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BRIEF REPORT

Beyond Direct Reference: Comparing the Present to the Past Promotes Abstract Processing

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A primary way that people make sense of their experience is by comparing various objects within their immediate environment to each other and to previously encountered objects. The objects involved in a comparison can be stimuli that are present within one's immediate environment, or mental representations of previously encountered stimuli that are now absent from one's immediate environment. In this research, we propose that the comparison process unfolds differently depending on whether an individual is comparing stimuli that are simultaneously present within a given context or is comparing a target stimulus to a stored representation of a previously encountered source stimulus. Across two studies, we found that people engage in more abstract processing when comparing a present stimulus to a previously encountered source than when comparing two simultaneously present stimuli. We discuss the implications of these findings for the role of abstraction in comparison and memory-based reasoning.

Keywords: comparison, abstraction, analogical reasoning, memory

A primary way that people make sense of their experience is by comparing various objects within their immediate environment to each other and to previously encountered objects. Such comparisons play a role in many of humans' most important and basic cognitive abilities ranging from categorization (e.g., Boroditsky, 2007; Rips, 1989; Rosch & Mervis, 1975; Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976), to problem solving (e.g., Gentner & Markman, 1997; Holyoak & Thagard, 1989; Ross, 1987, 1989), to decision-making (e.g., Hsee & Zhang, 2004; Johnson, 1984), to self-evaluation and social judgment (e.g., Festinger, 1954; Mussweiler, 2003). In general, the process of comparison entails relating one object or event (i.e., the target) to another distinct object or event (i.e., the source) and assessing their similarities and differences (Tversky, 1977; Tversky & Gati, 1978).

The objects or events involved in a comparison can be stimuli that are present within one's immediate environment, or mental representations of stimuli that are absent from one's immediate environment. For example, when evaluating a piece of art, one might compare it to another piece of art displayed in the same room. Here, the two pieces of art are simultaneously present within one's physical environment, and thus are both perceivable and available for direct reference. Alternatively, one might compare a piece of art to a previously encountered piece. In this case, comparing the two pieces requires comparing one stimulus to a stored mental representation of another stimulus that is now absent from one's immediate environment.

We propose that the comparison process unfolds differently depending on whether an individual is comparing stimuli that are simultaneously present within a given context or is comparing a target stimulus to a stored representation of a previously encountered source. Our central hypothesis is that, relative to when people make comparisons between two stimuli that are simultaneously present, when people make comparisons between a present stimulus and a stored representation of a previously encountered stimulus, they will tend to compare the two to each other at a higher, more abstract level.

Mapping in Comparisons

Comparing complex stimuli to each other involves a process of mapping wherein people identify correspondences between elements of a source stimulus and those of a target (Gentner, 1983; Gentner & Markman, 1994; Holyoak & Thagard, 1989). The mappings established between a target and a source can vary according to whether they are based on relatively concrete perceptual similarities (e.g., common appearance) or more abstract conceptual similarities (e.g., common relational roles). For example, in comparing the top panel of Figure 1 to the bottom panel, one might match the car in the top picture with the car in the bottom,

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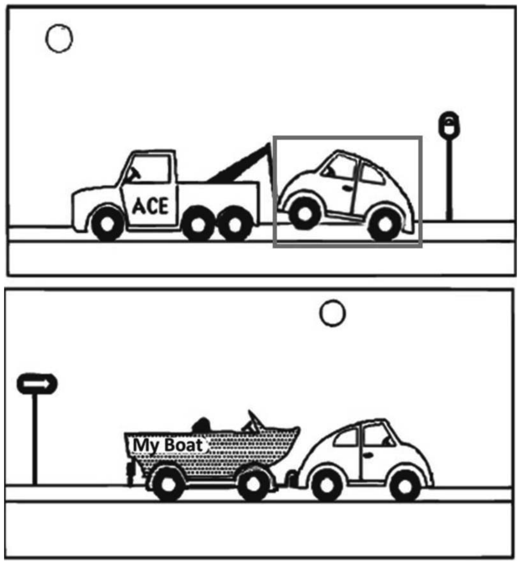

Figure 1. Example of one of the pairs of scenes presented to participants. Participants' task was to select the object in the target scene (the bottom picture) that "goes with" the highlighted object in the source scene (the top picture). In each pair of scenes, the target picture contains both a perceptual match (here, the car) and a relational match (here, the boat).

based on obvious perceptual similarities. However, an alternative mapping could match the car in the top picture with the boat in the bottom picture, because both occupy the relational role of being towed by another vehicle.

