Error bars are standard errors.

We interpret this pattern of data as providing evidence for the role of fluency in similarity judgments, albeit under somewhat circumscribed conditions. The fact that the fluency effect occurred only for the most similar pairs is consistent with the aforementioned theory of the role of expectations in judgments.

One puzzling finding is the slight reversal of the effect for low-similarity matches. That is, items under LOW CONTRAST viewing actually exhibited somewhat higher similarity ratings than those under normal conditions. One possible explanation rooted in this observation is that the LOW CONTRAST condition led people to use the middle of the scale more than under normal condition. This propensity may have been caused by a lower level of task effort for LOW CONTRAST items. In order to address this hypothesis, we tabulated the number of responses in the .5 range (between .4 and .6) and found no differences as a function of viewing condition. The mean probability of a participant giving a response in the middle range of the scale was .29 under normal viewing and .30 under LOW CONTRAST reading (*n.s.*). It remains to be seen whether the reversal at the lower end of the similarity continuum is a reliable phenomenon.

General Discussion

We began this paper by suggesting that similarity judgments contain a mixture of component processes. Some are distinct from the processes that uncover structural commonalities and differences. Here we address whether ease of processing of a word pair affects its judged similarity. In the first study, we showed that perceived similarity for a pair of words can be elevated by presenting those words on an earlier study list. We interpret this finding in terms of perceived processing fluency – being on a study list raised the perceived fluency for processing the pair which was, in turn, erroneously attributed to similarity. Importantly, this fluency effect only held for pairs that were present on a study list but were NOT recalled successfully. This finding is consistent with the hypothesis that explicit awareness of having seen the words earlier allowed participants to discount the elevated processing fluency without it spilling over to similarity judgments. We note that this interpretation is entirely consistent with research on the role of perceived fluency in memory judgments (e.g. Jacoby and Whitehouse, 1989).

In our second and third studies, we manipulated fluency though linguistic association and ease of perceptual processing, respectively. We found that familiar noun-noun compounds were rated as being more similar when the association between the words was made salient. The findings from the study on perceptual fluency were mixed: while we discovered an effect of perceptual fluency on highly similar word pairs, low-similarity items revealed a pattern inconsistent with the predictions of the fluency view.

A central concept of our framework is *comparability*, or the immediate sense of whether two items are sufficiently similar to warrant further processing. This assessment of initial similarity is likely to occur early in processing, perhaps with the goal of allocating further cognitive resources. There is reason to believe that comparison involves local-to-global processing which begins with simple feature-matching and progresses to the application of structural consistency constraints (Falkenhainer, Forbus, & Gentner, 1989; Goldstone & Medin, 1994). For example, Goldstone and Medin (1994) found that structural consistency was more likely to be respected in judgments of similarity if the comparison was given sufficient time to be carried out. These studies are consistent with the idea that similarity judgments involve a “fast and frugal” early assessment which may be followed by a more in depth structural comparison (Markman & Gentner, 2005).

Another important concept in our theory is the metacognitive expectation of fluency. Perhaps the best illustration of this principle is provided by Whittlesea and Williams (2001). They investigated the role that fluency and familiarity played in a recognition task. These authors showed that people rarely relied on processing fluency of a familiar concept in their "old" judgments because there was already a high expectation of fluency. However, unfamiliar concepts that elicited a high level of fluency were deemed as having been stored in memory because fluency was unexpected and no alternative explanation for the fluency was easy to generate.

It is also worth noting that the feeling of fluency is a feeling, the source of which is rarely available to consciousness. In order to ascertain the source of the feeling, people need to engage in attribution processes (LeDoux, 1996). This attribution process can be mistaken, leading the decision maker to make metacognitive errors. In the classic study of such misattribution, Dutton and Aron's (1974) participants misattributed anxiety for sexual arousal while crossing a perilous bridge. Perhaps in the same fashion, our participants were misattributing fluency for similarity.

Finally, while our perspective accounts for some effects of thematic relatedness, we do not claim that any pattern of similarity responses not accounted for by a process of structural comparison reflects a mistake on the part of research participants. In fact, dissimilar entities often participate in causal scenarios, yielding potential for rich inductions between them (e.g. Medin, Ross, Atran, Burnett, & Blok, 2002).

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