

# Accessing Distant Analogs Over Superficial Matches: ¿How Efficient is the Architecture of our Retrieval Systems?

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## Abstract

Traditional results using a cued-recall paradigm have allegedly demonstrated that distant analogs tend to be retrieved less often than disanalogous matches maintaining only surface similarity. Recent results, however, suggest that said advantage may be due to the inadvertent inclusion of structural similarity in surface matches. In two experiments we had distant analogs compete in LTM with two types of surface matches lacking any degree of structural overlap, but equated with the target in terms of element similarities. Distant analogs were less retrieved than stories maintaining similar first-order relations and objects with the target, but no overlapping structure. This difference disappeared when surface similarity involved only similar objects. Results show that the surface superiority effect relies on the type of surface matches that compete with distant analogs, thus suggesting a more complex picture of the forces that govern access to similar items in memory.

**Keywords:** analogy; retrieval; similarity; competition

## Introduction

When dealing with pressing situations like solving a problem, making a prediction, or seeking an explanation, a potentially useful heuristic consists in retrieving structurally similar episodes from long-term memory (LTM). By establishing a mapping between the current situation (*target analog*) and a structurally similar episode stored in LTM (*base analog*), the reasoner can export causal structures from the base to the target, thus advancing in the resolution of the task at hand. Potentially useful base analogs could belong to domains of knowledge that differ from that of the target. These base analogs pose a challenge to our retrieval mechanisms, since they resemble the target at an abstract level (structural similarity), but lack semantic resemblances at the level of individual elements (surface similarity).

To be fully adaptive, our memory systems should get all the information we need, but without retrieving more than we can use (Thagard, Holyoak, Nelson, & Gochfeld, 1990). Hence, an additional challenge for retrieving purely structural matches consists in avoiding the activation of superficial matches, which could outcompete structural matches during retrieval.

A long empirical tradition dating back to the 90s (e.g., Gentner, Rattermann, & Forbus, 1993; Wharton, Holyoak, & Lange, 1996) had allegedly demonstrated that purely superficial matches are more easily retrieved than purely structural matches. However, more recent studies (e.g., Raynal, Clement, & Sander,

2017, 2020) have claimed that the superiority of surface similarity obtained in prior studies does not reflect a competence limitation of our cognitive architecture, but rather an artifact of faulty experimental materials. Having amended the shortcomings of these materials, they elicited a majority of purely structural reminders. The aim of the present research is to further illuminate the debate about the relative difficulty of retrieving surface vs. structural matches from LTM. Before describing the results of two experiments, we briefly review the evidence supporting the surface superiority and the structural superiority accounts of analogical retrieval.

## The Surface Superiority Account

Using a cued-recall paradigm, Gentner et al. (1993) compared the retrieval of purely structural analogs with that of base items maintaining other types of similarities with the target. During a first phase of the procedure, participants were presented with short stories (all of them structurally different from each other), interleaved with distracters. To exemplify, in the base story of one of the critical sets an old hawk was attacked by a hunter whose arrows had no feathers. As Karla knew he wanted her feathers, she glided down and offered to give him a few, for what he pledged never to shoot at a hawk again. During a subsequent phase, participants received target stories—each of them bearing one of three types of similarity with one of the source stories of the prior session—and were asked to state which stories of the prior phase they were reminded of. One type of superficially similar targets had similar objects and first-order relations (*mere appearance matches*), but organized in a way allegedly not paralleling that of the base story. Keeping with the Karla set, the mere appearance target told about an eagle named Zerdia who had donated a few of her tailfeathers to a sportsman so he would promise never to attack eagles. One day Zerdia saw the sportsman coming with a crossbow and flew down to meet the man, but he attacked and felled her with a single bolt.

Results showed that the base stories were much more often retrieved after the presentation of superficially similar items than after the presentation of purely analogous stories. In contrast to the activity of evaluating the quality of an analogy, which relies mostly on abstract parallelisms, retrieval was therefore modeled as being driven mostly, though not exclusively, by low-level, semantic similarities between the individual elements that comprise the base and the target.

