The Color of Similarity

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Abstract

Conceptual Metaphor Theory (Lakoff & Johnson, 1980) posits that the metaphorical ways in which we talk about abstract concepts are indicative of the ways in which we think about those concepts. In a recent test of this hypothesis, Casasanto (2007) considered the metaphor SIMILARITY IS PROXIMITY. He found evidence to suggest that the effect of physical proximity on similarity ratings differs depending on whether the task requires a perceptual or conceptual judgment regarding the similarity of common objects: only for conceptual judgments did Casasanto find that physical proximity increased similarity ratings. We extend this finding, asking whether physical proximity will similarly affect conceptual, but not perceptual, judgments regarding the similarity between two color swatches.

Keywords: Color; Space; Metaphor

Introduction

The question of how concepts are represented and used is a fundamental one in Cognitive Science, touching on all areas of inquiry. The question becomes particularly problematic when the concepts considered are abstract, like similarity, rather than firmly grounded in observables in the world, like proximity. One influential proposal regarding how we use and reason about abstract concepts, Conceptual Metaphor Theory (Lakoff & Johnson, 1980a, 1980b), holds that abstract concepts are understood via connections to the more concrete concepts used metaphorically to talk about them. This would, in turn, imply that the way in which we reason about abstract concepts should show important parallels with the way in which we reason about the corresponding concrete concepts which form the bases for the metaphors. In this regard, Lakoff & Johnson (1980) argue "[a]s metaphorical concepts are defined in terms of nonmetaphorical concepts, they show entailment relations parallel to those for the corresponding nonmetaphorical concepts." (p. 197).

Recently, this claim from Conceptual Metaphor Theory has been put to the test (Casasanto, 2007). In this study, judgments of similarity were elicited for line-drawings of everyday objects (e.g., tools, clothing, furniture). Participants were instructed either to judge similarity by visual appearance or to judge similarity by function or use—the first type of judgment argued to be perceptual and the second type of judgment, conceptual. In addition, the line-drawings were presented either close together or far apart in order to test the hypothesis that, if similarity is understood via proximity, similarity ratings should be higher when the drawings are presented close together than when they are presented far apart. The results suggest that the effects of proximity on similarity judgments differ depending on whether the judgment being made is considered conceptual or perceptual. When participants judged similarity based on function (i.e., conceptual similarity), objects presented closer together in space were rated as more similar than objects presented further apart, in line with the conceptual metaphor SIMILARITY IS PROXIMITY. However, perceptual judgments produced the opposite result: objects presented closer together in space were rated as more distinct than objects presented further apart.

Casasanto interpreted these results as supporting the conceptual metaphor SIMILARITY IS PROXIMITY when participants are called upon to make conceptual judgments but not perceptual judgments, suggesting that the interplay between proximity and similarity may be more complex than the metaphor would lead us to believe.

While these results are compelling, it should be noted that the participants were instructed to base their similarity judgments on either conceptual or perceptual properties of the pictures. The account would be greatly strengthened if the distinction between conceptual and perceptual judgments could be made implicitly and without overt instruction, yet using a single set of stimuli. Happily, precisely this situation exists in the domain of color.

In their study of the Sapir-Whorf hypothesis, Kay and Kempton (1984) argue that "it is well known that triad distances for color stimuli reproduce discrimination distances faithfully, so long as the stimuli selected are chosen from a single lexical category" (p. 70). What this suggests is that distinctions made between colors within the same lexical category—like those labeled blue—are perceptual. In support of this, Kay and Kempton presented participants with color triads from which they were asked to select the color most different from the others. They found that participants who considered the three colors to be from the same lexical category selected in line with perceptual discrimination distance. However, when a conceptual distinction existed between the color swatches, as evidenced by description via separate color terms (blue and green), participants' choices differed from that which would be predicted based on discrimination distances, choosing as most different the color swatch that would be described with a different term than the other two. Further, when they were presented with colors from two lexical categories but blocked from using their color vocabulary (having agreed that the central chip was both green and blue), English speakers chose as would be predicted by perceptual discrimination distances. Taken together, these results suggest that the category boundary effect is indicative of a conceptual decision. As such, the domain of color admits of both conceptual and perceptual judgments without explicit instruction to that effect (note that the participants in Kay & Kempton's (1984) study were in all cases asked to choose the color swatch that was most different from the other two; no additional instructions were given to them).

