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Author
Casasanto, Daniel

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Similarity and Proximity: When Does Close in Space Mean Close in Mind?

Daniel Casasanto
(djc@psych.stanford.edu)
Stanford University, Department of Psychology,
420 Jordan Hall, Stanford, CA 94305 USA

Abstract

People often describe things that are similar as *close* and things that are dissimilar as *far apart*. Does the way people talk about similarity reveal something fundamental about the way they conceptualize it? Three experiments tested the relationship between similarity and spatial proximity predicted by Conceptual Metaphor Theory (Lakoff & Johnson, 1980, 1999). In all experiments, similarity ratings for pairs of words or pictures varied as a function of how far apart stimuli appeared on the computer screen. However, the direction of influence differed depending on the type of judgments participants made. Stimuli presented closer together were rated more similar during 'conceptual' judgments of abstract entities or unseen object properties, but less similar during 'perceptual' judgments of visual appearance. These contrasting results underscore the importance of testing Conceptual Metaphor Theory experimentally, and suggest that our sense of similarity arises from our ability to combine available perceptual information with stored knowledge of experiential regularities.

Keywords: Similarity, Space, Metaphor.

Introduction

How do people judge the similarity of words, objects, or ideas? Despite concerns about its usefulness as a construct (Goodman, 1972), similarity remains the focus of much psychological research, perhaps because our sense of similarity seems intimately linked with our capacity to generalize, to form categories, and to individuate concepts (Medin, Goldstone, & Gentner, 1993). Traditionally, cognitive psychologists have pursued two types of computational models of similarity: metric models (e.g., Shepard, 1987), and set-theoretic models (e.g., Tversky, 1977). In metric models, similarity is represented as distance in a multidimensional mathematical space, which is thought to correspond to a 'psychological space'. In set-theoretic models such as Tversky's (1977) contrast model, the similarity of two items is a linear combination of measures of their common and distinctive features.

Metric models have been criticized, notably by Tversky (1977), for two reasons: (a) they are better at capturing similarity between stimuli that vary quantitatively along simple, continuous, perceptual dimensions (e.g., color, musical pitch) rather than similarity between complex objects or ideas which may differ qualitatively in terms of the presence or absence of features (cf., Shepard, 1987), and (b) empirical data show that fundamental assumptions of metric models (i.e., minimality, symmetry, triangle inequality) are violated for judgments about some abstract relations. Despite these limitations, metric models have been shown to generalize widely. They also have intuitive appeal, perhaps because the technical metaphor of 'similarity as distance' used by scientists resonates with highly conventionalized metaphors used in everyday language. In English (and many other languages), when speakers talk about similarity they often use words and expressions that describe spatial relations. Things that are similar along nearly any dimension can be described as *close*, and things that are dissimilar as *far*. For example:

a. These two shades of blue aren't identical, but they're *close*.
b. The opposing candidates' stances on the issue couldn't be *farther apart*.

Is it possible that the way people talk about similarity reveals something fundamental about the way they conceptualize it? According to Conceptual Metaphor Theory (Lakoff & Johnson, 1980, 1999), metaphors like SIMILARITY IS PROXIMITY are more than ways of talking; they are windows onto the structure of mental representations in abstract domains. Our notion of similarity is abstract, like our ideas of justice or love, insomuch as it is (a) vaguely and variably defined, (b) highly context dependent, and (c) mentalistic: lacking a concrete referent in the physical world that can be perceived through the senses. According to Conceptual Metaphor Theory, abstract domains that are typically described using spatial language are also conceptualized, in part, in terms of space. Although for decades, arguments for Conceptual Metaphor Theory depended primarily on linguistic data, recently behavioral data have corroborated the claim that spatial representations support our conceptualizations of number (Dehaene, Bossini, & Giraux, 1993; Fisher, 2003), time (Boroditsky, 2000, 2001; Casasanto & Boroditsky, 2003, in press; Casasanto, et al., 2004; Núñez & Sweetser, 2006; Torralbo, Santiago, & Lupiáñez, 2006), and other abstract concepts including affect, goodness, power, rank, and value (Casasanto & Lozano, 2006; in press; Meier & Robinson, 2004; Schubert, 2005).

