
Rediscovering Symbols: The Role of Category Labels in Similarity Judgment*

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Traditionally, category labels were treated as indices pointing to the content of categories, and the role of category labels in similarity judgment has been deemed secondary. This study focused on the symbolic property associated with category labels and investigated why category labels influence similarity judgment. In two experiments, the authors employed morphed pictures of animal tissues and contrasted the effect of indexical labels and symbolic labels on similarity judgments. The results from the experiments suggest that the influence of category labels on similarity judgment partly comes from their *symbolic properties*. Category labels evoke background knowledge and highlight interconnections with other labels. This symbolic property plays a critical role in the influence of category labels on similarity judgment.

Keywords: Labeling, Stimulus similarity, Visual discrimination, Concepts, Choice behavior

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Traditional assumptions in similarity research are that concepts are

Journal of Cognitive Science 9: 89 - 109, 2008.

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* Acknowledgements: The authors would like to thank the anonymous reviewers for their insightful comments and helpful suggestions.

The author would like to thank Wookyoung Jung and Chaitra Rao for helpful comments. Please address all correspondence to Na-Yung Yu, Department of Psychology, Mail Stop 4235, Texas A&M University, College Station, TX 77843 or by e-mail nayungyu@gmail.com. The data described in the two experiments will be also reported in the Proceedings of 30th Annual Meetings of the Cognitive Science Society.

represented by a collection of attributes, and that the perceived similarity between concepts depends on the number of matching and mismatching attributes (Tversky, 1977). Although this attribute-based explanation can sometimes be useful, a growing number of studies have demonstrated that category information affects many aspects of inductive generalization (Gauthier, James, Curby, & Tarr, 2003; Huttenlocher, Hedges, & Vevea, 2000; Kay & Kempton, 1984; Walton & Banaji, 2004; Waxman & Braun, 2005; Yamauchi, 2005; Yamauchi, Kohn, & Yu, 2007; Yamauchi & Markman, 2000; Yamauchi & Yu, 2008). A particular concern addressed in this paper is the role that category labels play in the judgment of similarity. Many studies that explored this issue have suggested that the role of a category label depends on the contents to which the label points (e.g., Murphy & Medin, 1985; Pothos, 2005; Sloutsky & Fisher, 2004). For example, category labels are meaningful because they lead to representative descriptions of people, animals, objects, or events (e.g., Medin & Atran, 2004; Osherson, Smith, Wilkie, López, & Shafir, 1990). Thus, the impact of category labels on similarity judgment comes from what category labels represent, not from the labels themselves. Here, we propose an additional possibility: Category labels influence similarity judgment because of their *symbolic properties*.

We first review existing research examining the role of category labels in similarity judgment and then give a brief description of our symbol hypothesis, which provides an additional constraint on similarity judgment.

Previous Research: Index vs. Symbol

Traditional models of inductive judgment generally assume that categorical concepts, such as *tables*, *vegetables*, or *dogs*, consist of concrete exemplars, lists of features that category members have, and/or an abstract summary of these entities. For example, a category is represented by multidimensional distances between members of a category (Nosofsky, 1986; Posner, Goldsmith, & Welton, 1967), the distances between category members and their prototype (Minda & Smith, 2002), or a collection of attributes of category members (Osherson, et al., 1990; Tversky, 1977). Although these theories differ in specifics, they all agree that a categorical concept consists of characteristics shared by its members, and that category labels can be treated just like other features (Anderson, 1990).

The idea that category labels work like other features may be plausible for young children (Sloutsky & Fisher, 2004). However, this idea appears inadequate for adults, who have a more complex and integrated knowledge base. According to Peirce (1932, 1955; see also Markman, 1999), a category label not only points to specific entities but also clarifies the inter-relationship among concepts (Figure 1a). For example, we understand the label *bear* not only with respect to exemplars of bears but also in relation to other labels: *bears* are carnivorous like *dogs* and *foxes*, and *foxes* have brown fur like *bears*, but bears are different from *dogs* or *foxes* in size, and so on. In this example, one label (e.g., *bear*) exists relative to other labels (e.g., *dog* and *fox*), and the other labels (e.g., *fox* and *dog*) also exist relative to the first label (e.g., *bear*). According to Deacon (1997), this circular relationship makes a label a symbol (see also Bruner, Olver, & Greenfield, 1966, for a similar definition of symbols).