Explanations for this suboptimal retrieval pattern range from the computational to the evolutionary. In terms of computation, it has been considered that in contrast to the activity of comparing two situations concurrently active in working memory, which is computationally costly but ultimately tractable, the possibility of carrying out full structural matches between a target and all the items stored in LTM is psychologically unrealistic (Forbus, Gentner, & Law, 1995). From an evolutionary perspective, the sophisticated machinery capable of computing structural comparisons—a relative newcomer in evolutionary history—was conceived as running on the output of more archaic memory systems driven by element similarity. In terms of adaptation, it has been argued that in the Pleistocene environment in which our ancestors evolved, a failure to retrieve purely structural matches did not entail a serious limitation. As surface similarities were correlated with deeper, structural features (the *kind world hypothesis*, Gentner, 1989), the use of surface features as memory cues still supported the retrieval of literal similes, of comparatively higher inferential potential. This reliance on surface-level features might represent a more serious limitation when it comes to applying knowledge structures across disparate domains, as it is often the case while learning and reasoning in the STEM disciplines. In view of the potential implications of our memory architecture for cross-domain transfer, considerable efforts have been spent in devising ways of highlighting the structural features of educational contents, so as to increase their probabilities of being retrieved during the subsequent processing of analogous cases lacking surface similarity (e.g., Bernardo, 2001; Catrambone & Holyoak, 1989; Kubricht, Lu, & Holyoak, 2018).

### The Structural Superiority Account

Counter to this rather pessimistic conception of our retrieval mechanisms as an evolutionary *kluge* (an inelegant design resulting from haphazard mutations, Marcus, 2008), several authors (e.g., Blanchette & Dunbar, 2000; O'Keefe & Costello, 2008; Raynal, Clement, & Sander, 2017, 2020) have contended that the retrieval advantage of superficially similar items over purely structural matches is not the result of a faulty cognitive architecture, but rather an artifact of faulty experimental materials. According to Raynal et al., it stemmed from the fact that the target stories allegedly maintaining only surface similarity with the sources, inadvertently maintained non-negligible degrees of structural overlap as well. Even though the outcomes of the stories differ, previous segments of the overall structure render the stories analogous to a large extent. Going back to the Gentner et al. (1993) sample set presented above, in both cases someone attempts to avoid an attack by giving the attacker something that she presumes he wants, and the aggressor promises not to attack. In Raynal et al.'s (2020) words “Thus, the SSD [superficially similar disanalogs] target cue appears to be a literal match until the outcome of the stories differ (e.g., betrayal versus respect of this deal” (p. 3). In view of this potential confounding, it is hard to determine whether the retrieval advantage of superficially similar disanalogs over superficially dissimilar analogs reflects

a higher sensitivity to superficial features, or a sensitivity to the combination of structural plus superficial features.

In a recent attempt to readdress Gentner et al.'s (1993) superficial superiority hypothesis, Raynal et al. (2017, 2020) built a new set of stories wherein a distant analog competed in LTM against a superficially-similar story that did not maintain any kind of structural similarity with the target. This target told about an ambulant pizzaiolo who held a pizza truck in a popular place, but who reacted to the inconvenient settlement of another pizzaiolo in a nearby location by giving him generous advice about how to improve his dough. The target story ended that in order to show the former pizzaiolo how much he found his intention was nice, the second pizzaiolo relocated his truck to avoid competing with him. While the superficially dissimilar source analog reinstated this same abstract structure in the context of two girls who competed for attention from a boy to whom they are both attracted, the superficially similar disanalog told of a food truck called “At Alessandro & Fabio's”, whose clientele were fond of the authentic atmosphere steaming from this stand, held by two happy looking pizzaioli dressed in traditional Italian suits. However, the story ended that once the two pizzaioli had left this selling space, they switched to traditional German clothes for selling sausage specialties at “Hans and Hendrich's”.

