The Effect of Spatial Distance between Objects on Categorization Level

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Abstract

We show that spatial distance between two objects influences how people categorize these objects. We report three (two pre-registered) experiments that show that when objects are presented close together (proximal), they are more likely to be categorized in a superordinate category than when they are presented further apart (distant). In Experiments 1A and 1B, participants provided spontaneous category labels in an open response format. In Experiment 2, we asked participants to indicate their preference for either of two category labels. We found that when objects are close together, they are categorized more often into superordinate categories than when objects are far apart (Experiment 1A and 2). Our findings demonstrate that the categorization of objects is, in part, determined by where they are in relation to other objects. [127 words]

keywords: spatial distance, categorization, spatial grouping, spatial processes, clumpiness principle

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Understanding what objects are is a core task in human cognition. Such categorizations are not made in a vacuum but instead are influenced by variables outside the object (Loken, 2006; Murphy, 2004), such as a person's current needs (Bruner, 1957) or emotional state (Isen & Daubman, 1984), and goals (Loken, 2006). One variable that has been mostly overlooked is the spatial distance between objects. Given that two objects cannot occupy the same space at the same time, objects are always somewhere relative to each other in space. Indeed, in everyday life, objects are often presented spatially; for instance, in brochures, online shops, and survey forms. Previous research has shown that such spatial distance between objects matters for similarity judgments and choice: An apple and an orange set close together appear more similar (Casasanto, 2008) and might prove a more difficult choice than an apple and an orange set far apart (Lakens, Schneider, Jostmann, & Schubert, 2011; Schneider, Stapels, Koole, & Schwarz, 2020). Here we go beyond previous work and examine *what* people think about objects depending on the distance between them. Specifically, we examine whether spatial distance influences the level of categorization and propose that people are more likely to think about “fruit” when objects are close together compared to when they are far apart.

In general, objects can be categorized on three levels, superordinate, basic, and subordinate. An apple can be categorized as FRUIT (superordinate), APPLE (basic), and GRANNY SMITH (subordinate) (G.L. Murphy, 2004; Rosch, 1975; Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976)¹. The level on which an object is categorized has consequences for the properties and features that people attribute to this object. For instance, ob-

¹ What is considered a superordinate, basic, or subordinate category is relatively stable. However, training and experience might shift the basic category to higher or lower levels. For instance, for people who have no experience with trees, the basic level would be TREES, while people who have lived among trees all their life, the basic category might constitute ELM or OAK and TREES would be the superordinate level (G.L. Murphy, 2004)

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jects categorized on the superordinate level are often described in terms of abstract or functional properties. As an example, the category FRUIT would bring to mind that one can eat it and that it is healthy (Medin & Smith, 1984; G.L. Murphy, 2004). Objects categorized on the basic level are often described in terms of their parts or visual properties. An APPLE is green, round, and small (G.L. Murphy, 2004; Rosch et al., 1976; Tversky & Hemenway, 1984). Subordinate levels have all the basic category information but with additional specifications, such as light-green (Medin & Smith, 1984; Rosch et al., 1976; Tversky & Hemenway, 1984). The basic level of categorization is the default level of categorization. When people encounter new objects, they generally use the basic level of categorization (G. L. Murphy & Brownell, 1985; G.L. Murphy, 2004). However, objects in the world are not always encountered in isolation. Instead, objects often appear together in some spatial arrangement. For instance, people might see an apple and an orange together in a bowl or set out separately on a buffet. We propose that such differences in spatial distance between objects influence the level of categorization.

Spatial Distance and Categorization

Why would spatial distance influence categorization? One reason is that spatial distance is informative about the relationships between objects in the world. This is described by the *factor of proximity*, one of the laws of Gestalt theory. This law states that “*that form of grouping is most natural which involves the smallest interval*” (Wagemans et al., 2012; Wertheimer, 1938). Put simply, proximity (i.e., closeness) is a natural cue people use to group objects in their environment. The factor of proximity is so dominant in human perception that spatial groupings based on this principle are not easily unseen. For instance, most people perceive the following dots ● ● ● ● as two *pairs of dots* instead of *four dots*. The fact that it takes effort *not* to see the dots as pairs, illustrates the profound impact of spatial proximity in visual grouping. In sum, *close together goes together*.

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However, the law of proximity refers to visual grouping only, and makes no predictions about categorization levels. Nevertheless, there is reason to assume that proximity can influence categorization level. First, proximity to another object creates the perception that the objects *go together* – as illustrated by the dots above. Thus, proximal objects are more likely be perceived as a single group (“pair of dots”) rather than separate elements (“dots”). If a perceiver wants to make sense of a group, they need a level of categorization that can encompass all elements in the group. Superordinate categories are of a higher level of abstraction, less descriptive of the individual object, but more applicable to objects’ shared properties (Isen & Daubman, 1984; Rosch, 1975; Rosch et al., 1976), than basic categories and therefore likely more suitable as a category.

Second, in the environment, shared category membership and proximity often co-occur. That is, objects that are close to each other often also belong to the same category. For instance, flowers are often close to other flowers, and rocks are usually close to other rocks. In the human-made environment, this association is also present: books are put with other books, and cups are placed with other cups. Because of this learned association, proximity is a strong cue for shared category membership. This idea is summarized in the *Clumpiness Principle* (Casasanto, 2008). This principle proposes that stimuli in the environment are clumped together. Specifically, “physical closeness encourages construing stimuli as members of the same category” (Casasanto, 2008, p. 1053). So far, the relationship between proximity and categorization has not been tested directly. However, the Clumpiness Principle also posits a direct consequence of this categorization process, namely increased perceptions of similarity. This latter relationship has been demonstrated empirically, providing indirect support for the relationship between proximity and categorization.