In contrast to *symbolic labels*, *indexical labels* do not have recursive relationships with other labels, but merely point to entities (Figures 1b and 1c). For example, *Bob* is an indexical label because it denotes a specific person, and *Bob* as a label does not specify, for example, *Jane* as a label (Figures 1b and 1c). Category labels (e.g., *bear*) work like symbols when they exist both with respect to the entities to which they point (e.g., individual instances or the category of bears) and with respect to other symbolic labels (e.g., *dog* and *fox*).

We think that symbolic labels facilitate comparisons between concepts and accentuate commonalities and differences among related concepts (Clark, 1983; Gentner & Goldin-Meadow, 2003; Markman & Gentner, 1993a; Markman & Wisniewski, 1997; Piaget, 1952). For example, symbolic labels invite alignment between concepts and generate an awareness of their similarities as well as differences. Markman and Wisniewski (1997) showed that when items from the same superordinate category were presented (e.g., a desk and a table), participants were able to list many similarities as well as differences of the two concepts. However, when two unrelated items were presented (e.g., a desk and an elephant), the similarities and differences between the two concepts were not obvious. In this manner, we think that the symbolic property of category labels can enhance similarity when items have the same label and accentuates differences when items have different labels.

To test this idea, we employed a triad task (see Gelman & Markman, 1986;

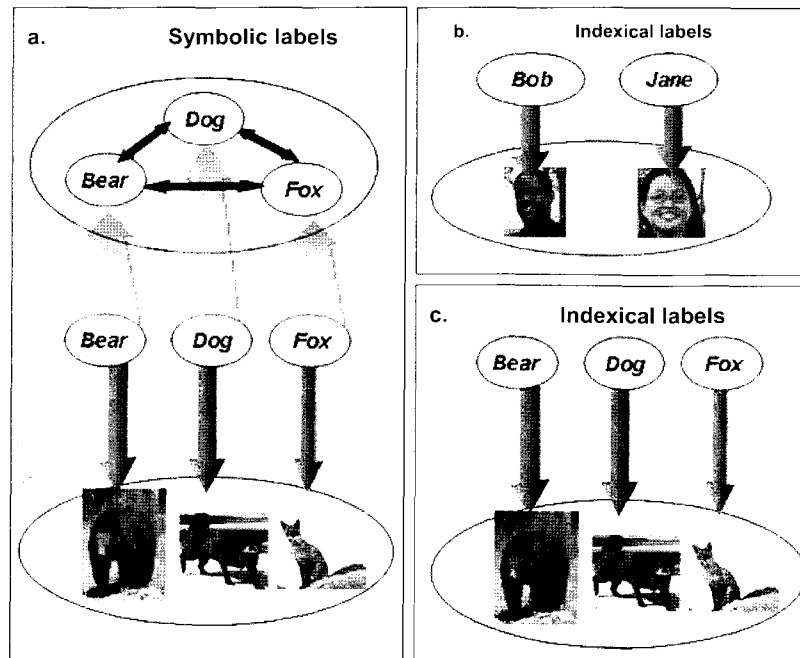


Figure 1. Illustrations of indexical labels and symbolic labels. Unidirectional arrows represent that the indexical labels such as Bob and Jane indicate particular people (b), and that indexical labels such as bear, fox, and dog indicate specific examples of bears, foxes, and dogs (c). The labels such as bear, fox, and dog are also symbolic labels: bidirectional arrows represent that the labels are characterized with respect to each other (a).

Sloutsky & Fisher, 2004 for a similar task). Participants were presented with three pictures of animal tissues: a target placed at the top and two base pictures placed at the bottom (Figure 2) and judged which base picture, left or right, was more similar to the target. In each stimulus frame, one base picture was more similar to the target than the other base picture (Figure 2a; later the more similar base picture is called “Bsim”; the less similar — thus more dissimilar — base picture is called “Bdis”). We measured the proportion of participants selecting the dissimilar base picture (Bdis) in three separate conditions: (a) pictures carried no labels (Figure 2a), (b) the target and the dissimilar base