There is additional evidence in the domain of color for a possible distinction in processing between conceptual judgments (subject to lexical category effects) and perceptual judgments. Gilbert, Regier, Kay, and Ivry (2006) found that discrimination performance varied depending on whether the odd color swatch in a discrimination task was presented to the right visual field or to the left. In the right visual field, reaction time was faster if the odd swatch and the distracters were from different lexical categories than if they were from the same category; no such difference was found if the odd swatch was presented to the left visual field. This suggests that the left visual field (and therefore the right hemisphere) may engage in perceptual processes, while the right visual field (and left hemisphere) may engage in either conceptual processes or both conceptual and perceptual processes.

In sum, it appears that judgments regarding features of a color swatch are most likely to be guided by perceptual processes when (a) the color swatches are drawn from the same lexical category (Kay & Kempton, 1984), or (b) the color swatches are presented to the left visual field (Gilbert et al., 2006). Conversely, conceptual judgments regarding color swatches are most likely when (a) the colors are drawn from different lexical categories (Kay & Kempton, 1984), or (b) the color swatches are presented to the right visual field (Gilbert et al., 2006). Given this evidence that both conceptual and perceptual judgments are available in the domain of color under separate sets of circumstances, we are in a position to ask whether Casasanto's (2007) result will extend to judgments of similarity between color swatches, in which case we would expect to see evidence of the conceptual metaphor SIMILARITY IS PROXIMITY when participants are making conceptual judgments of similarity, but not when they are making perceptual judgments.

Specifically, a within-category color pair presented to the left visual field would be considered a perceptual judgment match, and a between-category color pair presented to the right visual field would be considered a conceptual judgment match. If Casasanto's (2007) results extend to judgments of similarity between colors, we expect that similarity ratings for the perceptual judgment match will not follow the conceptual metaphor SIMILARITY IS PROXIMITY. In this case, colors presented close together are likely to have low similarity ratings and colors presented far apart are likely to have high similarity ratings. The opposite result is predicted for the conceptual judgment match, in which it is predicted that judgments of color similarity will follow the conceptual metaphor SIMILARITY IS PROXIMITY. In this case, colors presented close together are likely to have high similarity ratings and colors presented far apart are likely to have low similarity ratings.

There are two remaining conditions, each of which could be considered a mismatch: a within-category color pair (perceptual) presented to the right visual field (conceptual), and a between-category color pair (conceptual) presented to the left visual field (perceptual). There are at least two logical outcomes for these mismatched conditions. One possibility is that visual field will have a stronger influence over judgments of similarity than category status and the other is just the opposite, that categorical status will have a stronger influence over judgments of similarity than visual field. If visual field has a stronger influence on judgments in this task, then color pairs presented to the left visual field would be subject to more perceptual effects and color pairs presented to the right visual field would be subject to more conceptual effects regardless of the type of color pair in question. However, if categorical status has a stronger influence on judgments in this task, then within-category color pairs would be subject to more perceptual effects and between-category color pairs would be subject to more conceptual effects regardless of visual field presentation.

Experiment

This experiment tested whether the distinction Casasanto (2007) found between conceptual and perceptual judgments of similarity would appear in judgments regarding similarity between colors. If so, participants should rate color swatches as more similar when presented close together than when presented further apart when the comparison is conceptual. Conversely, participants should rate color swatches as more distinct when presented close together than when presented further apart when the comparison is perceptual.

Methods

Participants A total of 88 native English speaking undergraduates from the University of Louisiana at Lafayette community took part in this study in exchange for class credit.

Materials The stimuli consisted of four computer-generated colors from the blue-green continuum (Munsell 7.5G, 2.5BG, 7.5BG, and 2.5B), presented as 76 pixel x 76 pixel squares. The colors used in this study were identical to those used by Gilbert et al. (2006, p.493) and, following their nomenclature, will henceforth be referred to as colors A, B, C, and D. The use of these four colors permitted the formation of two within category pairs - within-green (A and B) and within-blue (C and D) - and one between category pair (B and C) - such that each pair accounted for approximately the same amount of difference in psychological color space.[1] The colors were presented to participants on a neutral grey background with RGB values of 178, 178, and 178.