The experiments reported here tested the hypothesis that our notion of similarity depends, in part, on mental representations of physical distance. In three experiments, participants rated the similarity of pairs of words or pictures, which were presented at varying distances on the computer screen (i.e., close, medium, or far apart). A simple prediction was made based on the distance metaphors for similarity that are used in metric psychological models of similarity and in everyday language: if people think about similarity the way they talk about it (i.e., similar things are *close*), then participants should judge stimuli to be more similar when they are presented close together on the screen than when they are presented far apart.

Experiment 1: Abstract Nouns

Experiment 1 tested whether participants would rate pairs of abstract nouns to be more similar in meaning when they appeared closer together on the screen. Abstract nouns (e.g., *Grief, Justice, Hope*) were chosen as stimuli for this first test of the relation between similarity and proximity because Conceptual Metaphor Theory posits that the meanings of abstract concepts (not *all* concepts) are structured metaphorically. Therefore, the predicted influence of space on similarity may be most evident for similarity judgments about abstract entities that cannot be perceived directly through the senses.

Methods

Participants 27 native English speaking participants from the Stanford University community performed this experiment, in exchange for payment.

Materials 72 abstract nouns (concreteness rating < 400) between 4 and 10 letters long were selected from the MRC Psycholinguistic Database. Nouns were randomly combined into 36 pairs (e.g., *Grief-Justice*, *Memory-Hope*, *Sympathy-Loyalty*). Words were presented on an iMac monitor (724 x 768 pixels resolution, 72 dpi) in 14 point courier font.

Procedure Participants viewed word pairs in randomized order, one word at a time, and rated their *similarity in meaning* on a scale of 1 (not at all similar) to 9 (very similar). Before the first word appeared, a pair of empty 'picture frames' (150 pixels wide, 50 pixels high) appeared on the vertical midline of the screen for 500 ms. The centers of the frames were separated horizontally by 150 pixels in the Close condition, 300 pixels in the Medium condition, and 450 pixels in the Far condition. Pairs of Close, Medium, and Far picture frames appeared in one of four positions on the far left, middle left, middle right, or far right of the screen. This variation in position was orthogonal to the variation in distance between words, and was intended to reduce demand characteristics of the task. After 500 ms, the first word in each pair appeared for 2000 ms in the leftmost picture frame, then disappeared. After a 500 ms inter-stimulus interval, the second word of the pair appeared in the rightmost picture frame for 2000 ms. The words of each pair were presented serially rather than simultaneously to rule out low-level explanations for any observed differences in similarity ratings across conditions due to differences in saccadic activity or sharing of visual attention. Participants saw each word pair once, and the assignment of word pairs to conditions was counterbalanced across subjects.

Results and Discussion

Results of Experiment 1 showed that stimuli were judged to be more similar when they were presented closer together than when they were farther apart (fig. 1). Z-scored similarity ratings were compared using one-way ANOVA. Ratings differed significantly across conditions, both by subjects ($F1(2,52) = 3.45$, $p<.04$) and by items ($F2(2,105) = 4.49$, $p<.02$). A one-tailed paired-samples t-test showed a difference between Close and Far trials when analyzed by subjects (difference = 0.28, $t(26) = 2.22$, $p<.02$ uncorrected, $p=.05$ after Bonferroni correction for multiple comparisons). A one-tailed independent-samples t-test confirmed this difference between Close and Far trials when analyzed by items (difference = 0.24, $t(36) = 2.74$, $p<.004$ uncorrected, $p=.01$ after Bonferroni correction).

The finding that stimuli were rated more similar when presented closer together is consistent with predictions based on Conceptual Metaphor Theory. One concern in interpreting these results was that some of the word pairs were judged to have very low similarity in all conditions, and that the influence of proximity may have been restricted to these pairs for which word meanings were difficult to compare. However, when data were mean-split, the same qualitative relationship between similarity and proximity was found for high-similarity and low-similarity pairs, analyzed separately.