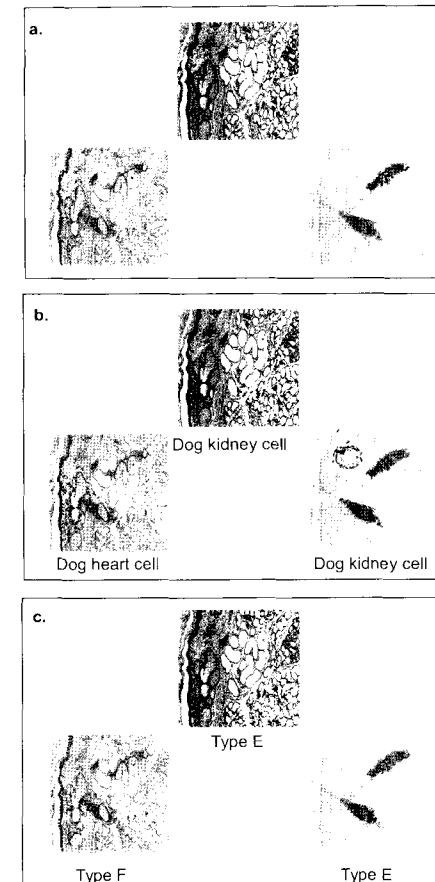


Figure 2. Sample stimuli in Experiment 1. In the no-label condition (a), pictures were shown without labels. In the cell-label condition (b), the same pictures were presented with fictitious cell labels such as dog kidney cell and dog heart cell. In the alphabet-label condition (c), pictures were presented with labels such as type E and type F. In Figure 2b and 2c, Bdis was shown with the same label as the target while Bsim was presented with a different label from the target.

picture (Bdis; the base picture placed at the right bottom in Figures 2b and 2c) had the same label, and (c) the target and the dissimilar base picture (Bdis) had different labels.

Hypothesis and predictions

Our hypothesis is that part of the influence of category labels on similarity judgment comes from their “symbolic property.” A category label is understood relative to other labels, and this creates a complex interwoven system of knowledge, which in turn affects similarity judgment. To test this hypothesis, two experiments were conducted using descriptive labels as a means of illustrating feature interrelatedness in a similarity judgment task.

Figures 2a-c show different category labels. The three pictures were presented without labels in Figure 2a. The same pictures were presented with symbolic labels in Figure 2b (“dog kidney cell” and “dog heart cell”) and indexical labels in Figure 2c (e.g., “type E” and “type F”). The alphabetical labels point to individual pictures, but they do not have conceptual associations with other labels. That is, these labels are indices pointing to specific pictures (Figure 2c). Although participants may be uncertain what exactly a dog kidney cell or a dog heart cell is, these fictitious labels could be interpreted in relation to other known concepts, such as dog, cat, kidney, or heart. For example, participants expect dog heart cells would be related to other well-known concepts such as dogs, hearts, and cells, thus symbolic labels help participants to understand the novel concepts better than indices such as type E or type F. We hypothesized that the impact of labels is particularly strong in the cell label condition (i.e., symbolic labels) than in the alphabetical label condition (i.e., indexical labels).

To test this hypothesis, we developed one between-subjects factor with 5 levels (Label Condition; no-label, different cell-label, same cell-label, different alphabet-label, same alphabet-label conditions). Pictures were presented without labels in the no-label condition (Figure 2a). In the different cell-label and same cell-label conditions, pictures carried fictitious names of animal cells, such as dog heart cell, dog kidney cell, etc. (Figure 2b). In the different alphabet-label and same alphabet-label conditions, pictures carried meaningless labels such as type E, type F, etc. (Figure 2c). These conditions differed in terms of whether the dissimilar base picture (Bdis) had the same or a different label than the target. In the same cell-label and same alphabet-label conditions, Bdis had the same label as the target (Figures 2b and 2c). In the different cell-label and different alphabet-label conditions, the attached labels were swapped, so that Bdis had a different label from the target. These

manipulations were implemented solely in the labels. All participants examined identical stimuli, except for the labels attached to each picture.

We predicted that these symbolic labels — dog kidney cell and dog heart cell — should influence similarity judgment (Figure 2b), but alphabetical labels — type E and type F — should not (Figure 2c). That is, the proportion of participants selecting dissimilar base pictures (Bdis) should go up or down when the target and the designated base pictures have the same label or different labels. This should happen primarily in the cell-label conditions, but not in the alphabet-label conditions.

Method

Participants. Two hundred twenty-seven undergraduate students participated in Experiment 1 for course credit. They were randomly assigned to one of five conditions: no-label ($n = 48$), same cell-label ($n = 48$), different cell-label ($n = 43$), same alphabet-label ($n = 47$), and different alphabet-label ($n = 41$) conditions.

Materials. Stimuli were triads of monochrome pictures (Figure 3). The target was an original picture of animal tissues, and the two base pictures (Bsim and Bdis) were of morphed images of two original pictures. Five pairs of original cell pictures were selected from a well-known textbook of veterinary histology (Bacha & Bacha, 2000). From these 10 pictures, five pairs were created. For each pair, one original tissue picture was merged with the other original picture to different degrees using MorphMan 4.0 (2003) software. Altogether, 90 morphed pictures were created from the five pairs of original pictures (18 morphed pictures from each pair).