Raynal et al. (2017, 2020) found that the retrieval of superficially dissimilar analogs (80%) was nearly four times higher than that of superficially similar disanalogs, a pattern of results that stands in sharp contrast with those obtained by Gentner et al. (1993): 20% distant analogs vs. 60% of mere-appearance matches. Given that the retrieval of superficially dissimilar analogs could not be attributed to the concurrent presence of structural similarity, the authors argued that surface similarity does not represent the main contributor to retrieval. On this account, our cognitive architecture is reasonably well-suited for locating abstractly related source analogs in LTM despite the competing effect of purely superficial matches.

### The Present Study

While we tend sympathize with Raynal et al.'s (2017, 2020) claim that structural overlap should be eliminated from superficially similar disanalogs, we contend that their attempt to remove structural similarity inconveniently entailed removing any overlap at the level of first-order relations, whose presence in Gentner et al.'s (1993) mere appearance matches was *definitional*. Rather than being an improved version of mere-appearance matches, Raynal et al.'s superficially similar disanalog should be considered somewhat akin to Gentner et al.'s (Experiment 3) *objects-only matches*, which resembled the source in terms of objects but not in relations. Given that mere appearance matches are more similar to their corresponding target than objects-only matches, a proper way of determining whether purely structural isomorphs are outcompeted by superficially similar disanalogs should distinguish between the potentially competing effect of these two types of similes. Following Raynal et al.'s remark about

the shortcomings of mere appearance matches used in prior studies, our mere-appearance matches were not just literal similes with a different final outcome, but stories built anew so that the first-order relations occupied completely different roles in the overall structure. In this way, they only shared with the target isolated actions, which were causally connected in a completely alternative way.

When pitting the effect of surface vs. structural similarity against each other, attention should also be drawn to the number of structural vs. superficial features in the materials. As a contrasting case, consider prior attempts to document the effects of either surface or structural similarity (e.g., Wharton, Holyoak, & Lange, 1996 and Trench & Minervino, 2015, respectively). The manipulations involved in these demonstrations only require two different levels (e.g. high vs low, high vs. moderate or some vs. none) of either surface or structural similarity, thus allowing for various degrees of freedom as to how to implement the intended manipulation. But when trying to determine which type of similarity exerts a stronger effect, there needs to be a more principled way of ensuring that the degree of structure in the structural source roughly equals the degree of surface in the superficially similar sources, be them of the mere-appearance or the objects only type. To be more concrete, imagine that we wanted to generate an objects-only match for the pizzaioli story whose degree of superficiality would match the degree of structural similarity between said target and the flirtatious girls' scenario. Should we include just two similar objects—as in Hans & Heinrich's story—or a near-ceiling proportion of them? In order to lay down a more leveled ground upon which the effects of structural and surface similarity could be contrasted, we constructed our materials such that the number of similar first order relations and/or similar objects in the mere-appearance and objects-only items equaled the number of structurally relevant first-order relations in the distant analogs.

With regards to the experimental design, we followed Raynal et al.'s (2017) decision to have the structural and the superficial sources of the same material sets compete in the LTM of participants, as opposed to having the target relate to either the structural or the superficial source, as implemented in Gentner et al. (1993). The rationale behind this decision involves being representative of the prevalent real-life condition wherein distant analogs coexist with purely superficial matches in memory.

## Experiment 1

### Method

**Participants** Sixty undergraduate students of Psychology volunteered to participate in the study. They were randomly assigned in equal number to the relations plus objects (R+O) and the objects-only (OO) conditions.

**Materials** Four sets of stories were built, each one containing a target situation and three source situations maintaining different types of similarity with the target. Superficially dissimilar analogs shared a system of higher-order relations