First, empirical work has shown that proximity facilitates similarity judgments, while distance facilitates dissimilarity judgments. For instance, when people view two similar

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squares close together, they are faster to determine whether they are indeed similar compared to when they are far apart. Conversely, when people view two dissimilar squares far apart, they are faster to determine whether they are dissimilar, compared to when they are close together (Boot & Pecher, 2010). Furthermore, when people see two objects close to each other, they process subsequent sentences about similarity faster compared to when they first see two objects far apart (Guerra & Knoeferle, 2014). Conversely, processing sentences about dissimilarity is faster when people first see two objects far apart compared to seeing two objects close together.

Second, spatial distance also influences how subjectively similar people judge stimuli to be. Specifically, stimuli set close together are judged to be more similar than stimuli set far apart. For instance, when people have to judge how similar two words are in meaning, nouns presented close together are perceived as more similar in meaning than nouns presented far apart on the computer screen (Casasanto, 2008). Similarly, two stick figures drawn close together are seen as having more similar political attitudes than stick figures drawn far apart (Winter & Matlock, 2013).

Yet, spatial closeness does not always lead to increased similarity. Sometimes, stimuli that are close together appear to be less similar. In fact, whether or not proximity leads to more similarity seems dependent on the type of judgment that people have to make. When people have to judge conceptual similarity - similarity on an abstract dimension - proximity leads to more similarity (Casasanto, 2008). For instance, when people see images of two tools and are asked how similar they are in use, a conceptual judgment, they judge tools presented close together as more similar than tools presented far apart. However, when people are asked how similar the tools are in their visual appearance – how they look - they judge tools presented close together as less similar than tools presented far apart (Casasanto, 2008).

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The observation that proximity only influences similarity in conceptual similarity judgments (i.e., tool use) has been explained through different underlying processes that comprise the similarity judgment (Casasanto, 2008). When people have to make a visual judgment of similarity, they can make direct use of the concrete sensory properties of the stimuli. This is because the stimulus itself holds information directly relevant to the task – for instance, through directly observable properties, such as color, shape, texture. In these instances, people do not need to rely on heuristics such as natural co-occurrences. However, when judging similarity on a conceptual level, along abstract dimensions like use or meaning, there is no information in the specific stimulus that can potentially inform these judgments. In this case, people draw on heuristics that might help them judge similarity. Shared category membership is such a heuristic that can inform similarity judgments. Thus, according to the Clumpiness Principle, proximity leads to similarity for conceptual judgments because of shared category membership (Casasanto, 2008).

Current Research

In the current work we directly examine whether there is a relationship between proximity and superordinate categorization as proposed by the Clumpiness Principle. Specifically, we propose that spatial distance between objects influences the degree to which superordinate categories come to mind when viewing objects. Specifically, when objects are close together, people will prefer superordinate categories more than when objects are far apart. While spatial distance between objects has been researched in the domain of similarity judgments and choice, less is known on how it affects categorization. Research on similarity judgments is concerned with whether close spatial distance makes *apples and oranges more similar*. In the current research, we are interested in whether spatial distance makes *apples and oranges more like fruit*. Examining categorization can help further understanding on whether objects take on different meanings depending on spatial distance. Such a finding would be relevant in

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a range of domains, from methodological considerations about stimulus presentation to decision-making, marketing psychology, and consumer behavior.

We present three experiments. We predict that close objects will elicit more superordinate categories than distant objects. Note that we do not focus on subordinate categories in this work because they are usually very similar to basic categories. We report how we determined our sample size, all data exclusions (if any), all manipulations, and all measures in the experiments. All pre-registrations, data, materials, and analyses scripts can be accessed here: <https://osf.io/qzu8x/>

Experiment 1A

Experiment 1A provides a first test of our idea. We showed participants images of objects and ask them to provide a label for each image. We predicted that for close objects, participants would more often name superordinate categories as labels than for far objects.

Method

Power Analyses. Because this was the first experiment we ran, we did not do formal power calculations and instead collected 100 participants per condition. Amazon Mechanical Turk provided slightly more participants.

Participants and design. A total of 206 participants were recruited from Amazon Mechanical Turk, and paid \$ 0.75 for completing a 7-10 minute survey that combined the current experiment followed by an unrelated experiment not reported here. A total of 24 participants were excluded from the analyses because they did not provide a response ($N = 6$) or provided multiple labels (e.g., “I see fruit: an apple and an orange.”; $N = 18$) on more than one trial. The remaining 182 participants (104 males, 77 females, 1 unreported) had a mean age of 37.57 years ($SD = 11.57$). Distance (proximal vs. distant) was manipulated between subjects.