From the 90 morphed pictures, two base pictures were selected, controlling for the physical difference between stimuli. Specifically, we developed three levels of physical difference — low-, medium-, and high-difference conditions — based on the degree of merging of the two original pictures (Figure 3). In the low-difference condition, the two base pictures were not very different (Figure 3a); in the medium-difference condition, the two base pictures were moderately different (Figure 3b); and in the high-difference condition, the two base pictures were highly different (Figure 3c). Two sets of base pictures were randomly selected at each level of physical difference and were combined with two original pictures in each pair, yielding 12 triads for each pair (a total of 60

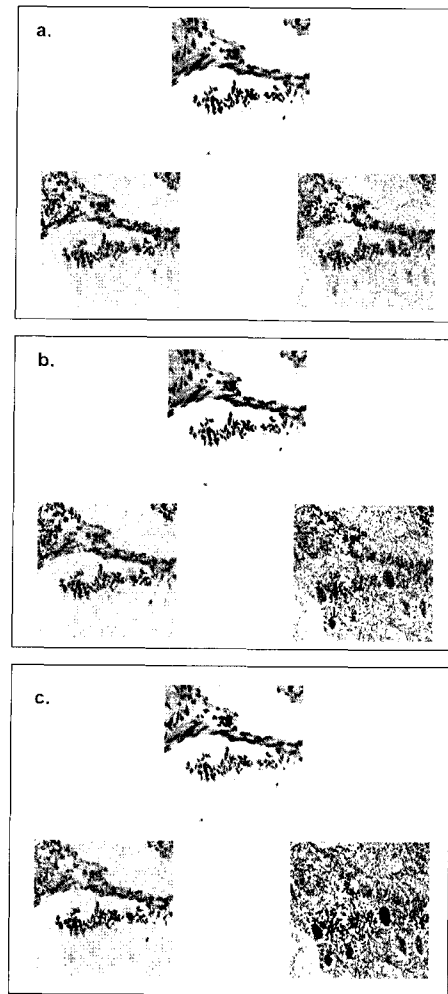


Figure 3. Three levels of physical difference. The two base pictures were very similar in the low-difference condition (a), moderately similar in the medium-difference condition (b), and very dissimilar in the high-difference condition (c).

triads = 5 animal pairs \times 12 triads).

Design. The experiment had a 5 (Label Condition: no-label, different cell-label, same cell-label, different alphabet-label, same alphabet-label conditions;

between-subjects) \times 3 (Physical Difference: low-difference, medium-difference, high-difference; within-subjects) factorial design. The dependent measure was the proportion of participants selecting dissimilar base pictures (Bdis) as more similar to the target than the other base pictures (Bsim).

Procedure. Participants were presented with 60 triads of pictures one at a time and judged which base picture was more similar to the target using left or right arrow key. The order of presenting stimuli was determined randomly, where Bdis was presented on the left or the right side an equal number of times. The entire experiment took approximately 15 minutes.

Results

Figure 4 summarizes the main results from Experiment 1. As predicted, cell labels influenced similarity judgment when the target and base pictures had the same label as well as when they had different labels. In contrast, the effect of alphabet labels was statistically negligible. Because participants in all label conditions were presented with identical triads of pictures, the differences between cell-label and alphabet-label conditions must have stemmed from the types of labels. We think that interrelatedness that cell labels highlighted was responsible for this disparity.

Cell labels vs. no labels. As predicted, when the labels were described with fictitious cell labels (e.g., dog kidney cell), similarity judgment changed considerably (Figure 4a), $F(2, 136) = 16.46$, $MSE = .07$, $p < .001$, $\eta^2 = .20$. The proportion of participants selecting the dissimilar base pictures (Bdis) was higher in the same cell-label condition ($M = .31$) than in the no-label condition ($M = .17$), $t(94) = 3.54$, $SE = .04$, $p = .001$, $d = .72$. In contrast, the proportion of participants selecting Bdis was lower in the different cell-label condition ($M = .12$) than in the no-label condition, $t(89) = 2.87$, $SE = .02$, $p = .005$, $d = .60$.

The interaction of label condition and physical difference was also significant; $F(4, 272) = 3.25$, $MSE = .01$, $p = .01$, $\eta^2 = .05$. Having the same label as the target elevated the proportion of participants selecting Bdis at all levels of physical difference compared with the no-label condition: low-difference, $t(94) = 3.76$, $SE = .04$, $p < .001$, $d = .77$; medium-difference, $t(94) = 3.06$, $SE = .04$, $p = .003$, $d = .62$; high-difference, $t(94) = 2.82$, $SE = .04$, $p = .006$, $d = .58$.