Previous research has shown that a variety of factors influence whether people's mappings are based on concrete perceptual commonalities versus abstract relational commonalities (e.g., Gentner & Namy, 1999; Goldstone, Medin, & Gentner, 1991; Goldwater & Markman, 2011; Holyoak & Thagard, 1989; Markman & Gentner, 1993; Ross, 1989; Vendetti, Wu, & Holyoak, 2014). We argue that whether two stimuli are presented simultaneously or sequentially is a basic factor that influences the relative salience of perceptual versus relational similarities, and thus whether mappings between the stimuli are based on common surface form or on a structural alignment of relational commonalities.

Transcending Direct Experience

We propose that when comparing a present target to a source that is absent from (vs. present within) direct experience, people use a higher level construal that emphasizes their more abstract structural properties over their more concrete perceptual properties. This proposal is based on construal level theory (CLT), which states that the ability to consider stimuli that are removed from direct experience is made possible by abstract thought, or high-level construal (see Trope & Liberman, 2010). Because the removal of a stimulus from direct experience entails a loss of access to its concrete perceptual details, if one is to maintain a mental representation of the stimulus in its absence, she must come to represent it at a conceptual level that does not depend on direct physical perception. According to CLT, people accomplish this by engaging in abstract processing that structures mental representations of stimuli around their central meaning while omitting incidental and peripheral features. A natural consequence is that memories will tend to be structured around more abstract representations of a stimulus or event than representations that are formed in its direct presence (Bartlett, 1932; Rumelhart & Ortony, 1977; see also Posner & Keele, 1970).

The research presented here also supports fuzzy trace theory (FTT), which argues that people maintain mental representations of past events by processing and storing information at multiple levels of abstraction in parallel (Brainerd & Reyna, 2002; Reyna, 2012). This results in the construction of both concrete representations, or "verbatim traces," that capture surface form and function to represent stimuli exactly as they appear; and more abstract representations, or "gist traces," that capture central meaning and omit low-level details specific to a single perceptual experience. Importantly, these representations have been shown to be dissociable such that the accessibility of concrete, or verbatim, representations declines rapidly as a stimulus becomes farther removed from direct experience, while more abstract, or gist, representations remain more stable over time. As result, when recalling information from memory, people tend to rely more on abstract representations of gist meaning as the stimulus becomes farther removed from direct experience (e.g., Fukukura, Ferguson, & Fujita, 2013; for review, see Reyna & Brainerd, 1995).

Overall, CLT and fuzzy trace theory converge on the central prediction that removing a stimulus from direct experience will lead people to compare it to other stimuli at a more abstract level that focuses on its central meaning and underlying structure. When two stimuli are simultaneously present within one's external environment, the availability of their concrete perceptual details for direct reference should increase the relative salience of any perceptual similarities and lead to greater weighting of concrete verbatim representations during comparison. Here, people should be more likely to establish mappings based on perceptual matches. On the other hand, when one of the stimuli is absent, the lack of access to its concrete perceptual details means people must rely on an abstract conceptual representation of it. As a result, comparing a present target to an absent source should increase the relative salience of more abstract commonalities, such as common relational structures, and increase reliance on gist representations. This should promote more relational mappings.

Present Research

In the current research, we provide evidence that relating a present target to an absent source leads people to focus on more abstract commonalities than when relating two presently available stimuli. We explore this by investigating the mappings that people draw between two distinct scenes and whether their mappings differ depending on whether the two scenes are presented sequentially or simultaneously. We adopted a picture mapping task used in previous research (see Markman & Gentner, 1993; Tohill & Holyoak, 2000) that presents participants with a pair of scenes, a source and a target, and asks them to identify correspondences across them. In this task, correspondences can be established based either on perceptual or relational similarities (see Figure 1).

We manipulated whether the source scene in the comparison was present or absent from the context of the target scene by presenting the two either simultaneously or sequentially. We predicted that people would tend to make more perceptual matches when the two scenes are presented simultaneously, but more relational matches when the two scenes are presented sequentially. This finding would provide evidence that comparing a present target to an absent source leads people to compare the two along more abstract features than comparing a present target to a concurrently present source. We tested this prediction in two studies, the second of which was a direct replication of the first.

Method

Participants

One hundred forty participants (51% female; $M_{age} = 37.44$; range = 19–70 years) and 144 participants (51% female; $M_{age} = 38.08$; range = 18–73 years) were recruited online through Amazon's Mechanical Turk for Studies 1 and 2, respectively. The sample sizes for Study 1 and Study 2 were determined to achieve approximately 80% power to detect a medium effect size ($d = .50$). For Study 1, this effect size was estimated based on pilot testing. For Study 2, the effect size was estimated using the observed effect size from Study 1.