with the target, such that a comprehensive schema could eventually be built to encompass both situations. While first order relations were similar but not identical to those of the target, objects were different. As an example, the target of one of our four sets told the story of a tennis player who was infatuated with his girlfriend and often bragged about her beauty in front of his friends. One of his friends got sick of his behavior and invited her to a party, with the result that a few months later he begun a relationship with her. The story ended that the tennis player lamented his exhibitionist behavior ever since. The superficially dissimilar source analog of this same set told about a clever scientist who was fascinated by his new theory and boasted about it in front of his graduate students. Tired about this attitude, one of his students took away the notebooks of the scientist and afterwards claimed authorship. This story ended that the professor long regretted having boasted about his theory the way he did (see Table 1 for a sample set of materials). In contrast to superficially dissimilar analogs, R+O sources had similar first-order relations as well as similar objects and object properties to those of the targets, but embedded in a network of second-order relations that did not maintain any degree of structural similarity with the target. Keeping with the above set of materials, the R+O source told that the pretty wife of a soccer player was taken to a party by another player of the team, who later became her husband. To alleviate his suffering, the former husband began boasting about having been married to such a pretty girl, an attitude that other team mates did not approve, and which later became a source of regret in itself. As can be appreciated, the analogous items shared the structure “bragging about a valuable thing causes irritation in another person and this motivates that the valuable thing gets appropriated by this other person”. Such structure is completely absent in the mere-appearance story. Finally, OO sources only shared similar objects with the target. In keeping with the above set of materials, the OO story told about a handsome soccer player who owed some money to a lady of outstanding beauty, but did not tell this team mates about this because he considered it wasn't relevant. He later took his teammates to a party without knowing she was working there. When she saw him, she immediately raised the topic of the debt, and he pretended having forgotten about it. Across the four sets of materials, if a distant analog shared  $n$  relevant relations with the target, the objects-only match was constructed so as to share  $n$  objects or object properties with it. In turn, the mere-appearance matches were built so as to share  $n$  relations plus  $n$  objects or object properties with the target. Six filler stories were built, bearing neither superficial nor structural resemblances with any of the critical stories. Four of these stories were interleaved among the 12 critical stories of the learning phase, and two were interleaved among the four stories included in the cued-recall phase.

**Procedure** During the encoding phase, participants of both conditions received a booklet including three groups of four short stories between 80 and 100 words in length. All four stories of each group appeared on a single page, and were

preceded by written instructions asking participants to read the stories very carefully, so as to be able to reproduce them in detail. Once the 6 min allotted to reading each group had elapsed, participants were asked to reproduce the 4 stories on the reverse of the page without being able to reread them.

Table 1: Sample set of source and target stories used in Experiments 1 and 2

**Target story.** Andrea was quite *stingy*. She noticed that the *door of the oven* was not closing very well. She thought of calling the *gas worker*, but anticipated that he would charge her a lot of *money*. She decided to call him later on, when her *economy* got better. In the meantime, she would work it out by placing a *latch* to attach the door to the *gas cooker*. It was not *aesthetic*. But as it functioned properly, she ended up never calling the gas worker.

**Relations plus objects (R+O) match.** Natalie was quite *thrifty*. Those days the electrical installations of the house ceased to work. Even though her *finances* were brittle, and that she knew it would cost a lot of *cash*, she hired the *electrician* to fix the installations. She learned a lot watching him work. One day she applied what she had learned to fix the *lid of mixer*, which was adjusting to the jar. She added some *pegs*, which fastened it to the *jar*. Although the jar was not *pretty*, she called the electrician to tell him about her achievement.

**Objects-only (OO) match.** Sophie was quite *thrifty*. She kept her savings inside a *mixer* without a *lid*. While she was counting her money, the *electrician* rang her bell in order to retrieve some *pegs* he had forgotten. As he started talking about public *finances*, she was only thinking about her having left all the money quite *messy*, such that anyone who paid a visit would know how much *cash* she had saved. She told the electrician she had to say goodbye to him in order to leave for work. When he left, she rushed to tide up her money and hide the mixer.

**Superficially dissimilar analog (Experiment 1).** Karen felt that her goalkeeper gloves were no longer fit to her hands. She thought of asking a *seamstress* for help, but guessed that this would take too long. Independent as she was, she decided to fix them herself, and to take them to the seamstress when her fixture got less tight. She had them fasten her wrists by attaching some rubber bands to the gloves so as to make them fasten to her wrists. They looked rather odd, but as they worked, she ended up never asking the seamstress for help.

**Superficially dissimilar analog (Experiment 2).** Thinking in his London students, the Russian professor had written a textbook in English, whose grammar made the reading *uneasy*. He thought of hiring an English teacher to improve it, but realized that this would take months, and his students needed the textbook right away. In an expeditious manner, he decided to employ a google translator, and to hire a native expert once classes concluded. Several poorly-written segments remained. But as students somewhat managed to learn with this version, he ended up never calling a native speaker.