Having different labels depressed the proportion of participants selecting

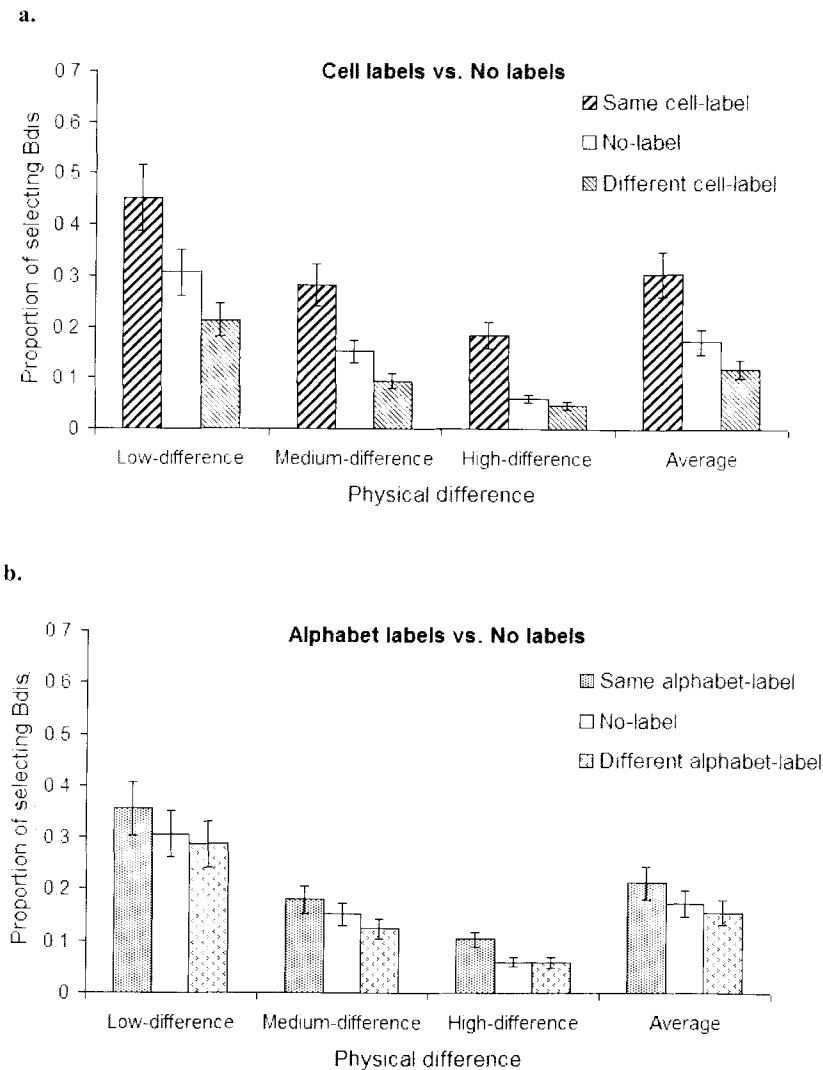


Figure 4. Mean proportions of participants selecting Bdis (i.e., the dissimilar base pictures) over Bsim in Experiment 1. The mean proportions were shown separately for the same cell-label, no-label, and different cell-label conditions (a), and for the same alphabet-label, no-label and different alphabet-label conditions (b). The error bars represent two standard error units calculated from each condition.

Bdis in the low and medium levels of physical difference: low-difference, $t(89) = 3.59$, $SE = .03$, $p = .001$, $d = .75$; medium-difference, $t(89) = 2.18$, $SE = .03$, $p = .03$, $d = .46$. The difference between the two conditions was not significant in the high-difference condition, $t(89) = .76$, $SE = .02$, $p = .45$, $d = .16$. The lack of significance in the high-difference condition was partly due to a floor effect. The mean proportion of participants selecting Bdis was already too low in the no-label condition ($M = .06$) to have any impact of different symbolic labels.

Alphabet labels vs. no labels. In contrast to the cell-label conditions, the influence of the alphabet labels were statistically negligible, $F(2, 133) = 2.11$, $MSE = .04$, $p = .13$, $\eta^2 = .03$ (Figure 4b). The effect of alphabet labels was not significant regardless of whether the base picture and the target had the same label, $t(93) = 1.23$, $SE = .03$, $p = .22$, $d = .25$; or different labels, $t(87) = .93$, $SE = .02$, $p = .36$, $d = .20$. The impact of indexical labels was not significant in any of the physical difference conditions (all $ps > .1$; Figure 4b).