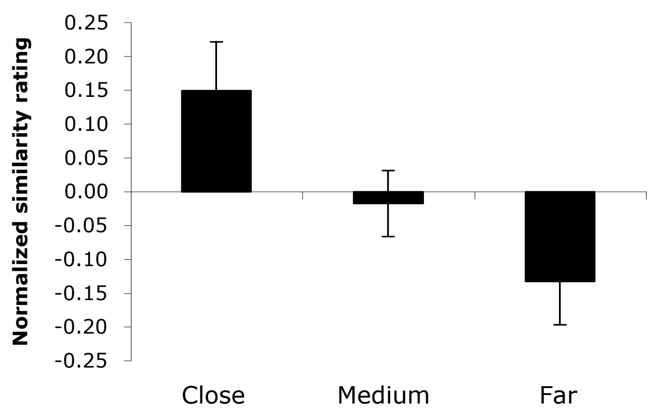

Figure 1. Similarity ratings for pairs of abstract nouns varied significantly as a function of their spatial separation on the screen, consistent with predictions based on Conceptual Metaphor Theory. Error bars indicate s.e.m.

Experiment 2: Unfamiliar Faces

Experiment 2 tested whether the results of Experiment 1 would generalize to a different type of stimulus for which similarity had to be computed along different dimensions. To judge the similarity of the abstract nouns pairs, participants had to retrieve word meanings from memory, and to reason about unseen properties of abstract entities.

Because the appearance of words is arbitrarily related to their meaning, the visual stimuli themselves provided little information (if any) that was relevant to the similarity judgment. Would distance still influence similarity judgments as in Experiment 1 even if more of the relevant information were given perceptually, in the visual stimuli, themselves? According to Conceptual Metaphor Theory, it should.

Although 'concrete' entities that can be perceived directly are *not* posited to be structured metaphorically (Lakoff & Johnson, 1999), people use the SIMILARITY IS PROXIMITY metaphor to describe similarity between both abstract and concrete things, alike: just as two abstract words can be said to be *close in meaning*, two lines can be *close in length*, two paint chips can be *close in color,* two shirts can be *close in size*, and two faces can be *close in appearance.* The relation between similarity and proximity in linguistic metaphors generalizes broadly (so broadly, in fact, that it is difficult to imagine a case in which similarity cannot be described in terms of distance). The same metaphor can describe similarity along both conceptual and perceptual dimensions. Therefore, if people conceptualize similarity the way they talk about it, the same prediction about the relation between similarity and proximity should hold for both conceptual judgments about abstract entities and perceptual judgments about concrete entities.

For Experiment 2, participants judged the similarity of pairs of unfamiliar faces. Whereas participants in Experiment 1 were instructed to judge similarity of abstract words based on their *meanings*, participants in Experiment 2 were instructed to judge similarity of faces based on their *visual appearance*.

Methods

Participants 33 native English speaking participants from the MIT community performed this experiment, in exchange for payment.

Materials and Procedure 60 pairs of unfamiliar faces were constructed from a database of University of Pennsylvania ID card photos. Half were male-male and half were female-female pairs. Faces pairs were presented exactly as word pairs were presented in Experiment 1, with the following exception: the height of the 'picture frames' was changed to accommodate the size of the photos (150 pixels wide by 200 pixels high).

Results and Discussion

Results of Experiment 2 showed that stimuli were judged to be more similar when they were presented *farther apart* than when they were presented closer together (fig. 2). Z-scored similarity ratings were compared using one-way ANOVA. Ratings differed significantly across conditions, both by subjects ($F1(2,64) = 3.61$, $p<.04$) and by items ($F2(2,177) = 3.29$, $p<.04$). A two-tailed paired-samples t-test showed a difference between Close and Far trials when analyzed by subjects (difference = 0.16, $t(32) = 2.90$, $p<.007$ uncorrected, $p=.02$ after Bonferroni correction). A two-tailed independent-samples t-test confirmed this difference between Close and Far trials when analyzed by items (difference = 0.12, $t(118) = 2.45$, $p<.02$ uncorrected, $p=.05$ after Bonferroni correction).

Whereas in Experiment 1 closer stimuli were judged to be more similar, in Experiment 2 closer stimuli were judged to be *less* similar. Thus, Experiment 2 results not only fail to show an influence of proximity on similarity in the direction that was predicted based on Conceptual Metaphor Theory (i.e. closer = more similar), they also show a highly significant effect of proximity on similarity judgments in the exact opposite direction.