*Note.* Underlined words represent similar first-order relations across the source and the targets. Italized expressions represent similar objects and object properties across the base and the targets. The English translation does not strictly respect the original wording.

The booklets received by participants in the R+O condition included the distant analogs and the R+O matches of each set in counterbalanced order and interleaved with four distracters. The analog and the R+O match of each set were separated by at least 3 stories from different sets. The OO booklets followed a similar structure, with the difference that R+O stories were replaced by the OO stories from their corresponding sets.

After a short break, participants were handed a second booklet containing the target stories of each set, interleaved by two unrelated stories serving as distracters. For each of them they were asked to state which of the stories read during the previous session this new story reminded them of. They were told that they could report more than one, or leave the space blank if no stories were recalled. There was no time limit for this second task.

## Results and Discussion

Figure 1 displays the retrieval rates of distant analogs, R+O matches and OO matches by the R+O and the OO conditions. During the learning phase, the R+O group had received the superficially dissimilar analog as well as the R+O source of each of the four sets of materials. Two judges not acquainted with the purpose of the study received each participant's responses together with the stories read by such participant during the previous phase. For each of the participants' responses, they were asked to identify which of the studied stories it referred to. A base story was coded as retrieved whenever there was agreement between both judges. Judges agreed in 93% of the cases, and solved cases of disagreement by discussion. The R+O disanalog was retrieved more often than the superficially dissimilar analogs,  $M = .96$  ( $SD = .12$ ) vs.  $M = .53$  ( $SD = .27$ ),  $t(29) = -8.097$ ,  $p < .001$ . As in traditional cued recall studies like Gentner et al. (1993), these results reveal that the joint presence of similar objects and first-order relations exerted a more powerful effect on retrieval than purely structural similarity. Given that we followed Raynal et al.'s (2017) suggestion to avoid any degree of structural similarity in the superficially similar disanalog, the results are immune to the possible confounding allegedly affecting Gentner et al.'s materials.

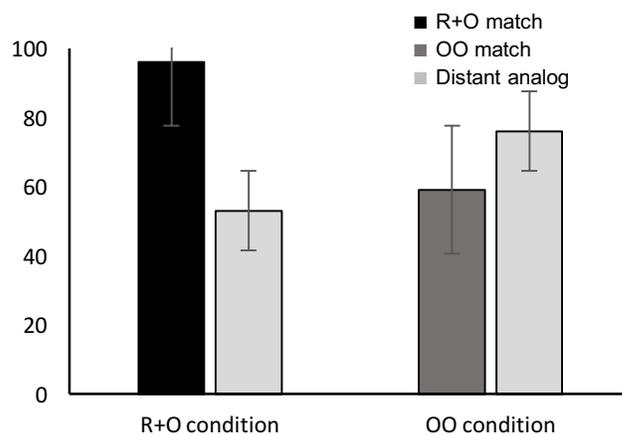


Figure 1. Percentages of R+O matches, OO matches, and distant analogs retrieved, Experiment 1.

As opposed to the R+O group, the OO group had received the superficially dissimilar analog as well as the OO source of each of the four sets of materials. There was a nonsignificant trend towards a higher retrieval of the superficially dissimilar analogs over the OO disanalogs,  $M = .76$  ( $SD = .23$ ) vs.  $M = .59$  ( $SD = .34$ ),  $t(29) = 1.980$ ,  $p = .057$ .

Quite notably, the retrieval rates of superficially dissimilar analogs across conditions amply surpasses those obtained in traditional studies like Gentner et al. (1993) or Wharton et al. (1996). In order to assess whether these unusual levels of distant retrieval reflect a suboptimal semantic distance between the superficially dissimilar sources and their corresponding targets, in Experiment 2 we modified the first order relations and objects of the superficially dissimilar analogs so as to make them more distant from the corresponding ones in the target. The new objects and relations still rendered the situations analogous, but at a higher level of abstraction.