Cell labels vs. alphabet labels. The cell-label conditions were also significantly different from the alphabet-label conditions, $F(3, 175) = 11.94$, $MSE = .08$, $p < .001$, $\eta^2 = .17$. The proportion of participants selecting Bdis was significantly higher in the same cell-label condition than in the same alphabet-label condition, $t(93) = 2.47$, $SE = .04$, $p = .02$, $d = .51$. In contrast, the proportion of participants selecting Bdis in the different cell-label condition was significantly lower than that in the different alphabet-label condition, $t(82) = 2.06$, $SE = .02$, $p = .04$, $d = .45$.

Taken together, these results suggest that category labels influence similarity judgment partly because the labels are symbols. Cell labels influenced similarity judgment, whereas the influence of the alphabet labels was statistically negligible. Experiment 2 tested the generality of this contention. If our symbol hypothesis is valid, then a similar result should emerge for other labels, which carry symbol-like or index-like properties.

Experiment 2

The stimuli employed in Experiment 2 were identical to those used in Experiment 1 (Figure 2a). However, we modified what the labels represented. In one condition, the labels were associated with names of diseases. In the

other condition, the labels were associated with names of painters who painted these pictures. In both cases, the names of labels were unfamiliar to participants (e.g., *Gotorrhea* or *Scrakies* for names of diseases and *Goyama* or *Dalica* for names of painters) but they were different in terms of how the labels could be interpreted. Given disease labels, for example, the labels can be understood with respect to other diseases such as cholera, influenza, or cancer. Given painter labels, the labels can be understood with respect to specific pictures shown in each stimulus frame, but interpreting these labels with respect to other abstract painters should be difficult for our undergraduate participants, unless they had in-depth knowledge about art history. As a result, we predict that the impact of labels will be stronger in the disease-label conditions than in the painter-label conditions.

Method

Participants. Two hundred nineteen undergraduate were randomly assigned to the same disease-label ($n = 53$), different disease-label ($n = 56$), same painter-label ($n = 56$), and different painter-label ($n = 54$). One participant who almost exclusively responded with one arrow key (at least 82% of the trials) was excluded from the data analysis.

Materials & Design. Stimuli in Experiment 2 were identical to those described in Experiment 1. The design of the experiment was 4 (Label Condition; same disease-label, different disease-label, same painter-label, different painter-label; between-subjects) \times 3 (Physical Difference; low-difference, medium-difference, high-difference; within-subjects) factorial. The dependent measure was also identical to the one in Experiment 1.

In the same disease-label and different disease-label conditions, the triad pictures were introduced as cells infected by different diseases. In the same painter-label and different painter-label conditions, the same pictures were presented as abstract paintings drawn by different artists. In the same disease-label and same painter-label conditions, Bdis had the same label as the target. In the different disease-label and different painter-label conditions, Bdis had a different label from the target.

Procedure. The procedure of Experiment 2 was identical to that described in Experiment 1.

Results

As in Experiment 1, the disease-label conditions were significantly different from the painter-label conditions, $F(3, 214) = 21.35$, $MSE = .07$, $p < .001$, $\eta^2 = .23$ (Figure 5). The proportion of participants selecting the dissimilar base pictures (Bdis) was significantly higher in the same disease-label condition ($M = .29$) than in the same painter-label condition ($M = .18$), $t(107) = 3.03$, $SE = .04$, $p = .003$, $d = .99$ (Figure 5a). The two conditions were not different when target and base stimuli (Bdis) had different labels (Figure 5b).

There was an interaction effect between the label condition and physical difference factors, $F(6, 428) = 5.62$, $MSE = .06$, $p < .001$, $\eta^2 = .07$. Given the same-label conditions (Figure 5a), the proportion of participants selecting Bdis was significantly higher in the same disease-label condition than in the same painter-label condition at all levels of physical difference: low-difference, $t(107) = 3.18$, $SE = .04$, $p = .002$, $d = .87$; medium-difference, $t(107) = 2.36$, $SE = .04$, $p = .02$, $d = .70$; high-difference, $t(99) = 2.48$, $SE = .04$, $p = .01$, $d = .93$. The proportion of participants selecting Bdis was not statistically different in the different disease-label condition and the different painter-label condition at all levels of physical difference (all $ps > .1$; Figure 5b).