Procedure Participants were seated at a comfortable viewing distance (approximately 70 centimeters) from a computer screen, upon which each of the possible one-step pairs – A-B, B-C, and C-D – was presented eight times in randomized order. Upon each presentation, participants were asked to rate the similarity of the presented colors on a scale of 1 (not at all similar) to 9 (very similar).[2]

The order of the trials was as follows: participants first viewed a neutral grey computer screen (set at a resolution of 1024 x 768 pixels) for one second. A black fixation cross (50 x 50 pixels) then appeared in the middle of the screen for 1.5 seconds; participants were instructed to focus their visual attention on the fixation cross whenever it was present on the screen. With the fixation cross still on the screen, the first square of color was presented in one of four randomly selected positions: either on the left or the right side of the fixation cross, and at a distance of either 75 pixels or 100 pixels from the center of the fixation cross to the edge of the color stimulus. After a one second presentation, the first color stimulus was removed from the screen. The second color stimulus was presented immediately following the removal of the first color stimulus, either on the same side of the fixation cross as the first stimulus (experimental trials) or on the opposite side of the fixation cross (filler trials); it too remained on the screen for one second. All possible color positions were aligned along the same horizontal axis as the fixation cross. After the second color stimulus was removed from the screen, a rating scale appeared, and the participant was asked to rate the similarity between the two color swatches they had just viewed. Similarity ratings and reaction times were recorded for each trial.

In order to determine whether the visual field within which the colors were presented might lead to either perceptual (left visual field) or conceptual (right visual field) processing (an extension of Gilbert et al., 2006), test trials were designed such that the second color stimulus was restricted to appear in the same visual field as the first color stimulus. Within each visual field, stimuli were presented either close together (50 pixels distance between nearest edges) or far apart (100 pixels distance between nearest edges), for a total of four possible presentation situations for each pair and eight possible locations for each color. In each case, the first stimulus was presented closer to the fixation cross, and the second was presented more towards the periphery of the screen. Thus, the first stimulus in the near condition was presented at a distance of 100 pixels from the center of the fixation cross to its edge, with the second stimulus at a distance of 226 pixels from the center of the fixation cross to its edge. The first stimulus in the far condition was presented at a distance of 75 pixels from the center of the fixation cross to its edge, and the second stimulus, at a distance of 251 pixels from the center of the fixation cross to its edge. Order of presentation of the two colors in the pair (e.g., A-B or B-A) was randomly determined on each trial.

Because we were interested in the possible effect of the visual field on perceptual vs. conceptual judgments, it was very important to ensure that the pairs of color samples were actually perceived in the target visual field. Thus, to reduce participants' ability to predict the location of the second stimulus and, thence, the likelihood that they would make saccades away from the fixation cross, filler trials were designed such that the second color stimulus would appear in the visual field opposite that of the first color stimulus. During the filler trials, the second stimulus was presented the same distance from the fixation cross as the first stimulus but on the opposite side of the fixation cross. By design, half of the trials that each participant completed were experimental trials as described above, and half were cross-fixation filler trials, ensuring that participants would not be able to predict whether the second color sample would appear on the same side of the screen as the first stimulus (test condition) or on the opposite side of the screen (filler trial condition). Participants completed a total of 12 experimental trials and 12 filler trials.

After completing the similarity judgment task, participants engaged in a lexical boundary task to determine whether their lexical boundary coincided with the predicted one, which falls between colors B and C; data from participants whose lexical boundary differed was excluded from further analysis. In the lexical boundary task, a neutral grey screen was presented for 1 second. A black fixation cross (50 x 50 pixels) then appeared in the middle of the screen for 1.5 seconds. While the fixation cross remained on the screen, the color samples from the similarity judgment task were displayed one at a time. Each of the four color stimuli (A, B, C and D) was presented individually, in random order, in each of the eight positions on the computer screen that had served as possible color stimulus locations during the color comparison task (75 pixels to the left of the fixation cross, 100 pixels to the left of the fixation cross, 150 pixels to the left of the fixation cross, 175 pixels to the left of the fixation cross, 75 pixels to the right of the fixation cross, 100 pixels to the right of the fixation cross, 150 pixels to the right of the fixation cross, and 175 pixels to the right of the fixation cross). After a second-long exposure to the color, participants were asked to use their computer keyboard to indicate whether they thought the color they just saw was blue, indicated by pressing the B key, or green, indicated by pressing the G key. Participants were instructed

[1] Gilbert et al. (2006) did determine that in both CIEL*a*b and CIEL*u*v color spaces the interstimulus distances for the within-green colors was slightly less than the distances for the between-category colors, but the distances for the within-blue colors was slightly greater than the distances for the between-category colors. However, when averaged together, the within-distance exceeded the between-distance for both color spaces.