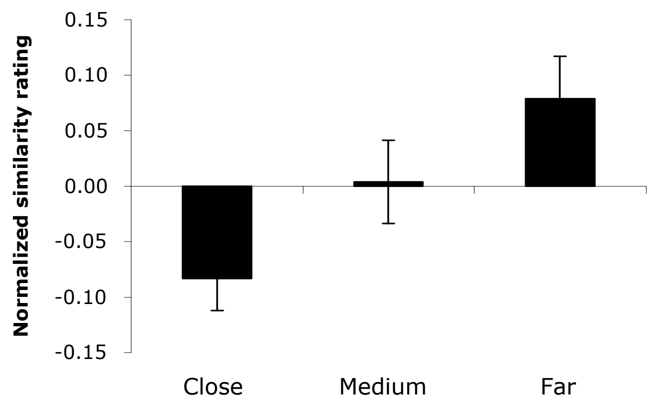

Figure 2. Similarity ratings for pairs of faces varied significantly as a function of their spatial separation on the screen, but contrary to predictions based on Conceptual Metaphor Theory. Error bars indicate s.e.m.

Experiment 3: Object Pictures

Why did proximity have opposite effects on similarity ratings for abstract nouns and unfamiliar faces? Experiments 1 and 2 differed both in the kind of stimulus participants judged (i.e., verbal vs. pictorial) and in the kind of judgments they made (i.e., 'conceptual' judgments based on meaning vs. 'perceptual' judgments based on visual appearance). Experiment 3 evaluated whether the results of Experiments 1 and 2 differed because of the type of stimulus or the type of judgment.

For Experiment 3, different judgments were made on the same set of stimulus pictures, which depicted common objects. Half of the participants were instructed to judge their similarity in visual appearance (a perceptual judgment), and the other half to judge their similarity in function or use (a conceptual judgment). If the difference between the results of Experiments 1 and 2 was due to a difference in the type of experimental materials used, then results of both Experiments 3a and 3b should resemble those of Experiment 2, in which pictorial stimuli were used: closer stimuli should be judged to be less similar, regardless of the type of judgment participants made. By contrast, if the difference between results of the first two experiments was due to participants judging abstract, unseen properties of the stimuli in Experiment 1 but judging concrete, perceptible properties of the stimuli in Experiment 2, then results of Experiment 3a (conceptual judgment) should be similar to those of Experiment 1 (i.e., closer stimuli should be judged more similar), whereas results of Experiment 3b (perceptual judgment) should be similar to those of Experiment 2 (i.e., closer stimuli should be judged less similar).

Methods

Participants 40 participants performed Experiment 3a and an additional 40 performed Experiment 3b, in exchange for payment. All were native English speakers from the MIT community.

Materials and Procedure 30 pairs of objects were constructed from the Snodgrass & van der Wart line drawings. Objects were paired only within semantic categories (e.g., tools, clothing, furniture) to facilitate meaningful comparisons. Object pairs were presented as in previous experiments, with the following exception: stimuli appeared at one of two distances on the screen (instead of three), to maximize the difference between the Close condition, in which the centers of pictures were separated by 150 pixels, and the Far condition in which the centers of pictures were separated by 600 pixels.

Results and Discussion

Results showed that during conceptual judgments (Experiment 3a), closer stimuli were judged to be more similar (Fig. 4, left). By contrast, during perceptual judgments (Experiment 3b), closer stimuli were judged to be less similar (Fig. 4, right). Similarity ratings were z-scored, and a mixed ANOVA with Distance (Close, Far) as a within-subjects factor and Judgment Type (Perceptual, Conceptual) as a between-subjects factor showed a significant 2-way interaction by subjects, ($F1(1,78) = 12.23$, $p<0.001$) with no main effects. This significant interaction was confirmed in 2-way ANOVA by items, with Distance (Close, Far) and Judgment Type (Perceptual, Conceptual) as between-subjects factors ($F2(1,116) = 12.12$, $p<0.001$), with no main effects.

Planned pair-wise comparisons tested the difference between Close and Far trials in Experiments 3a and 3b, by subjects and by items. Two-tailed paired samples t-tests showed that Close trials were rated significantly more similar than Far trials during conceptual judgments (Experiment 3a: difference = .10, $t(39) = 2.59$, $p<.02$ uncorrected, $p=.03$ after Bonferroni correction), whereas Close trials were rated significantly less similar than Far trials during perceptual judgments (Experiment 3b: difference = .09, $t(39) = 2.46$, $p<.02$ uncorrected, $p=.04$ after Bonferroni correction) when analyzed by subjects. Two-tailed independent-samples t-tests confirmed that this same pattern was found when data were analyzed by items: Close trials were rated significantly more similar than Far trials during conceptual judgments (Experiment 3a: difference = .10, $t(58) = 2.35$, $p<.03$ uncorrected, $p=.04$ after Bonferroni correction), whereas Close trials were rated significantly less similar than Far trials during perceptual judgments (Experiment 3b: difference = .10, $t(58) = 2.56$, $p<.02$ uncorrected, $p=.03$ after Bonferroni correction).