Additional analysis. To obtain a further insight, we compared the disease-label and painter-label conditions to the no-label condition in Experiment 1 on an exploratory basis. When the target and base picture (Bdis) had the same labels, the proportion of participants selecting Bdis was significantly higher in the disease-label condition than in the no-label condition; $t(99) = 3.33$, $SE = .04$, $p = .001$, $d = .66$. Such a difference was absent between the painter-label and the no-label conditions; $t(102) = .42$, $SE = .02$, $p = .67$, $d = .08$.

When the target and the base picture (Bdis) had different labels, the proportion of participants selecting Bdis was significantly lower in the disease-label condition than in the no-label condition; $t(101) = 5.11$, $SE = .02$, $p < .001$, $d = 1.01$. A similar effect was present between the painter-label and in the no-label conditions; $t(100) = 3.78$, $SE = .02$, $p < .001$, $d = .75$.

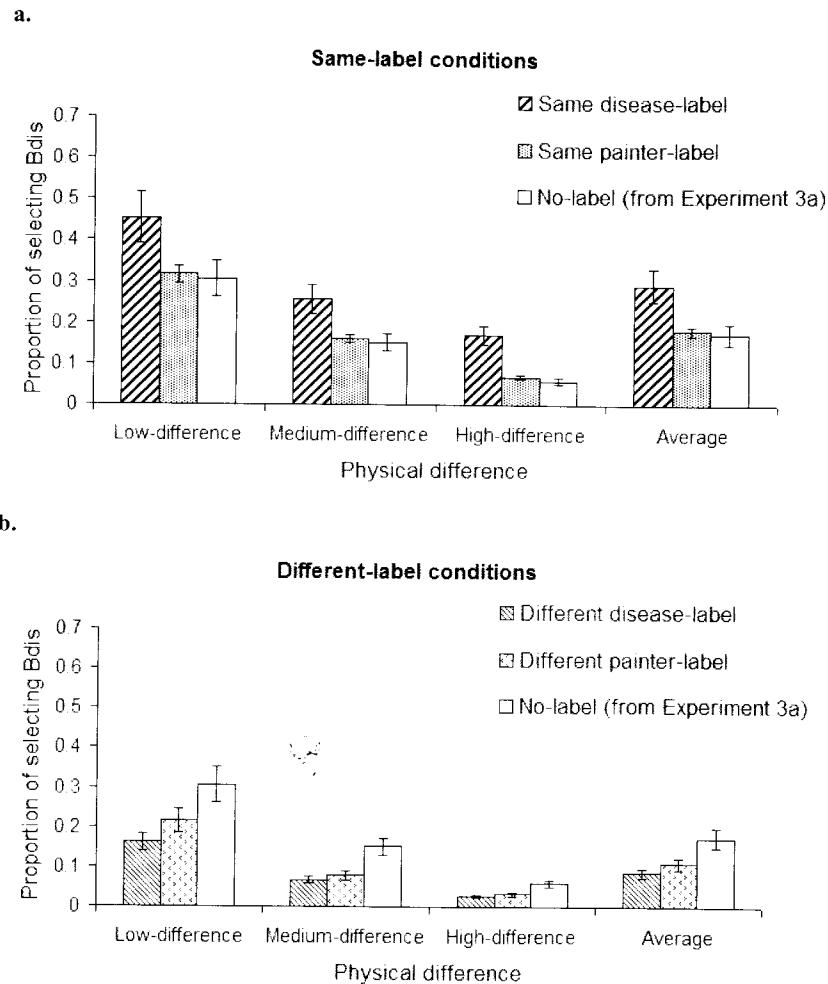


Figure 5. Mean proportions of participants selecting Bdis (i.e., the dissimilar base pictures) over Bsim in Experiment 2. The mean proportions are shown separately for the same-label conditions (a) and for the different-label conditions. The performance in the no-label condition in Experiment 1 is also included to facilitate a comparison. The error bars represent two standard error units calculated from each condition.

General Discussion

How do category labels influence the perception of similarity? To address this question, we used a variant of the triad task that has been used widely in developmental studies (e.g., Gelman & Markman, 1986; Sloutsky & Fisher, 2004). The results of Experiment 1 suggest that the symbolic property embedded in category labels plays a role. While fictitious cell labels (e.g., *chicken lung cell*) influenced similarity judgment, alphabet labels (e.g., *type E*) did not. Fictitious cell labels such as *dog kidney cell* can be understood in relation to other familiar labels such as *cat*, *heart*, and *cell*, while alphabet labels such as *type E* and *type F* cannot. Experiment 2 replicated these results with fictitious disease labels (e.g., *Gotorrphoea*) as contrasted to fictitious labels representing names of painters.