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Procedure. Participants were presented with ten pairs of objects (modelled after Casasanto, 2008). Objects were presented on a white background of 800 by 600 pixels (width by height). Images of the objects were rescaled to fit in a white frame with a width of 150 pixels. We selected the objects from Rosch (1975) and aimed to use the most typical exemplars for each category. However, the original exemplars were exemplar names, not images. Thus, we selected the exemplars with the highest goodness of fit to the category with the pre-condition that the exemplars would be reasonably different visually. Thus, in cases where we expected the visual representations of the exemplars to lack clear differences, we opted for the next best exemplar. For instance, for the category VEHICLES, the highest rated exemplar was *automobile*, the second rated exemplar was *station wagon*. When presented verbally, these are clearly different, but when presenting images of both, participants might not differentiate between the two. Therefore, we opted for the third highest rated exemplar truck, which would have a very different image than automobile. This led to the following objects (category given in brackets): orange and apple (fruit), chair and sofa (furniture), automobile and truck (vehicle; truck being ranked third in the goodness-of-exemplar rating), gun and knife (weapon; knife being ranked seventh after pistol, revolver, machine gun, rifle and switchblade), pea and carrot (vegetable), saw and hammer (carpenter's tools), robin and sparrow (birds), football and baseball (sports), doll and top (toys), pants and shirt (clothing), (see Appendix A).

In the proximal condition, the 150 pixel white frame images were placed adjacent in the center of the white background, with 0 pixels between them. In the distant condition, they were placed 50 pixels from the left and right borders of the background, leaving 444 pixels between them (see Figure 1). Note that because the images of the objects were placed in a white frame for consistency purposes, the objects themselves do not touch each other in the proximal condition. However, the invisible white frames were indeed placed adjacent.

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For half of the participants the object pairs were presented proximal, for the other half they were presented distant. To keep the instructions as neutral as possible, participants were asked to “*please label these images*”. Participant’s responses were counted as a superordinate category when the label described both objects (e.g., FRUIT), and as basic category when the label described both objects (e.g., an APPLE and an ORANGE). At the end of the experiment, participants indicated age and gender.

Figure 1: Proximal condition (left), with objects close together. Distant condition (right), with objects far apart.

Statistical analyses. We computed a mixed effects logistic regression in which we entered distance (contrast-coded: distant = -0.5, proximal = 0.5) as a fixed factor and participants and stimuli as random factors. The binary outcome variable was dummy-coded (categorization: basic = 0, superordinate = 1).² We estimated the mixed model in R (R Core Team, 2017) using the packages *lme4* (Bates, Maechler, Bolker, & Walker, 2015) and *lmerTest* (Kuznetsova, Brockhoff, & Christensen, 2017).

² We initially planned and pre-registered to aggregate the data within participants and across stimuli to conduct a *t*-test. However, the reviewers suggested to run a mixed model, properly taking the variability in stimuli into account. We report the results of our initial analyses in the Supplementary Material.

Results and Discussion

The mixed effects logistic regression showed that the probability of using a superordinate category was higher for proximal stimuli ($M = 57.12\%$, $SD = 44.64$) than for distant stimuli ($M = 46.12\%$, $SD = 47.13$), $b \pm SE = 29.78 \pm 1.95$, $z = 15.27$, $p < .001$. The variance of the intercept by participants and stimuli was $\sigma^2 = 744.56$, and $\sigma^2 = 23.61$, respectively.

Thus, in line with our prediction, when objects were close together, people were more likely to use superordinate categories than when objects that were far apart (Figure 2).

Figure 2: Results of Experiments 1A (left), 1B (center), and 2 (right). Experiments 1A and 1B display the use of superordinate categories (in percentages) for distant and proximal stimulus pairs. Experiment 2 displays the mean rating for distant and proximal stimulus pairs with higher rating scores indicating the tendency towards the superordinate category and lower rating scores indicating the tendency towards the basic category. Error bars represent the standard error of the mean.

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Experiment 1B

In Experiment 1A, the pattern of the results was in line with our hypothesis. In Experiment 1B we were interested to see whether the effect would extend to objects that were less prototypical for their category. Pre-registration for this project can be found here:

<https://osf.io/9qt4m>

Method

Power Analyses. We assumed an effect size of $d = 0.24$, based on the data collected in Experiment 1A and aimed for 95% power, resulting in a minimum sample size of 754 participants. Because of residual funding, we decided to collect a total of 825 participants.

Participants and Design. Eight-hundred twenty-five participants (426 females, 397 males, 2 others, $M_{\text{age}} = 38.10$ years, $SD = 11.91$) were recruited on Amazon Mechanical Turk and paid \$0.40 for 3 minutes. A total of 23 participants were excluded from the analyses because they did not provide a response ($N = 3$) or provided multiple labels (e.g. “I see fruit: an apple and an orange.”; $N = 18$) or both ($N = 2$) on more than one trial. The remaining 802 participants (388 males, 412 females, 2 other) had a mean age of 38.21 years ($SD = 11.95$). Distance (proximal vs. distant) was manipulated between participants.

Procedure. The procedure was identical to Experiment 1A. We used the following objects that were selected from around the median of prototypicality ratings in Rosch (1975; original category given in brackets) while still being fit for visual presentation: lemon and mango (fruit), buffet and lamp (furniture), subway and tractor (vehicle), missile and whip (weapon), potato and green onion (vegetable), crowbar and screws (carpenter's tool), water-skiing and ice skating (sport), fire engine and balloons (toy), tuxedo and stockings (clothing). The category "birds" was not included in the experiment because in Experiment 1A, most of the participants were unable to name the different kinds of birds based on visual depictions, leading to responses such as "a bird and a bird". This resulted in 9 object pairs (see Appendix

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B). The stimulus images were created like in Experiment 1A. However, because of Qualtrics survey software presentation restrictions, the background image was resized to 770 by 577 pixels (instead of 800 by 600 pixels in Experiment 1A). For the proximal condition, stimuli were still placed adjacent, with 0 pixels between them. For the distant condition the images were placed adjacent the left and right borders (instead of 50 pixels away from them like in Experiment 1A) with 470 pixels between them.

