# Are Superficially Dissimilar Analogs better retrieved than Superficially Similar Disanalogs?

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**Abstract**

In the present study, we tested the assumption that structural similarity overcomes surface similarity in the retrieval of past events, by observing whether structural similarity alone is a better cue than surface similarity alone. To do so, in three story-recall experiments, we provided the participants with multiple source stories and then with a target cue story. This target cue only shared surface similarity with one source story, and structural similarity with another source story. In Experiment 1A, a Superficially Similar Disanalog source story (SSD) and a Superficially Dissimilar Analog source story (SDA) were presented among Superficially Dissimilar Disanalog source stories (SDDs). A soundness rating task was used in Experiment 1B to control the absence of structural similarity among the SSDs presented in Experiment 1A. In Experiment 2, the number of SSDs was increased in the aim to reproduce more ecological conditions. In Experiment 3, a filler task was introduced and supplementary source stories were presented in order to make the study more similar to previous story-recall paradigms. The results of the three story-recall experiments support the dominance of structural over surface similarities in analogical retrieval. The role of a structurally-based access regarding the retrieval of Superficially Similar Analogs (SSAs) and SDAs is discussed, as well as the factors underlying the rare occurrence of SDAs retrievals in previous experiments.

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Highlights

- Dissociating surface and structure similarities permits to assess their influence on retrieval
- Analogical retrieval is predominantly driven by structural similarity
- Surface similarity fails to drive retrieval when separated from structural similarity
- Rare occurrence of structural retrievals in previous experiments is misleading

Abstract

In the present study, we tested the assumption that structural similarity overcomes surface similarity in the retrieval of past events, by observing whether structural similarity alone is a better cue than surface similarity alone. To do so, in three story-recall experiments, we provided the participants with multiple source stories and then with a target cue story. This target cue only shared surface similarity with one source story, and structural similarity with another source story. In Experiment 1A, a Superficially Similar Disanalog source story (SSD) and a Superficially Dissimilar Analog source story (SDA) were presented among Superficially Dissimilar Disanalog source stories (SDDs). A soundness rating task was used in Experiment 1B to control the absence of structural similarity among the SSDs presented in Experiment 1A. In Experiment 2, the number of SSDs was increased in the aim to reproduce more ecological conditions. In Experiment 3, a filler task was introduced and supplementary source stories were presented in order to make the study more similar to previous story-recall paradigms. The results of the three story-recall experiments support the dominance of structural over surface similarities in analogical retrieval. The role of a structurally-based access regarding the retrieval of Superficially Similar Analogs (SSAs) and SDAs is discussed, as well as the factors underlying the rare occurrence of SDAs retrievals in previous experiments.

*Keywords*: analogy, analogical retrieval, structural similarity, story-recall task, abstract encoding

# Are superficially dissimilar analogs better retrieved than superficially similar disanalogs?

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## 1. Introduction

Analogies are crucial to take advantage of knowledge from our past experiences to make sense of new situations (Chalmers, French, & Hofstadter, 1992; Gentner, 1983; Gick & Holyoak, 1980). Determining the processes on which analogies rely and the conditions of their occurrence is of central importance to better understand the role that analogies have on our cognition. It has been proposed that the detection of relational regularities across situations, at the heart of analogy-making, is made possible by a mapping process that is oriented rather towards abstract correspondence (termed structural similarity) than towards superficially close objects and their attributes (interchangeably termed surface or superficial similarity) (Goldstone, Medin, & Gentner, 1991; Gentner, Rattermann, & Forbus, 1993; Gick & Holyoak, 1980). If we imagine one is presented with a situation where a student has worked hard to get into a highly selective art school, but after her application was rejected, she claims to be relieved by the fact that she will not be joining such a narrow-minded school. Then, if one is asked to compare this situation with a Superficially Dissimilar Analog situation (SDA), predictions stemming from previous works about the mapping process would be that, he or she would notice structural overlap and bypass surface dissimilarities. For instance, this SDA could depict the story of a young man who has booked a table in a renowned restaurant. After running into a traffic jam, he arrives late and his reservation was given away; he finally says to his girlfriend that dining in such a soulless institution would have not even been romantic. This situation does not have superficial matches with the first one since the objects are not taken from the same semantic domain: the surface features in the first situation are *a student, an art school, an application*, *the rejection of this application* and *the narrow-mindedness* of the school, whereas in the second one they are *a young man and*

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*his girlfriend, a restaurant, a reservation, the cancelation of this reservation* and *the soulless aspect* of the restaurant. Still, correspondences are easily perceived: both situations exhibit common abstract relations since *someone fails to achieve an intended goal and in consequence ends up denigrating it*, just as in Aesope's *sour grapes* fable (Festinger, 1957).