Planned comparisons also revealed that retrieval of analogs was lower when competing in LTM against R+O matches than against OO matches,  $M = .53$  ( $SD = .27$ ) vs.  $M = .76$  ( $SD = .23$ ),  $t(58) = -3.564$ ,  $p = .001$ . The increased retrieval rate of distant analogs in the OO group as compared to that of the R+O condition suggests that the presence of a stronger surface competitor in LTM might exert a detrimental effect on the retrieval of a structural analog. Hence, an additional objective of Experiment 2 was to replicate and generalize this finding.

## Experiment 2

### Method

**Participants** Sixty undergraduate students of Psychology volunteered to participate in the study. They were randomly assigned in equal number to the R+O and the OO conditions.

**Procedure and Materials** Materials were identical to those of Experiment 1, except that the superficially dissimilar analogs included first-order relations that were more different from their corresponding elements in the target than those of Experiment 1. In keeping with the story set described in Experiment 1, the target situation told the story of a tennis player who was infatuated with his girlfriend and often presumed about her beauty in front of his friends, with the result that one of his friends got sick with his behavior and invited her to a party and later begun a relationship with her. As opposed to the superficially dissimilar analog used in Experiment 1—which told about a scientist who presumed about his new theory in front of his graduate students, with the result that one of his students took away the notebooks of the scientist and afterwards claimed authorship—the distant analog used in Experiment 2 told about a wealthy family who openly enjoyed the luxurious playground of their property before the eyes of their humble neighbors, who objected this reckless fun. When the family went out for vacation, their neighbors got in and made irresponsible use of the facilities. As this example illustrates, while the analogy of Experiment 1 includes two cases wherein bragging causes appropriation, the superficially dissimilar analog of Experiment 2 constituted an

episode wherein the reckless enjoyment of a valuable object leads to an unconsented use by others (see Table 1 for a complete example). The procedure and coding scheme followed with the R+O and OO groups was identical to that of Experiment 1. A base story was coded as retrieved whenever there was agreement between both judges. They agreed in 87% of the cases, and solved cases of disagreement by discussion.

### Results and Discussion

Figure 2 displays the retrieval rates of distant analogs, R+O matches and OO matches by the R+O and the OO conditions. As in Experiment 1, the R+O group retrieved the R+O disanalogs more often than the superficially dissimilar analogs,  $M = .97$  ( $SD = .09$ ) vs.  $M = .28$  ( $SD = .27$ ),  $t(29) = -13.006$ ,  $p < .001$ . In contrast, retrieval of the OO stories did not differ from that of the superficially dissimilar analogs,  $M = .72$  ( $SD = .24$ ) vs.  $M = .71$  ( $SD = .2$ ),  $t(29) = -.177$ ,  $p = .861$ . As in Experiment 1, the retrieval of distant analogs was lower when competing in LTM against R+O matches than against OO matches,  $M = .28$ ,  $SD = .27$ , vs.  $M = .71$ ,  $SD = .2$ ,  $t(58) = 7.168$ ,  $p < .001$ . Taken collectively, results showed that having resorted to more distant analogs did not alter the general retrieval patterns obtained in Experiment 1.

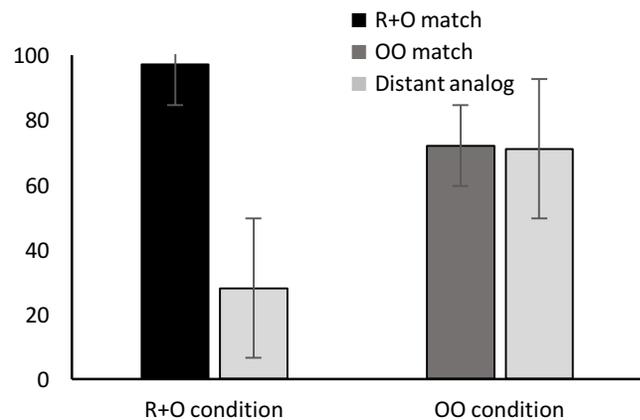


Figure 2. Percentages of R+O matches, OO matches, and distant analogs retrieved, Experiment 2

### General Discussion

In two experiments we obtained that superficially similar disanalogs sharing similar first-order relations as well as similar objects with the target (i.e., mere-appearance matches) were more frequently retrieved than superficially dissimilar analogs. This retrieval advantage is in line with traditional results of the story-reminding tradition, typically interpreted as evidence for the superiority of surface similarity during memory retrieval. Raynal et al. (2017, 2020) had contended that the superior retrievability of mere-appearance matches obtained by Gentner et al. (1993) could have originated in the inadvertent inclusion of similarity in higher-order relations.