Statistical analyses. The statistical analyses were identical to those in Experiment 1A. Following the reviewers' suggestions, we computed a mixed effects logistic regression in which we entered distance (contrast-coded: distant = -0.5, proximal = 0.5) as a fixed factor and participants and stimuli as random factors. The binary outcome variable was dummy-coded (categorization: basic = 0, superordinate = 1). The analyses that were planned in the pre-registration are presented in the Supplementary Materials.

Results and Discussion

Although there was a tendency to use more superordinate categories for proximal stimuli ($M = 17.55\%$, $SD = 35.04$) than for distant stimuli ($M = 13.86\%$, $SD = 32.68$), the mixed effects logistic regression did not show a statistically significant effect, $b \pm SE = 0.36 \pm 0.64$, $z = 0.57$, $p = .572$ (Figure 2). The variance of the intercept by participants and stimuli was $\sigma^2 = 265.55$, and $\sigma^2 = 0.06$, respectively.

Descriptively, participants generally preferred basic categories ($M = 84.29\%$, $SD = 33.91$) over superordinate categories ($M = 15.71\%$, $SD = 33.91$). To test whether this basic category advantage was also statistically significant, we computed a mixed effects logistic regression without distance as a fixed effects factor. This null-model predicts the probability of giving a basic vs. a superordinate category regardless of the distance between the stimuli but still taking variability in participants and stimuli into account. This analysis showed that the basic category advantage was statistically significant, $b \pm SE = -11.16 \pm 0.43$,

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$z = -24.97, p < .001$ (participants: $\sigma^2 = 266.85$; stimuli: $\sigma^2 = 0.06$). It seems that due to the medium levels of typicality of the stimuli (Rosch, 1975), participants were biased towards basic categories, preventing the distance effect from emerging.

Experiment 2

While Experiment 1A shows that in spontaneous labeling tasks, people generate on average more superordinate categories for close objects than they do for far, Experiment 1B did not show statistical differences. One reason for this might be that our primary dependent variable was dichotomous. This means that subtle differences are harder to detect. For instance, it might be that when two objects are far, the basic category is preferred strongly over the superordinate category, while in the close condition, the basic category is only slightly preferred. This still constitutes a relevant change in preference, but it cannot be detected in a dichotomous choice variable. In Experiment 2 we remedy this by presenting participants with a relative preference scale for either basic category or superordinate category labels.

Furthermore, in Experiment 1B it might have been difficult for participants to generate a superordinate category for the pairs, as evidenced by the strong bias towards basic categories compared to Experiment 1A. To make sure that in Experiment 2 our object pairs elicited relatively homogenous category associations across participants we conducted a pretest to select object pairs.

Method

Power Analyses. Based on previous work we aimed to detect an effect of $d_z = 0.16$ with a power of 95% which resulted in 309 participants. To account for possible dropout, we set our sample size to 350 participants. The experiment was pre-registered here:

<https://osf.io/zcmsn/>

Participants and design. We recruited 350 participants (176 females, 174 males) on Amazon Mechanical Turk and paid \$0.30 for 3 minutes. In line with the pre-registration, six

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participants were excluded because they were not native English speakers (including them did not change the results), resulting in a final sample of 344 participants (174 females, 170 males, $M_{\text{age}} = 38.59$ years, $SD = 11.88$). Because we used a scale ranging from preference for basic to superordinate category, it was not possible for participants to give multiple labels like in Experiment 1A and 1B. Nor was it possible for participants to skip trials. Therefore, in this data set, there were no missing responses and no exclusions. Spatial distance was manipulated within participants (proximal vs. distant, see below for details on how we realized this). The stimulus/distance combination was counterbalanced between participants, such that the objects that were presented distant in one counterbalance condition, were presented proximal in the other condition and vice versa. Participants completed 7 proximal and 7 distant trials.

Procedure. Participants gave their informed consent and were subsequently presented with 14 pairs of objects (see Appendix C) half presented far apart and half presented close together (modelled after Casasanto, 2008). We asked participants to "*please indicate how you would categorize*" on a 10-point scale. The scale was anchored on the left with basic categories (e.g., "apple & orange" = 1), and on the right with a superordinate category (e.g., "fruits" = 10) (see Figure 3). Thus, higher scores indicated a stronger preference for the superordinate category for a given pair.

For our stimuli, we first generated 35 pairs of objects for our pretest (see Supplemental Material); 8 of these pairs were the exact same as used in Experiment 1A. We selected objects that elicited the most agreement over participants both on the basic and superordinate categories (see Supplemental Material for extensive descriptions and ratings). This resulted in the 14 object pairs for which participants indicated on a scale how they would categorize them. Notably, the pretest results also led to the inclusion of the 8 pairs from Experiment 1A,

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suggesting that these pairs elicited strong agreement among participants for both the superordinate and basic categories associated with the objects (see Appendix C).