Results of Experiment 3 suggest that the contrasting effects of proximity on similarity judgments found for Experiments 1 and 2 were not due to superficial differences between the verbal and pictorial stimuli. Rather, the effect of proximity on similarity depends on the kind of judgment participants make: conceptual judgments about abstract entities or unseen object properties vs. perceptual judgments about visible stimulus properties.

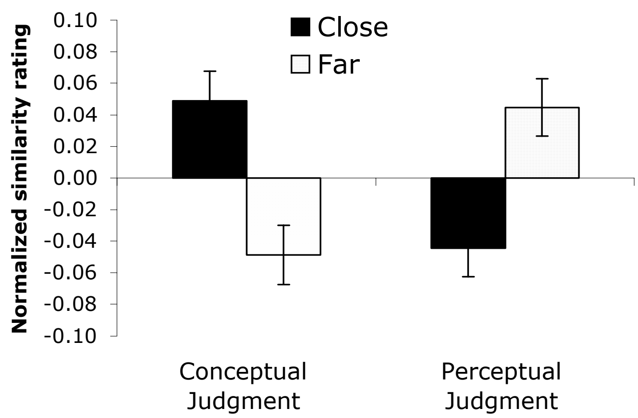

Figure 3. Results of Experiment 3a (left) and 3b (right). Similarity ratings for pairs of object pictures varied significantly as a function of their spatial separation on the screen. For the same set of stimuli, the relation between similarity and proximity was consistent with predictions based on Conceptual Metaphor Theory during Conceptual Judgments (Experiment 3a), but inconsistent during Perceptual Judgments (Experiment 3b). Bars indicate s.e.m.

General Discussion

Experiments 1-3 tested whether similarity ratings for words and pictures vary as a function of how far apart stimuli appear on a computer screen. Results showed that physical proximity influenced similarity judgments significantly in all experiments, but the direction of influence varied according to the type of judgment participants made. Closer stimuli were rated more similar during 'conceptual' judgments of abstract entities or unseen object properties (Experiments 1 and 3a), whereas closer stimuli were rated less similar during 'perceptual' judgments of the visual appearance of faces and objects (Experiments 2 and 3b).

Conceptual judgments followed the simplest prediction based on the SIMILARITY IS PROXIMITY metaphor (Lakoff & Johnson, 1980, 1999): when stimuli appeared closer in physical space they were judged to be 'closer' in participants' mental similarity space, as well. Perceptual judgments showed the opposite pattern, however, contrary to predictions based on linguistic metaphors for similarity.

Can these results be accommodated within a Conceptual Metaphor framework? The outcome of Experiments 1-3 is broadly consistent with the claim that abstract entities are mentally represented metaphorically, whereas concrete entities that can be perceived directly are represented non-metaphorically, on their own terms (Lakoff & Johnson, 1980, 1999). Still, Conceptual Metaphor Theory is hard-pressed to account for the difference between the effects of space on perceptual vs. conceptual judgments, given that the same spatial metaphors for similarity can be used to describe both low-level perceptual properties and high-level conceptual properties: similarities in appearance, function, or meaning can all be described using words like *close* and *far*. Thus, linguistic metaphors suggest that the same conceptual metaphor underlies our notions of both perceptual and conceptual similarity. Although Experiments 1 and 3a supported the metaphor-based prediction that stimuli presented closer in space would be judged to be more similar, Experiments 2 and 3b showed the opposite pattern of results. Overall these studies pose a challenge to Conceptual Metaphor Theory, and suggest that we cannot necessarily infer relations between similarity and proximity in people's nonlinguistic mental representations from patterns in metaphorical language.