Procedure

The procedure for Studies 1 and 2 was identical. Participants were randomly assigned to either the sequential presentation condition (Study 1: $n = 68$; Study 2: $n = 71$) or the simultaneous presentation condition (Study 1: $n = 71$; Study 2: $n = 73$). In each condition, participants were shown five pairs of pictures. In each pair, one of the pictures served as the source and the other as the target. All procedures were approved by New York University's Institutional Review Board.

Manipulation

Participants in the sequential condition received the following instructions:

> In what follows, you will be shown five pairs of pictures. For each pair, you will see the pictures one at a time and you will be given 5 s to examine each. After you see both pictures in the pair for 5 s, the first picture will reappear and one of the objects in this picture will become highlighted. After you see what object has been highlighted, click the arrows to proceed onto the second picture. At this point, you should think about which object in the second picture corresponds to the object highlighted in the first picture. After you have decided, click the arrows and then type in the response box the name of the object in the second picture that corresponds to the object highlighted from the first picture.

Participants in the simultaneous condition received a different set of instructions:

> In what follows, you will be shown pairs of pictures and will be given 10 s to examine them. After 10 s, one of the objects in the top picture will become highlighted. At this point, you should think about which object in the bottom picture corresponds to the object highlighted in the top picture. Once you have made a decision, click the arrows, and then type the name of this object in the response box.

Thus, for each pair of pictures, participants in both conditions completed an initial presentation phase—where they saw the pictures for the first time—and a mapping phase—where they saw an object become highlighted in the source and had a chance to map it onto a corresponding object in the target. In the initial presentation phase, participants were given 10 s total (5 s on each picture in the sequential condition and 10 s on the pair of pictures in the simultaneous condition). During the mapping phase, participants were given as much time as they wanted. After studying the pictures during the mapping phase, all participants clicked to proceed to the response page which only displayed the following question, "What in the second (*bottom*) picture corresponds to the object that was highlighted in the first (*top*) picture?" (see Figure 2). Participants entered their response in a text box below.

Dependent Measure

Our main dependent measure was the proportion of relational matches that participants made. This measure was obtained by coding participants' text responses for whether they identified an object occupying the same relational role (coded as 1), or an object that looked similar as corresponding to the highlighted object (coded as 0). Any response that could not easily be categorized as a relational or a perceptual match was left uncoded and was not factored into that participant's overall proportion. The final measure was the proportion of coded responses that were relational matches. Additionally, we measured how long participants spent on the screens during the mapping phase (see Figure 2).

Results

Study 1

One participant was excluded from these analyses for failing to provide any responses that could be coded as either a relational or a perceptual match. Overall, only 10% of responses in Study 1 were left uncoded and the average number of analyzable responses provided by each participant was 4.55 (out of 5). The average number of uncoded responses did not differ between conditions ($p > .30$). More importantly, there was not a significant correlation between the number of uncoded responses and the proportion relational matches, $r = -.04$, $p = .65$.

As predicted, we found that participants in the sequential condition made a higher proportion of mappings based on relational matches ($M = .60$, $SD = .37$) than participants in the simultaneous condition ($M = .43$, $SD = .35$), $t(137) = 2.82$, $p < .01$, $d = .48$ (see Figure 3). Previous research on comparison has shown that increasing the amount of time people spend making a comparison tends to increase the extent to which people focus on global (over local) features of the stimuli involved in the comparison (Goldstone & Medin, 1994). In a secondary analysis seeking to rule out time spent on the mapping phase of the task as an alternative explanation, we conducted a multivariate regression and found that the effect of condition on the proportion of relational matches remained significant even when adjusting for the amount of time spent during mapping phase of each trial, $b = .08$, $SE = .03$, $t(136) = 2.62$, $p = .01$, $r_{semipartial} = .22$.

Study 2

Again, one participant was excluded from these analyses for failing to provide any responses that could be coded as either a relational or a perceptual match. Overall, only 9% of responses in