Participants indicated for each pair how they would categorize it on a 10-point scale ranging from the basic category to the superordinate category. The scale ends were: pants³ & shirt - clothes; burger & French fries - fast food; fork & knife - silverware; dollar bill & quarter - money; apple & orange - fruits; couch & chair - furniture; necklace & ring - jewelry; carrot & peas - vegetables; cat & dog - pets; car & truck - vehicles; gummy bears & chocolate - candy; hammer & saw - tools; doll & top - toys; gun & knife – weapons (See supplemental material for pre-test). At the end of the survey, participants indicated age, sex, and whether they were native English speakers.

Objects were presented on a white background measuring 800 by 600 pixels (width by height). We rescaled object images to a maximum width of 200 pixels and a maximum height of 200 pixels without changing the width-to-height ratio. We ensured that both objects were equally large by requiring the circumference of both object images to be equal. In the proximal condition, images were presented in the center of the background with 2 pixels between them. In the distant condition images were presented 2 pixels from the left and right edge of the background. Thus, in the distant condition, images were always separated by at least 396 pixels (mean distance = 492 pixels, SD = 90 pixels, min = 409 pixels (pets), max = 752 pixels (knife and fork, portrait orientation), second max = 578 (pants and shirt)). Finally, to fit the Qualtrics Survey software, images (objects and background) were rescaled to 740 by 555 pixels.

³ “Pants” is the most appropriate noun for American English speaking samples. For British English samples, “trousers” would have been more appropriate.

Please indicate how you would categorize:

apple & orange

fruits

Figure 3. Example of a proximal pair in Experiment 2.

Statistical analyses. As in Experiments 1A and 1B, we followed the reviewers' suggestions and conducted a mixed model analysis. We report our pre-registered analyses in the supplementary material. The model specification was as in the previous two experiments, except that due to the continuous nature of the outcome variable (rating scale), we employed a mixed effects linear regression (in contrast to the mixed effects logistic regression in Experiments 1A and 1B). Distance was entered as a contrast-coded fixed factor (distant = -0.5, proximal = 0.5), participants and stimuli were entered as random factors.

Results and Discussion

The mixed model analysis showed that superordinate categories were preferred more for proximal objects ($M = 6.41$, $SD = 2.52$) than for distant objects ($M = 6.17$, $SD = 2.58$), $b \pm SE = 0.24 \pm 0.08$, $t(4,458.00) = 2.83$, $p = .004$ (Figure 2). The variance of the intercept by

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participants and stimuli was $\sigma^2 = 5.08$, and $\sigma^2 = 1.37$, respectively. For the scale ends “dollar bill & quarter - money”, we erroneously presented a Euro bill and Euro coin. However, excluding this stimulus pair did not change the pattern of results, $b \pm SE = 0.26 \pm 0.09$, $t(4,120.43) = 2.91$, $p = .004$ (variance of the intercept by participants: $\sigma^2 = 5.41$; by stimuli: $\sigma^2 = 1.00$). This means that when objects are close together, people prefer the superordinate level of categorization more than when objects are far apart.

The findings from Experiment 2 provide a conceptual replication of our findings in Experiment 1A, using a different dependent variable and extending the number of stimuli. Notably, 8 of the stimulus pairs that emerged as most suitable from extensive pretests turned out to be the exact pairs from as in Experiment 1A, suggesting that for spatial distance to influence categorization, the objects need to have strong associations with both the basic as well as the superordinate categories.

General Discussion

We examined how the spatial distance between objects in the world influences categorization levels. We hypothesized that objects presented close together would be categorized more often in superordinate categories than objects presented far apart. Experiment 1A and Experiment 2 show that this is the case. Participants preferred superordinate over basic categories when presented with the two categorization levels, and also generated more superordinate categories in an open response format. This suggests that spatial distance between objects influences what comes to people’s minds spontaneously.

Experiment 1B painted a different picture. In this experiment we used objects that were only moderately prototypical for their superordinate category from which we selected them. We found that almost all responses - regardless of distance - referred to basic categories, suggesting that a superordinate category did not come to mind, or at least less strongly than the basic categories. Perhaps this means that the findings from Experiment 1A and 2 are

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limited to objects that have relatively clear basic and superordinate categories associated with them. Experiment 2 seems to indirectly support this reasoning. The objects used in Experiment 2 were carefully pretested to elicit homogenous basic and superordinate categories across all participants. Using these stimuli, the effect of distance on preferences for superordinate categories emerged. Notably, the pretest for Experiment 2 also showed, in retrospect, that the stimuli we used for Experiment 1A elicited these homogenous responses as well, suggesting that prototypicality or category fit might be an important moderator of the effect of spatial distance on categorization level.

Taken together these findings suggest that, at least for prototypical exemplars, spatial distance influences the categorization level. This finding is in line with the Clumpiness Principle (Casasanto, 2008) that suggests that proximity, category membership, and similarity are interrelated in human cognition. However, hitherto, the empirical evidence for this principle was limited to the relationship between proximity and similarity (Boot & Pecher, 2010; Casasanto, 2008; Guerra & Knoeferle, 2014; Winter & Matlock, 2013) while the link between proximity and category membership lacked empirical evidence. In this work we provide this evidence and show that – at least for prototypical exemplars – proximity increases the degree to which objects are categorized together in a superordinate category.