Previous studies have also reported positive associations between proximity and *conceptual* similarity for both abstract and relatively concrete entities. Sweetser (1998) observed that speakers sometimes bring their hands closer together in space to indicate the similarity of abstract ideas via spontaneous co-speech gestures. Goldstone (1994) asked participants to arrange various tokens of the letter "A" on the computer screen such that more similar tokens were positioned closer in space. Importantly, although in principle similarity between tokens of the letter "A" could depend on perceptual properties of the stimuli, Goldstone noted that when participants were asked to indicate similarity via spatial proximity they focused on "abstract commonalities" between tokens (pg. 385). Whereas participants' non-spatial same/different judgments of the "A" stimuli were driven by perceptual similarity, instructing participants to arrange stimuli according to the rule that 'closer = more similar', led them to "tap into a level of similarity that is relatively cognitive rather than perceptual" (pg. 385). This complex relationship between spatial proximity, conceptual similarity, and perceptual similarity appears to have been unexpected in the Goldstone study, as it was in the present study.

Conceptual Metaphor Theory does not predict the pattern of data reported here, and it is possible that no current theory of similarity predicts it *a priori*. However, considering the computation of similarity to be a rational statistical inference based on regularities in our environment may help to situate the observed pattern of results in an ecological framework (Anderson, 1991; Shepard, 1987; Tenenbaum & Griffiths, 2001). As Gestalt psychologists observed, the world appears to be pervasively clumpy (Wertheimer, 1923/1939). Things that belong to the same category tend to be found close together, and also tend to be similar to one another compared with things that belong to different categories. Given that we are continually exposed to such organization, and that recognizing clumpiness may be useful for reasoning about our environment, it seems plausible that people implicitly learn and use a set of relations that could be called The Clumpiness Principle (building on Wertheimer's principles of proximity and similarity): Proximity α Similarity α Category Membership.

Tenenbaum & Griffiths (2001) proposed a Bayesian model according to which the similarity of two items is computed in terms of the probability that they are members of the same category (i.e., drawn from the same statistical distribution). In their model, the probability that items share category membership is proportional to the likelihood that they do given the information present in the stimuli, per se, and also proportional to the probability that they do given the observer's prior experience and stored knowledge. If we assume this generalization-based view of similarity, then in the present experiments participants' estimates of the probability that stimulus items belonged to the same category (and, therefore, of their similarity) depended in part on perceptible information given in the stimulus, and in part on their implicit knowledge of the Clumpiness Principle. In the case of *conceptual* similarity judgments, little relevant perceptual information was available in the stimulus items, so participants' heuristic use of the Clumpiness Principle was evident: greater proximity was used as an index of more probable shared category membership and of greater similarity. In the case of the *perceptual* similarity judgments, however, participants' estimates of the probability that stimulus items belonged to the same category were likely to depend more strongly on the perceptible information given in the stimuli, themselves, which overwhelmed any influence of the Clumpiness Principle.

On this proposal, when perceptible information was available in the stimuli (and was relevant to the task), participants used it. Participants may have judged closer stimuli to be *less* similar in Experiments 2 and 3b because proximity facilitates noticing small differences during perceptual judgments that might go unnoticed for stimuli presented farther apart[1]. By contrast, when perceptual information wasn't available in the stimuli (in Experiment 1) or wasn't relevant to the required judgment (in Experiment 3a), then participants' judgments reflected their heuristic use of the knowledge that proximity correlates with category membership and with similarity.

Thus, it may be possible to account for the contrasting effects of proximity on conceptual and perceptual similarity

[1] Since all stimuli were presented serially, this explanation requires that proximity facilitates noticing small differences even when members of a pair are never seen simultaneously. Although further research is needed to test this assumption, this seems plausible given evidence that the location of stimuli is automatically indexed in memory and accessed during retrieval, even when this spatial information is task-irrelevant (Richardson & Spivey, 2000).

judgments if the computation of similarity is considered to be a process of rational inference that optimally combines perceptible information at hand with stored knowledge of experiential regularities (Anderson, 1991; Shepard, 1987; Tenenbaum & Griffiths, 2001).

Conclusions

Three experiments showed that similarity ratings for pairs of words and pictures were affected systematically by their spatial separation on the computer screen. Our judgment of similarity appears to depend, in part, on our experience of spatial proximity, but not always as predicted by spatial metaphors in language. When participants made conceptual judgments about abstract entities or unseen object properties, stimuli presented closer together were judged to be more similar than stimuli presented farther apart, consistent with predictions based on Conceptual Metaphor Theory. By contrast, when participants made perceptual judgments about visible stimulus properties, stimuli presented closer together were judged to be less similar than stimuli presented farther apart, contrary to predictions based on linguistic metaphors.