[2] The nine-point scale used in this study followed that used by Casasanto (2007).

to make responses during this task using their dominant hand. Color categorization responses and reaction time were recorded.

Design We used a 2 (Distance: close or far) x 2 (Categorical Status: within or between) x 2 (Visual Field: right or left) design. All factors were varied within subjects.

Analysis and Results

Lexical Boundary Determination Of the 88 total participants, 96.6% consistently labeled (eight out of eight trials) color A as green, 72.7% consistently labeled color B as green, 73.9% consistently labeled color C as blue, and 97.7% consistently labeled color D as blue. 21 participants produced more than two inconsistent labels and were thus eliminated from further analysis. Of these 21 participants, 18 produced at least two of their inconsistent labels in response to the same color stimulus, indicating that this color was likely to be correctly identified by the participant only seventy-five percent of the time. Although participants were not formally screened for color vision, all but one had normal color vision by self-report. That participant was accordingly removed from further analysis. The data from one additional participant was analyzed separately.[3] 41 of the remaining 66 participants produced no inconsistent labels, and 25 of the remaining 66 participants produced only one inconsistent label, the production of which was attributed to random error.

To determine whether the category status of a stimulus might vary as a function of its location on the screen, the consistency of color labeling for all 88 participants was analyzed. There were found to be no significant differences in inconsistent labeling between visual fields (right, left), distance from fixation point (75 pixels, 100 pixels, 150 pixels, 175 pixels), and color label (green, blue); however, there were significant differences between the mean number of inconsistent labels for colors closest to the predicted lexical color boundary (B and C) and the mean number of inconsistent labels for colors further away from the predicted lexical color boundary (A and D). The mean number of inconsistent labels for the colors closest to the predicted lexical color boundary (M = 5.25; SD = 1.91) was significantly greater than the mean number of inconsistent labels for the colors further away from the predicted lexical color boundary (M = 0.38, SD = 0.5); $F(1, 30) = 97.09$, $p < .0001$. Along with the naming patterns cited above, this suggests that the lexical boundary does indeed fall between colors B and C for our participants overall, as predicted based on previous results (Gilbert et al., 2006).

Similarity Ratings To analyze the test condition results, raw similarity ratings were z-scored individually for each participant. Z-scored similarity ratings were compared using a three-way ANOVA with Distance (close, far), Categorical Status (within, between), and Visual Field (right, left) as all within-subjects factors. Ratings showed a marginally significant two-way Distance by Categorical Status interaction ($F(1, 64) = 3.68$, $p = 0.0594$) with a main effect of Categorical Status ($F(1, 64) = 30.69$, $p < .0001$). No other significant effects or interactions were found.

As predicted, the main effect of Categorical Status revealed that judged similarity for within-category color pairs was significantly higher than for between-category color pairs (Figure 1). That colors from the same lexical category were rated as significantly more similar than colors from different lexical categories is simply a replication of the results reported by Kay and Kempton (1984); lexical color boundaries affect the perception of color similarity.

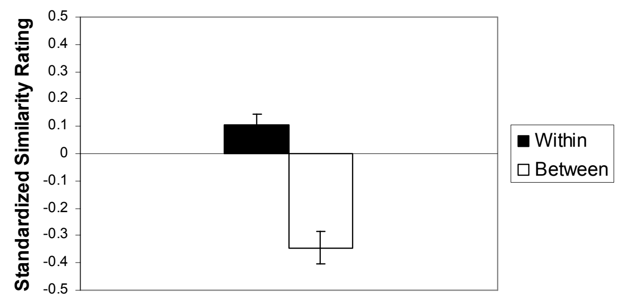

Figure 1: Standardized similarity ratings for pairs of colors as a function of their categorical status. Within-category colors (i.e., within-green and within-blue) were rated as more similar and between-category colors were rated as more dissimilar (i.e., green-blue). Bars indicate standard errors.