Our work also demonstrates a moderation of the basic category level advantage. In general, people prefer the basic category and this level of categorization is the default level of categorization when people encounter objects (see Supplemental Materials for analyses of this in our data). When people have to categorize an object, they are faster to determine whether something is an APPLE, rather than FRUIT (Fan et al., 2012; Johnson & Mervis, 1997; Murphy, 2004; Murphy & Smith, 1982; Rosch et al., 1976). While the basic category advantage is a robust phenomenon, different moderators have been documented (e.g., Macé, Joubert, Nespoulous, & Fabre-Thorpe, 2009; Murphy & Brownell, 1985; Rogers & Patterson,

2007). We add to this work by identifying a contextual moderator, namely spatial distance between objects. Our findings show that when (prototypical) objects are close together, superordinate categories are preferred more (and thus basic categories less) than when they are far apart.

Future Research

In all our studies, we used self-report measures to examine categorization levels. Using these measures, we found that people preferred superordinate categories more for proximal than for distant stimuli. At the same time, we might not have been able to detect more subtle effects. For instance, in Experiment 1B, people named more basic categories than in Experiment 1A. Above, we have suggested that this might be because spatial distance does not influence categorization for objects that are less prototypical. However, there might be another possibility. Perhaps in Experiment 1B, proximity did suggest shared category membership, but finding a suitable superordinate category *label* might have been too difficult. Eventually, participants might have given up, reverting to the basic category instead. Our self-reports would not have been able to pick up on such differences in difficulty, but more process-oriented measures, such as response times or mouse-tracking, would. One could for instance examine whether categorization of proximal pairs, regardless of category labels, take longer than those for distant pairs. Using such measures to get more fine-grained insight into the effects reported here would be a fruitful avenue for future work.

Our work adds to existing work examining the effect of spatial distance between objects on judgment processes. In particular, previous work has shown that proximity makes influences similarity judgments (Casasanto, 2008; Winter & Matlock, 2013) as well as difficulty in dichotomous choice (Lakens, Schneider, et al., 2011; Schneider et al., 2020). One question is how these different processes unfold temporally. One possible sequence could be that upon perceiving objects, the distance between objects influences categorization levels in

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line with the Clumpiness Principle (Casasanto, 2008). Next, this shared category membership influences similarity because members of the same category are more similar than members of different categories (Brewer & Weber, 1994; Brown, Novick, Lord, & Richards, 1992; Mussweiler, 2003; Mussweiler & Bodenhausen, 2002). Finally, choosing between more similar options is more difficult than choosing between dissimilar choice options (Mellers & Biagini, 1994). Testing these processes in a single model is an exciting direction for future research.

Finally, in the work presented here we found that superordinate categories were preferred more for proximal than for distance stimuli, in line with our predictions. One might argue that the opposite prediction is also possible: proximal stimuli lead to less preference for superordinate categories. For instance, in similarity judgments, close spatial distance leads to more similarity when the judgment task is conceptual, but less similarity when the judgment task is focused on visual comparison (Casasanto, 2008). Could a similar reversal be observed for categorization tasks? Our data cannot speak to this question. However, future research might juxtapose visual and conceptual categorization to investigate this question.

Conclusions

In this work, we examined the influence of spatial distance between objects on categorization level. We found that when objects are set close together, people prefer superordinate categorization more than when the objects are set far apart. As such, our work shows that spatial distance between objects systematically influences the categories that come to people's minds and the meaning of the objects they encounter. An apple and an orange set far apart, are just that, "an apple and an orange." But when the same apple and orange are set close together, they become "fruit." In sum, *what* an object is, is in part, determined by *where* it is relative to other objects.

Open Practices Statement

All data, materials, and analyses scripts can be accessed here: <https://osf.io/qzu8x/>.

Experiments 1B and 2 were pre-registered, Experiment 1B: <https://osf.io/9qt4m/>, Experiment 2: <https://osf.io/zcmsn/>.

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Appendix A: Stimulus pairs in Experiment 1A

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Appendix B: Stimulus pairs in Experiment 1B

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Appendix C: Stimulus pairs in Experiment 2

(proximal condition only, see online materials for complete stimulus sets)

Supplemental Materials

We initially planned to perform the statistical analyses on data that was aggregated within participants (and across stimuli). However, the reviewers suggested to run mixed model analyses which – unlike the aggregation approach – would take the variability between stimuli into account. For the sake of transparency, we here report the results of our initial analyses which are mostly similar to the results reported in the main document.

Experiment 1A

We aggregated the data by computing the frequency of superordinate categories each participant provided. A visual inspection of the frequency distribution revealed that the data deviated from a normal distribution. We thus opted for the Mann-Whitney-U-test, the non-parametric equivalent of an independent t -test, to analyze the data. For each comparison, we report the effect size d that we derived from the Z -value of the Mann-Whitney-U-test (Fritz, Morris, & Richler, 2012) obtained by the *coin* package for R (Hothorn, Hornik, Wiel, & Zeileis, 2008).

Participants who saw objects close together used superordinate categories more ($M = 5.70$, $SD = 4.46$, mean rank = 98.50) than those who saw objects far apart ($M = 4.55$, $SD = 4.67$, mean rank = 84.65), $U = 4,770$, $Z = 1.87$, $p = .031$, $d = 0.28$ (one-sided).