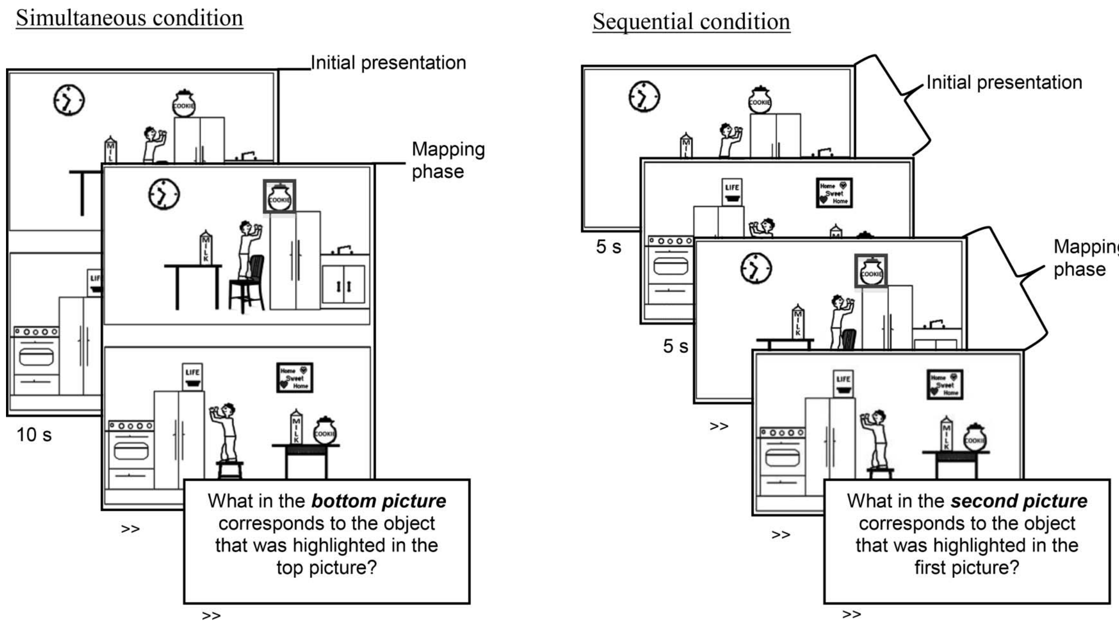

Figure 2. Schematic of how the pairs of scenes were presented to participants in each condition.

Study 2 were left uncoded and the average number of analyzable responses provided by each participant was 4.57 (out of 5). Although the average number of uncoded responses was marginally different between conditions ($p = .09$), the number of uncoded responses was not significantly related to the proportion of relational matches, $r = .01$, $p = .95$.

Replicating Study 1, we found that participants in the sequential condition made a higher proportion of mappings based on relational matches ($M = .55$, $SD = .39$) than participants in the simultaneous condition ($M = .39$, $SD = .36$), $t(141) = 2.52$, $p = .01$, $d = .42$ (see Figure 3). Additionally, we again found that participants in the sequential condition made a higher proportion of relational matches than did participants in the simultaneous condition even when adjusting for time spent during the mapping phase of each trial, $b = .07$, $SE = .03$, $t(140) = 2.20$, $p = .03$, $r_{\text{semipartial}} = .18$. Data files for both studies are available at osf.io/cxkpn.

Discussion

We found that when comparing two scenes, presenting them sequentially led people to focus more on their relational commonalities, whereas presenting the same scenes simultaneously led people to focus more on their perceptual commonalities. Impor-

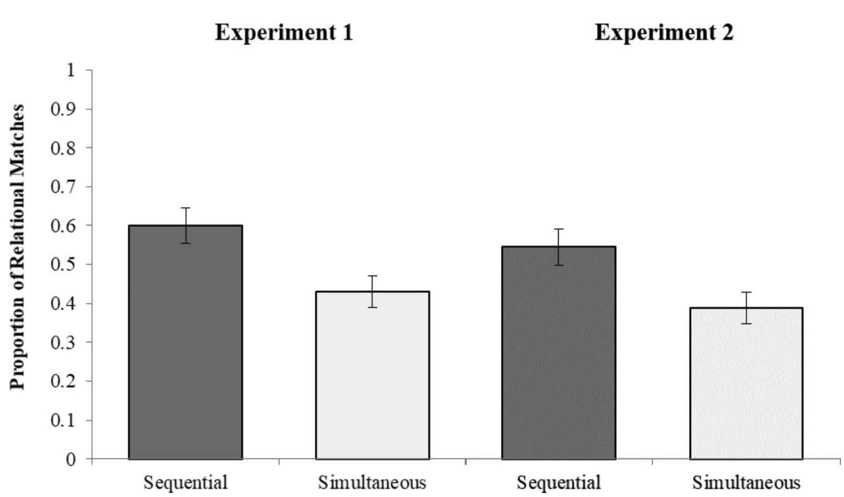

Figure 3. Proportion of relational matches made by participants within each condition. In both Experiments 1 and 2, participants made more relational matches (vs. perceptual matches) between two scenes when the scenes were presented sequentially on different screens than when they were presented simultaneously on the same screen. Error bars represent 1 standard error above and below the mean.

tantly, this increase in relational matching is not simply the result of a lack of perceptual matching. Instead, we propose that relational matches were the result of a shift in cognitive processing toward more abstract levels of conceptual representation (see also Reyna & Brainerd, 1995). The open-ended design of our current studies supports this interpretation. Because the relational match was never supplied, any such response was the result of active engagement in abstract processing.