Our primary question was whether the influence of the metaphor SIMILARITY IS PROXIMITY was restricted to conceptual judgments of similarity for color samples, as it was for objects (Casasanto, 2007), with the opposite effect for perceptual judgments. We thus varied the expected type of judgment in two ways: via categorical status, and via visual field. To recap, we predicted that within-category judgments would be perceptual, while between-category judgments would be conceptual (Kay & Kempton, 1984), and we predicted that judgments of pairs presented to the left visual field would be perceptual, while judgments of pairs presented to the right visual field would contain a conceptual component (either alone or in combination with a perceptual one) (Gilbert et al., 2006).

We first ask whether categorical status will interact with proximity. As predicted, we observed that judged similarity for within-category pairs is lower when the colors appeared close together than when they appeared far apart. Conversely, we observed that judged similarity for between-category pairs is higher when the colors appeared close together than when they appeared far apart (Figure 2).

[3] It was determined that this participant had a lexical boundary between A and B rather than between B and C. In the lexical boundary task, this participant labeled color B as an example of blue seven out of eight times and color A as an example of green eight out of eight times. No other inconsistent labels were produced by this participant.

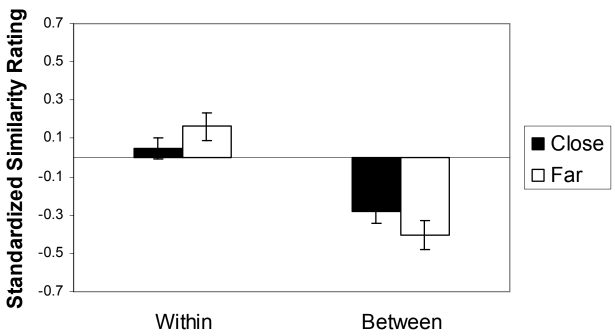

Figure 2: Standardized similarity ratings for pairs of colors as a function of categorical status and physical distance. For within-category pairs, similarity ratings were lower when the colors were presented close together than when they were presented far apart (left panel); for between-category pairs, similarity ratings were higher when the colors were presented close together than when they were presented far apart (right panel). Bars indicate standard errors.

We next ask whether visual field will interact with proximity, thus extending the findings of Gilbert et al (2006). Contrary to the predictions, we did not observe any difference in the effect of proximity on judgments of color similarity across the two visual fields. Presenting color stimuli at different distances had the same effect in the right visual field (conceptual) as the left visual field (perceptual), ($F(1, 64) = 1.05$, $p = .3100$).

General Discussion

It has long been established that judged similarity between pairs of color samples will be higher for within-category pairs than for between-category pairs, despite similar discrimination distances (Kay & Kempton, 1984). However, Kay & Kempton argue that the two kinds of comparisons – within- and between-category – are in fact indicative of two kinds of processes – perceptual and conceptual. In this study, we take up this hypothesis, probing for further effects resulting from this distinction.

Recently, Casasanto (2007) found compelling evidence that the metaphorical means with which we speak about abstract concepts may affect perceptual judgments regarding those concepts in a very different way from how it affects conceptual judgments. In his study examining the conceptual metaphor SIMILARITY IS PROXIMITY, Casasanto found that for conceptual comparisons, seeing the objects to be compared close together led to higher similarity ratings than when the objects were presented far apart; the converse was true in the case of perceptual comparisons.

Given that both perceptual and conceptual processes are implicitly available for judgments about color, the current study tested whether Casasanto's (2007) finding would extend to judgments of the similarity between physically different color samples. The results suggest that it may. When participants perceived colors as coming from the same lexical category (and, thereby, perceptually different while conceptually the same), increasing the distance between the color samples resulted in an increase in similarity ratings. However, when participants perceived colors as coming from two different lexical categories (and, thereby, both perceptually and conceptually different), increasing the distance between the color samples resulted in a decrease in similarity ratings. This seems to substantiate the claims made by Casasanto (2007) that proximity and conceptual similarity have a strong positive relationship, while proximity and perceptual similarity do not.