Experiment 1B

As in Experiment 1A, we aggregated the data by computing the frequency of superordinate categories each participant provided. Visual inspection of the distribution showed that the data deviated from a normal distribution. Thus, we used the non-parametrical equivalent of an independent t -test, the Mann-Whitney-U-test. In line with our hypothesis, participants who saw the objects proximal used more superordinate categories ($M = 1.57$, $SD = 3.14$, mean rank = 414.78) than those who saw the objects distant ($M = 1.24$, $SD = 2.93$, mean rank = 388.22), $U = 85,727$, $Z = 2.29$, $p = .011$, $d = 0.16$ (one-sided).

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While the expected effects emerged in the non-parametric test, the pattern of results was less clear in parametric statistical tools. It is important to keep in mind that the results of parametric tests need to be considered very carefully when the assumptions regarding the distribution are violated as is the case here. For the sake of completeness, we report the analysis nonetheless. We pre-registered a repeated measures ANOVA with type of categories (superordinate vs. basic) as within-subjects factor and distance (proximal vs. distant) as between-subjects factor. In the pre-registration, we detailed that we expected an interaction effect such that more basic categories would be used for distant stimulus pairs while more superordinate categories would be used for proximal stimulus pairs. Descriptively speaking, the predicted pattern emerged. Participants who saw the objects proximal used more superordinate categories ($M = 1.57$, $SD = 3.14$) than those who saw the objects distant ($M = 1.24$, $SD = 2.93$), while participants who saw the objects distant used more basic categories ($M = 7.71$, $SD = 2.93$) than participants who saw the objects proximal ($M = 7.37$, $SD = 3.14$). However, the interaction did not reach the level of statistical significance, $F(1, 800) = 2.41$, $p = .121$, $\eta_p^2 < .01$. There was however, a significant main effect for the level of categorization, $F(1, 800) = 816.84$, $p < .001$, $\eta_p^2 = 0.51$. Basic categories were used more often ($M = 7.54$, $SD = 3.04$) than superordinate categories ($M = 1.41$, $SD = 3.04$) regardless of distance (basic category advantage). Again, note that these are not appropriate analyses and the result should be not be overinterpreted.

Pretests for Experiment 2

In order to find labels for the anchors of the rating scale in Experiment 1 (i.e. labels for the “superordinate categories” end and labels for the “basic categories” end), we conducted two pretests. The goal of Pretest 1 was to find superordinate categories for two objects presented in a picture. Pretest 2 then identified the corresponding basic categories for the objects.

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Participants and Design. One hundred participants participated in Pretest 1 (52 males, 48 females, $M_{\text{age}} = 35.72$ years, $SD = 10.88$) and one hundred in Pretest 2 (56 males, 44 females, $M_{\text{age}} = 34.75$ years, $SD = 10.50$). In Pretest 1, all participants were presented with all object pairs and indicated a label for both objects. In Pretest 2, each participant was presented with only one of the objects of each stimulus pair and indicated a label for that object only.

Procedure. We generated a pool of 35 object pairs that shared the same superordinate categories but were different from each other. In Pretest 1, participants were shown pictures of these object pairs and asked to “*indicate which category fits both objects*” in an open response. Object pairs for which the same superordinate category was named more than forty times were selected for Pretest 2. In Pretest 2, the participants were presented with one object of the object pairs and asked to “*please label the object.*” After they had given their response, they were asked to indicate “*how typical the objects [was] for the category X,*” with X being the superordinate category that was identified in Pretest 1. The rating slider ranged from 0 (“*not typical at all*”) to 100 (“*very typical*”). When participants gave a rating of below 20, i.e., they rated the previously identified superordinate categories as untypical, we asked them “*what would be an adequate name for the category?*”.

Results. In Pretest 1, 28 out of 35 object pairs were given the same superordinate categories at least forty times (100 participants labeled each object pair). In Pretest 2, for 16 object pairs, the individual objects were given the same basic category at least twenty times (50 participants labeled each object). For two of these object pairs (flowers and balls), the corresponding superordinate category was also named more than ten times. As such, for these pairs, the individual objects seemed to bring to mind both the basic category as well as the superordinate category, which would have been a confound in our main experiment, and we did not use these object pairs. The final set of stimuli thus consisted of 14 object pairs. The

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pretests ensured that they shared the same superordinate category and that each individual object evoked the same basic category across participants.

Finally, the average typicality score was 85.17 ($SD = 7.84$), indicating that the individual objects were generally typical for the selected superordinate category. Additionally, we found that participants named an alternative superordinate category for individual objects only on 0.62 times on average ($SD = 1.45$), emphasizing the fit of the individual objects to our selected superordinate categories. To illustrate this with an example as presented in Table 1, 54 out of 100 participants gave the superordinate category "clothes" for the pants and t-shirt, which were presented together in Pretest 1. In Pretest 2, when presented with an image of the pants only, 33 out of 50 participants gave it the basic category "pants". Likewise, when presented with an image of the t-shirt only, 40 out of 50 participants gave it the label "t-shirt". Only two participants gave the superordinate category "clothes" as a label for the pants. These results indicate that the pictures of the pants and t-shirt used in Pretest 1 bring to mind the superordinate category "clothes" and the basic categories "pants" and "t-shirt". Thus, the stimulus pair was selected for Experiment 1.