As we built our materials following Raynal et al.'s advice to eradicate overlapping structure from mere-appearance matches (our R+O matches were not just literal similes with a different ending), our results are immune to the abovementioned confounding. It could be argued, however, that if participants were initially reminded of the mere-appearance story, the juxtaposition of this story with the target could have sharpened participant's perception of the relational structure of the target, thus increasing the chances of retrieving the distant analog (i.e. the late abstraction principle, Gentner, Loewenstein, Thompson & Forbus, 2009). Even though this could have been the case had we employed mere-appearance matches which, as denounced by Raynal et al., shared a significant amount of structure with the target, the fact that our mere-appearance items were especially crafted to avoid such overlap renders a relational emphasis rather unlikely, let alone subsequent interdomain retrieval. In a prior study on analogical problem-solving, Minervino, Olguín and Trench (2017) had participants of the experimental condition compare Duncker's (1945) Radiation problem with a disanalogous problem (the *Candle* problem; Duncker, 1945). Minervino et al. expected that despite the lack of a shared system of relations, the challenge of comparing the tumor to the candle problem would still encourage a more abstract representation of the problems' goals and/or restrictions, such as the fact that in both situations one has to prevent a negative outcome from occurring (harming healthy tissues and dripping wax on the floor, respectively). Counter to expectations, participants' comparisons neither led to coherent schemas, nor to subsequent relational retrieval. Based on this evidence, the possibility that distant retrieval could have been inflated by participants spontaneously comparing the target to the mere-appearance match seems very unlikely.

In another condition of our experiments, we had the distant analogs compete in participants' LTM against disanalogous stories maintaining similarity with the target only at the level of individual objects. Unlike the objects-only matches employed by Raynal et al. (2017, 2020), the number of object similarities of our objects-only items was equated to the number of relevant first-order relations in the superficially similar sources. While the results of our first experiment revealed a non-significant trend towards higher retrieval of superficially dissimilar analogs over competing OO matches, no such trend was observed when resorting to superficially dissimilar analogs that were relatively more distant than those of Experiment 1. Whereas the superior retrieval of OO matches in Gentner et al.'s (1993) study could conceivably have originated in the inadvertent inclusion of structural features (Raynal et al., 2020), the opposite result of Raynal et al. might have originated in having included an insufficient number of similar objects. The lack of differences obtained in our OO conditions represents an intermediate position between the results of Gentner et al. and those of Raynal et al., and speaks of a more complex picture than the extreme positions endorsed by the above authors. While Gentner et al. might be right in claiming that superficially similar items having similar objects and first-order relations with the target

are more retrievable than items displaying purely structural similarity, this advantage does not seem to hold when surface similarity reduces to the level of individual objects. Thus, it would seem that our retrieval mechanisms are neither as sophisticated as has recently been proposed, nor as limited as has traditionally been assumed.