Access, Availability, and Use in Comparisons

By focusing on the process of mapping correspondences between a source and a target, the present investigation pertains specifically to the issue of how a given source is used to make sense of a target, provided that it has indeed been accessed for comparison. The question of how a source is *used* in a comparison is distinct from the question of whether that source is *accessed* for comparison in the first place. Previous research has shown that when a source and a target are encountered sequentially, the likelihood of accessing the source for comparison to the target depends more on their superficial similarity than their structural similarity (Gentner, Rattermann, & Forbus, 1993; Ross, 1989). In the present work, we demonstrate that once a previously encountered source has been accessed for use in a comparison, people will tend to focus more on its relational structure than if that source is encountered simultaneously with the target. Our results taken together with previous literature may suggest an interactive pattern such that, when stimuli are presented sequentially, the likelihood of accessing a given source for comparison is based more on superficial similarity but that, once accessed, the use of the source in the comparison is guided more by relational similarities (see also Gentner et al., 1993; Ross, 1989).

Furthermore, even when an appropriate source has been accessed, in order for a given relational structure guide comparison, that relational structure must first be *available* to the perceiver. In the studies presented here, the stimuli depicted simple relationships that were presumably familiar to participants. In cases where a particular underlying structure within a source is novel or unavailable to a perceiver, it is possible that sequential presentation may negatively impact the likelihood of identifying that relational structure at all.

Highlighting these distinctions between *access, availability*, and *use* can help reconcile the current findings with previous work, which has consistently shown that presenting two examples of a problem together (vs. sequentially as isolated cases) increases the likelihood that people extract their common relational structure and apply it to future analogous problems (e.g., Gentner, Loewenstein, & Thompson, 2003; Loewenstein, Thompson, & Gentner, 1999; Richland & McDonough, 2010; Rittle-Johnson & Star, 2007; for meta-analysis, see Alfieri, Nokes-Malach, & Schunn, 2013). In these cases, simultaneous presentation affords two potential benefits. First, it increases the likelihood that people *access* the appropriate source and use it during comparison (often through explicit instructions to compare the two examples) whereas people often treat the sequentially presented examples as separate isolated cases and fail to compare them at all. Second, simultaneous presentation may facilitate the initial learning of novel structural relationships by easing the demands placed on working memory while an individual engages in structural alignment of the various elements of potentially complex scenes.

However, while sequential presentation may present obstacles to successful analogical transfer from a source to a target, classic studies show that if the appropriate source is accessed and its underlying relational structure is available, people can use that structure to guide analogical transfer to a subsequent target (Gick & Holyoak, 1983). That is, if people are taught the underlying structure of a source problem and are reminded of that source when presented with a target, they can use that source to generate an analogical solution for the target problem.

Importantly, the findings of the present research pertain specifically to the issue of level of processing in comparison rather than issues of access to and availability of any particular mental representation of a structural relationship, though such questions represent important avenues for future research.

The Prospective Function of Memory

The current research may speak to the role of abstraction in the prospective function of memory. Proponents of this functionalist account of memory argue that its primary purpose is to support prospection by using past experience to construct simulations of anticipated future events (Schacter, Addis, & Buckner, 2007). However, in contrast to accounts positing that people simulate future events by recombining concrete details of past experiences, we argue that abstract thought that omits such concrete details is critical for prospection (see also Reyna, Rahimi-Golkhandan, Garavito, & Helm, 2018). From our perspective, the central challenge for memory is not to construct mental representations that mirror an experience as an exact replica, but rather to construct and call upon mental representations from past experience that are useful for guiding behavior in subsequent contexts.

Abstraction facilitates the application of memories to subsequent situations by emphasizing general underlying structures that are consistent across discrepant contexts wherein circumstantial details are liable to vary. Thus, not only does abstract conceptual thought enable people to maintain a mental representation of an event or object after it is removed from direct perception, it also supports the application of that mental representation to diverse contexts.

Taken together, the research presented here may have far-reaching implications for memory-based reasoning. Our results highlight the propensity for people to engage in abstract processing when applying memory from one experience to subsequent contexts. This suggests that when people draw upon memory of previously encountered stimuli to make sense of their current experience, their categorizations, evaluations, and understanding will be based on higher level representations than when they compare concurrently present stimuli.

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