These findings underscore the importance of testing Conceptual Metaphor Theory experimentally, and suggest that it is not possible to infer the relationship between similarity and proximity in people's nonlinguistic mental representations based solely on patterns in metaphorical language. Results encourage further exploration of how spatial proximity influences similarity judgments, and more generally, of how people integrate available perceptual information with their implicit knowledge of experiential regularities during similarity judgments.

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References

Anderson, J. (1991). The adaptive nature of human categorization. *Psychological Review*, 98(3), 409-429.

Boroditsky, L. (2000). Metaphoric structuring: understanding time through spatial metaphors. *Cognition*, 75(1), 1-28.

Boroditsky, L. (2001). Does language shape thought? Mandarin and English speakers' conceptions of time. *Cognitive Psychology*, 43(1), 1-22.

Casasanto, D., & Boroditsky, L. (2003). Do we think about time in terms of space? in *Proceedings of the 25th Annual Conference of the Cognitive Science Society*, Boston.

Casasanto, D., Boroditsky, L., Phillips, W., Greene, J., Goswami, S., Bocanegra-Thiel, S., et al. (2004). How deep are effects of language on thought? Time estimation in speakers of English, Indonesian, Greek, and Spanish. in *Proceedings of the 26th Annual Conference of the Cognitive Science Society*, Chicago.

Casasanto, D., & Boroditsky, L. (In Press). Time in the mind: Using space to think about time. *Cognition*.

Casasanto, D., & Lozano, S. (2006). Metaphor in the mind and hands. in *Proceedings of the 28th Annual Conference of the Cognitive Science Society*, Vancouver, BC.

Dehaene, S., Bossini, S., & Giraux, P. (1993). The mental representation of pairity and number magnitude. *Journal of Experimental Psychology: General*, 122(3), 371-396.

Fischer, M. (2003). Cognitive representation of negative numbers. *Psychological Science*, 14(3), 278-282.

Goldstone, R. (1994). An efficient method for obtaining similarity data. *Behavior Research Methods, Instruments, & Computers*, 26(4), 381-386.

Goodman, N. (1972). Seven strictures on similarity. In N. Goodman (Ed.), *Problems and Projects* (pp. 437-447). New York: Bobbs-Merrill.

Lakoff, G., & Johnson, M. (1980). The metaphorical structure of the human conceptual system. *Cognitive Science*, 4, 195-208 .

Lakoff, G., & Johnson, M. (1999). *Philosophy in the flesh: The embodied mind and its challenge to Western thought*. Chicago: University of Chicago Press.

Medin, D., Goldstone, R., & Gentner, D. (1993). Respects for similarity. *Psychological Review*, 100(2), 254-278.

Meier, B., & Robinson, M. (2004). Why the sunny side is up: Associations between affect and vertical position. *Psychological Science*, 15(4), 243-247

Núñez, R., & Sweetser, E. (2006). Looking ahead to the past: Convergent evidence from Aymara language and gesture in the crosslinguistic comparison of spatial construals of time. *Cognitive Science*, 30(3), 401-450.

Richardson, D., & Spivey, M. (2000). Representation, space, and Hollywood Squares: Looking at things that aren't there anymore. *Cognition*, 76, 269-295.

Schubert, T. (2005). Your highness: Vertical positions as perceptual symbols of power. *Journal of Personality and Social Psychology*, 89(1), 1-21.

Shepard, R. (1987). Toward a universal law of generalization in psychological science. *Science*, 237(4820), 1317-1323.

Sweetser, E. (1998). Regular metaphoricity in gesture: Bodily-based models of speech interaction. *Paper presented at the 16e Congrès International des Linguistes*.

Tenenbaum, J., & Griffiths, T. (2001). Generalization, similarity, and Bayesian inference. *Behavioral and Brain Sciences*, 24, 629-640.

Torralbo, A., Santiago, J., & Lupiáñez, J. (2006). Flexible conceptual projection of time onto spatial frames of reference. *Cognitive Science*, 30(4), 745-757.

Tversky, A. (1977). Features of Similarity. *Psychological Review*, 84(4), 327-352.

Wertheimer, M. (1923/1938). Laws of Organization in Perceptual Forms. In W. Ellis (Ed.), *A source book of Gestalt psychology*. London: Routledge & Kegan Paul.