Even though the results of our OO conditions did not replicate the advantage of superficially dissimilar analogs over OO matches obtained by Raynal et al. (2017), the raw retrieval rates of our distant analogs of Experiment 1 were overall more similar to those of Raynal et al. than to those of traditional studies of story-reminding. While it is true that the retrieval rates of superficially dissimilar analogs dropped significantly when employing first-order relations and objects that were more distant from the target than the ones employed in Experiment 1, this drop-off was less intense when distant analogs competed with relatively weaker alternatives such as OO matches. Hence, while our results tend to be largely consistent with the superficial superiority hypothesis of analogical retrieval, they are not at odds with Raynal et al.'s claim that the retrieval of distant analogs can on occasions be higher than traditional studies would suggest, especially when their relational structure does not need to be re-represented at relatively high levels of abstraction. It should be noted, however, that the retrieval rates of all three types of base items were somewhat higher than in traditional studies (retrieval of mere-appearance matches was at ceiling in both experiments). This general inflation in the levels of retrieval could perhaps be attributed to the particular tasks we used to enforce an adequate encoding of base items in LTM. As compared to the tasks typically employed by standard studies for said purpose (e.g., ratings of imageability or pleasantness), taking a memory test could have been relatively more conducive to later retention, a phenomenon known as the *testing effect* (Roediger & Karpicke, 2006). Current work is underway to assess whether the unusually high retrieval rates of distant analogs recently obtained with a cued-recall paradigm generalize to more naturalistic procedures lacking an episodic link between the presentation of the target and the encoding of the sources.

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### References

- Bernardo, A. B. I. (2001). Principle explanation and strategic schema abstraction in problem solving. *Memory & Cognition*, *29*, 627-633.
- Blanchette, I. & Dunbar, K. (2000). How analogies are generated: The roles of structural and superficial similarity. *Memory & Cognition*, *28*, 108-124.
- Catrambone, R., & Holyoak, K. J. (1989). Overcoming contextual limitations on problem-solving transfer.

- Journal of Experimental Psychology: Learning, Memory, and Cognition*, 15, 1147-1156.
- Duncker, K. (1945). On problem solving. *Psychological Monographs*, 58 (5, Whole No. 270).
- Forbus, K., Gentner, D., & Law, K. (1995). MAC/FAC: A model of similarity-based retrieval. *Cognitive Science*, 19, 141-204.
- Gentner, D. (1989). The mechanisms of analogical transfer. In S. Vosniadou & A. Ortony (Eds.), *Similarity and analogical reasoning*. Cambridge, UK: Cambridge University Press.
- Gentner, D., Rattermann, M. J., & Forbus, K. (1993). The roles of similarity in transfer: Separating retrievability from inferential soundness. *Cognitive Psychology*, 25, 431-467.
- Gentner, D., Loewenstein, J., Thompson, L., & Forbus, K. (2009). Reviving inert knowledge: Analogical abstraction supports relational retrieval of past events. *Cognitive Science*, 3, 1343-1382.
- Kubricht, J. R., Lu, H., & Holyoak, K. J. (2017). Individual differences in spontaneous analogical transfer. *Memory & Cognition*, 45, 576-588.
- Markus, G. (2008). *Kluge: The Haphazard Evolution of the Human Mind*. New York: Houghton Mifflin.
- Minervino, R., Olguín, V. & Trench, M. (2017). Promoting interdomain analogical transfer: When creating a problem helps to solve a problem, *Memory & Cognition*, 45, 221-232.
- O’Keefe, D., & Costello, F. (2008). A fast computational model of analogical retrieval (and mapping). *Proceedings of the 30<sup>th</sup> Annual Conference of the Cognitive Science Society* (pp. 2003–2008). Austin, TX: Cognitive Science Society.
- Raynal, L., Clement, E., & Sander, E. (2017). Challenging the superficial similarities superiority account for analogical retrieval. *Proceedings of the 39<sup>th</sup> Annual Conference of the Cognitive Science Society* (pp. 2957-2962). Austin, TX: Cognitive Science Society.
- Raynal, L., Clement, E., & Sander, E. (2020). Are Superficially Dissimilar Analogs better retrieved than Superficially Similar Disanalogs? Advance online publication. <https://doi.org/10.1016/j.actpsy.2019.102989>
- Roediger, H. L., & Karpicke, J. D. (2006). Test-enhanced learning: Taking memory tests improves long-term retention. *Psychological Science*, 17, 249-255
- Thagard P., Holyoak K. J., Nelson G., Gochfeld, D. (1990) Analog retrieval by constrain satisfaction. *Artificial Intelligence*, 46, 259–310
- Wharton, C. M., Holyoak, K. J., & Lange, T. E. (1996). Remote analogical reminding. *Memory & Cognition*, 24, 629-643.