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Table 1

Results of both pretests: Frequencies of superordinate and basic categories. For example, the first row shows that when presented with two bikes, 81 out of 100 participants said “bikes”. Only two categorized the mountain bike as a “mountain bike” (basic level). Instead, 23 categorized the mountain bike as “bike” (superordinate level). This means that most participants had no trouble naming the superordinate category, most did not have basic categories at the ready for the different objects. Thus, the stimulus pair was not selected for Experiment 1.

Superordinate categories (2 objects shown at a time)		Basic Categories (1 object shown at a time)		
Expected	<i>Mentioned by</i> <i>N (of 100)</i>	Expected	<i>Mentioned by</i> <i>N (of 50)</i>	<i>Mentioned by</i> <i>N (superord. cat.)^A</i>
bikes	81	mountain bike	2	23
		Holland bike	0	25
birds	97	raven	8	14
		pigeon	24	20
bottles	36	beer bottle	-	-
		wine bottle		
bread	75	toast	26	17
		rye bread	0	38
cloths	8	cleaning cloths	-	-
		tissues		
clocks	47	grandfather clock	15	26
		watch	43	0
clothes	54	pants	33	2
		t-shirt	40	0
colors	35	red	-	-
		blue		
silverware	41	fork	42	3
		knife	26	2
soda	62	Coke	5	-
		Fanta	1	
fast food	45	burger	21	0
		French fries	28	0
fish	93	goldfish	34	14
		carp	1	49

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flags	94	Canadian flag	19	27
		American flag	13	36
flowers	97	rose	38	11
		tulip	20	23
fruits	95	apple	41	8
		orange	43	4
furniture	65	couch	24	2
		chair	45	4
games	88	board game	19	20
		cards	32	0
glasses	66	wine glas	25	19
		beer glas	0	38
craft supplies	16	scissors	-	-
		glue	-	-
jewelry	90	necklace	33	11
		ring	33	2
lights	60	lamp	37	1
		fairy lights	0	25
money	71	dollar bill	30	14
		quarter	34	3
pasta	77	tortellini	12	23
		spaghetti	13	22
pens	9	pen	-	-
		pencil	-	-
pets	66	dog	43	1
		cat	47	1
religion	0	mosque	-	-
		church	-	-
shoes	84	sneakers	12	17
		high heels	9	20
balls	77	basketball	37	11
		soccer ball	31	11
stone	25	brick	-	-
		cliff	-	-

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candy	78	Gummi bears	31	10
		chocolate	42	5
tools	84	hammer	40	7
		saw	32	3
toys	89	doll	46	3
		top	29	5
vegetables	87	carrot	41	6
		peas	27	3
vehicles	83	car	38	5
		truck	25	0
weapons	90	gun	39	3
		knife	31	1

Note: The expected superordinate category (first column) and the number of times it was named among 100 participants (second column). The expected basic categories (third column) and the number of times they were named among 50 participants each (fourth column). The number of times the expected superordinate category was named when asking for a basic category (fifth column). Objects of superordinate categories that were named less than 40 times in the first pretest were not included in the second pretest, hence the dashes in the last two columns. Categories that were selected for the main experiment are printed in bold.

^A Number of times the intended superordinate category was given when asking for a basic category.

Analyses Experiment 2

We aggregated the data by computing the mean rating for each participant for proximal and distant stimuli. In line with the directional hypothesis, we performed a one-tailed paired *t*-test and found that superordinate categories were preferred more for proximal objects ($M = 6.41$, $SD = 2.52$) than for distant objects ($M = 6.17$, $SD = 2.58$), $t(343) = 2.50$, $p = .006$, $d = 0.13$, 95% CI [-0.02, 0.28]. For the scale ends “dollar bill & quarter - money”, we erroneously presented a Euro bill and Euro coin. However, excluding this stimulus pair did not change the pattern of results, $t(343) = 2.55$, $p = .006$, $d = 0.14$. This means that when objects are close together, people prefer the superordinate level of categorization more than when objects are far apart.

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We further suspected that there were large individual differences in the tendency to prefer basic vs. superordinate categories. This notion is supported by a strong correlation between ratings of distant and proximal stimulus pairs, $r(342) = .76, p < .001$. The more the participants rated proximal stimulus pairs in the direction of superordinate categories, the more they also rated distant stimulus pairs in the direction of superordinate categories. Conversely, the more they rated distant stimulus pairs in the direction of the basic categories, the more they also rated proximal stimulus pairs in the direction of basic categories. This means that the participants had a clear tendency to either rate most of the stimulus pairs in the direction of superordinate categories or in the direction of basic categories, regardless of the distance between the stimuli. Despite this tendency, for proximal stimulus pairs participants still favored the superordinate categories in contrast to distant stimulus pairs for which they favored the basic categories.

Basic Category Advantage

We examined the basic category advantage in our aggregated data. See below the analyses for each experiment.

Experiment 1A

An asymptotic Wilcoxon-Pratt signed-rank test revealed that participants used superordinate categories ($M = 5.12, SD = 4.59$) slightly more than basic categories ($M = 4.76, SD = 4.54$), $Z = 2.31, p = .021$.

Experiment 1B

An asymptotic Wilcoxon-Pratt signed-rank test revealed that that participants used basic categories ($M = 7.54, SD = 3.04$) significantly more often than superordinate categories ($M = 1.41, SD = 3.04$), $Z = 20.64, p < .001$.