While our results do lend support to the hypothesis originally posited by Casasanto (2007), there is at least one alternative explanation for the current findings which does not invoke Conceptual Metaphor Theory. When colors were presented close together, participants may have had a tendency to compare them on a more perceptual basis, lessening any effects which might be linked to categorical status. However, when colors were presented far apart, perceptual comparison may have been more difficult. As a result, participants may have relied more on their conceptual knowledge of the colors to help them solve this relatively harder problem (cf., Kay & Kempton, 1984). It may thus be that increasing the distance between colors in turn increases the likelihood that participants will use categorical information to make judgments of similarity. This would mean that presenting colors far apart should produce effects more consistent with the categorical status of the color pair. If the effects of categorical status are such that within-category colors are rated as more similar overall and between-category colors are rated as more dissimilar overall, then the prediction here is that within-category colors should be rated as more similar when presented further apart than when presented close together. Conversely, between-category colors should be rated as more dissimilar when presented further apart. This pattern of results is presented in Figure 2. Increasing the distance between colors could simply be strengthening the effects of categorical status.

One issue with both explanations is that the interaction we observed between physical proximity and categorical status was only marginally significant. One possible explanation for this lies in the difference between interstimulus distance in the close condition (a separation of 50 pixels) and the far condition (a separation of 100 pixels), a difference of only fifty pixels. It may be that this difference in distances between the two conditions was sufficient but not optimal for observing the differential effects of proximity on judged similarity, an issue that we leave to future research.

We also note that category status may not be the only indicator of type of judgment, as it has also been observed that discrimination of color may differ depending on whether the target colors are presented to the left visual field or to the right (Gilbert et al., 2006). We thus asked whether the same interplay of conceptual metaphor and type of judgment would be evident when the type of judgment was manipulated via visual field presentation, thus extending from Gilbert et al's (2006) findings. Our results suggest that it may not. This may seem surprising, given the marked visual field difference in reaction time patterns for a color discrimination task observed by Gilbert and his colleagues (2006). We note in this regard that, while they examined reaction time differences, we were looking at differences in consciously-made similarity ratings. It is possible that, given the conscious attention that enters into a similarity rating, the conceptual-perceptual distinction that arises from presentation to a single visual field may wash out, as the judgments at issue likely occur after visual field differences are resolved. It is possible – indeed likely – that the consciously-available categorical status which was varied in our materials plays the larger role in the conscious act of judging similarity, an effect which was made evident in situations where the information from categorical status and that from visual field presentation represented a mismatch. Given these possibilities, we plan to eliminate the visual field manipulation from our future studies of the interplay between physical proximity and judged similarity. This may provide us both with a stronger manipulation of physical proximity (due to the increased screen space available for a single trial) and also with a cleaner measure of any effects that proximity may have on consciously made judgments of similarity.

Finally, the differences noted between the effect of proximity for within- vs. between-category color pairs suggests a possible solution to the long-standing controversy regarding the possibility of Whorfian effects on color perception and memory (e.g., Davidoff, Davies, & Roberson, 1999; Heider, 1972; Lucy & Shweder, 1979, inter alia). Given that there are two kinds of processing readily available for colors – conceptual and perceptual – with different patterns of effects, it may be that that these two kinds of processing surface in different sets of tasks, or when different portions of the color space are considered. As a result, we may see Whorfian effects in just those situations which invite conceptual processing, but not in situations which invite perceptual processing. We leave further consideration of this issue to future research.

Conclusions

Casasanto (2007) observed that when perceptual information was available in the stimuli and was relevant to the task, participants used it. In this situation proximity may facilitate noticing small differences with the result that objects presented close together are judged to be less similar than those presented far apart. When perceptual information was not available or was not relevant to the task, participants evidenced an influence of the metaphor SIMILARITY IS PROXIMITY, judging objects presented close together as more similar than those presented far apart.

Although perceptual information about colors is constantly available, we observed a similar distinction between perceptual similarity judgments and conceptual ones with lexical category status as the indicator for the type of judgment being made. Our results thus corroborate and extend Casasanto's finding, and suggest a new way of considering how we think about similarity in a variety of domains. The influence of conceptual metaphor on the abstract concept of similarity may be limited to situations involving conceptual reasoning.

Acknowledgements

We would like to thank John V. Anderson for his help with data collection, and the members of the Language and Cognition Lab at UL Lafayette, in addition to Zachary Estes and three anonymous reviewers, for comments and helpful discussion.

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