We suggest that the symbolic relationship of conceptual labels plays a crucial role in the judgment of similarity. This relationship cannot be simulated simply by stimulus-driven attention weight given to category labels (see Corbetta & Shulman, 2002, for the distinction between goal-directed and stimulus-driven attention). It is not bound by an indexical relationship to specific exemplars; it is most likely that category labels, unlike other indices, work as symbols. As indices, labels have arbitrary relationships with the entities that they represent; unlike indices, symbolic labels are understood with respect to other related symbols (Deacon, 1997; Peirce, 1932, 1955; see also Bruner et al., 1966). We suggest that this conceptual property inherent in symbolic representation makes category labels meaningful in similarity judgment.

Our symbol hypothesis extends the theory-based account of similarity judgment (Murphy & Medin, 1985; Wisniewski & Medin, 1994). According to the theory account, background knowledge modifies the diagnosticity of the features by making some features more salient than others. This process is determined by the task and the background knowledge of the observer. Our symbol hypothesis extends this view by suggesting that category labels are important because the symbolic property of category labels highlights commonalities and differences among related concepts (see Markman & Gentner, 1993b; Markman & Wisniewski, 1997).

Symbol, similarity, and developmental shift

Why do category labels influence similarity judgment in adult participants while the impact of category labels is relatively limited in young children (e.g., Sloustky & Fisher, 2004)? Although more empirical studies are needed to fully answer this question, we tentatively suggest that this discrepancy arises from a developmental shift associated with children's mental representations of objects.

In early developmental stages, the distinction between real objects and indices of the objects is obscure (DeLoache, 2004; Perner, 1991; Piaget, 1952). For example, 9-month-old infants do not fully understand that a picture of a cup represents an index of a real cup. Infants around this age often try to grasp the cup in a picture just like they would grasp a real cup (DeLoache, Pierroutsakos, Uttal, Rosengren, & Gottlieb, 1998; Pierroutsakos & Troseth, 2003). As they grow older, they come to understand what indices mean. For example, 18-month-old infants understand that a novel word *whisk* can indicate a picture of a whisk as well as a real whisk (Preissler & Carey, 2004). Three-year-old children are capable of understanding that a miniature toy and a miniature room are indices of a big toy and a real room (DeLoache, 2002; DeLoache, Mendoza, & Anderson, 1999). After seeing an experimenter hiding a miniature toy in a miniature room, children are able to find the big toy in the real room.

As children grow older, they gradually grasp the notion of "symbols." The developmental shift from indices to symbols may be aided by linguistic communications taking place in everyday situations and depends on the domain of knowledge to which children are accustomed (Keil, 1989). Studies of syntactic development in children suggest that communication plays a crucial role. For example, children initially, loosely connect two or three words to communicate specific items or motions (Lieven, Pine, & Baldwin, 1997; Tomasello, 1998, 2000). Children at 2 to 3 years of age tend to use language more indexically to point out particular items in their communication (Pine & Lieven, 1997). Later, children mimic adults' sentences to communicate properly; this exercise generates more adult-like syntax in their sentences (Tomasello, Kruger, & Ratner, 1993). Gradually, many communicative constraints, such as taking the intention of a speaker into account (Bloom, 1996; Clark, 1983; Grice, 1957), conversational agreements between

interlocutors (Malt & Sloman, 2004; Markman & Makin, 1998), and cultural and historical precedents (Malt, Sloman, Gennari, Shi, & Wang, 1999), shape what category labels can represent (see also Loenstein & Gentner, 2005; Lupyan, Rakison, & McClelland, 2007).

Eventually, fully developed symbolic relations of category labels emerge. As a result, category labels are placed in rich networks of knowledge, which helps the speaker perform a variety of complex functions, such as creating a metaphor ("my job is a *jail*"; Glucksberg & Keysar, 1990) as well as a metonymy ("*the pen* is mightier than *the sword*"), accentuating stereotypical beliefs ("Linda is a *feminist*"; Gelman & Heyman, 1999; Walton & Banaji, 2004; Yamauchi, 2005), and producing new concepts by combining multiple labels (e.g., "street lawyer," Estes & Glucksberg, 2000; Wisniewsky, 1998).

Conclusion

This study examined why category labels influence similarity judgment in adult participants. We suggest that category labels, unlike other attributes, have special properties. Category labels work as symbols evoking background knowledge and connections with other labels. We suggest that this symbolic property is a critical factor in the influence of category labels on similarity judgment.

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