However, two analog situations are hardly ever concurrently encountered in the real world. Thus, when facing a new situation, one must retrieve a familiar analog situation from Long Term Memory (LTM) in order to establish the mapping between the two situations. Studies focusing on the determinants of analogical retrieval have widely converged on a major effect of surface similarity, whereas the role played by structural similarity remains unclear (Gentner et al., 1993; Gick & Holyoak, 1980; Trench & Minervino, 2015). In the present paper, we argue that studies which supposedly demonstrated the dominance of surface over structural similarity do not actually test the influence of surface similarity in the absence of structural similarity because they either explicitly aimed to compare the frequency of retrieval of Superficially Similar Analogs (SSAs) versus SDAs, or omitted the presence of some structural similarities among the Superficially Similar Disanalogs (SSDs). Following this proposal, the main purpose of this paper is to assess whether structural similarity overcomes surface similarity (the *structure dominance* hypothesis) when a fair competition is made possible by the isolation of the two types of similarities in different stimuli.

## 1. 1. The cognitive relevance of a structurally-based retrieval

### *1. 1. 1. The misleading strength of a surface similarity-based retrieval*

According to the *kind world* hypothesis formulated by Gentner and Medina (1998), relying primarily on surface similarity is an efficient strategy for retrieving structurally similar situations, since situations sharing similar objects are also generally similar at a more abstract level, and are thus Superficially Similar Analogs (SSAs). Studies showing that objects activate the likely relation that they share in daily-life (Bassok, Pedigo, & Oskarsson, 2008)

also suggest a certain consistency in the relations that can be found between similar objects on different occasions. For instance, imagine that the person who was told the *sour grapes* event in the *restaurant* context, now hears about a new event which involves the same set of objects: *a young man and his girlfriend, a restaurant, a reservation, the cancelation of this reservation* and *the soulless aspect* of a restaurant. As this new event presents the same objects as the previous one, it is also possible that it involves the same *sour grapes* structure. Relying on surface similarity to retrieve the first event when faced with the superficially similar second event would then be relevant since the two events would also match at the more abstract level of their *sour grapes* structure.

However, similar sets of objects are not rigidly associated with only one structure in our environment. We encounter similar objects in a variety of structurally dissimilar situations. Indeed, an event involving *a young man and his girlfriend, a restaurant, a reservation, the cancelation of this reservation* and *the soulless aspect* of a restaurant can very well describe a largely different structure from the *sour grapes* one. Maybe the new event involving this set of objects was about a *young man and his girlfriend* who *canceled* their *reservation* in a fancy *restaurant* because they preferred to keep things simple, and who went to a fast food where the *soulless aspect* of the place left them totally indifferent. This suggests that generally when someone encounters a given situation, he or she may have previously encountered several SSDs. Thus, relying exclusively on surface similarity for retrieval would lead to many dead ends. One would frequently be reminded of a SSD, and would then, in the mapping between this situation and the target cue, come to realize the structural irrelevance of the retrieved situation. This surface similarity-based retrieval would be detrimental to our functioning since it would frequently require mobilizing cognitive resources to reject the validity of the irrelevant retrieved situations.

Reciprocally, two different sets of objects can share a very similar structure in two situations (*e.g.* the *sour grapes* situations in the *art school* and the *restaurant* context). If we were unable to ignore the surface dissimilarity and to notice the structural similarity alone, we would then be prevented from drawing potentially valuable inferences between two situations that are highly similar at an abstract level (Schank, 1982). The fact that a structurally-based access would rarely occur, also suggests that the structure of a target cue situation could rarely be highlighted through spontaneous analogies (Catrambone & Holyoak, 1989).

Moreover, since the type of feature that is encoded conditions the type of retrieval that can be processed (Hammond, Seifert, & Gray, 1991; Hofstadter & Sander, 2013; Wharton, et al., 1994; Wharton, Holyoak, & Lange, 1996), the failure to base retrievals on structural similarity leads to the conclusion that the encoding of the situations mainly focuses on surface features rather than on structural features: "One explanation for the low degree of appropriate recall is that people often encode cases in a situation-specific manner, focusing mainly on their surface features" (Gentner, Loewenstein, & Thompson, 2003, p. 393). However, surface-level encoding would imply that one's understanding of a situation is restricted to the consideration of the objects he or she perceives instead of extracting meanings that are more abstract. Contrary to this view, a number of studies suggest that abstraction processes permit to discard the irrelevant features and focus on the relevant abstract structures from our experiences (Hampton, 2003), which is a necessary condition for a structural similarity-based access. Indeed, structurally-based retrievals require abstraction in the representations of the situations before the mapping stage (Dietrich, 2010).

### *1. 1. 2. Evidence for the abstract encoding of situations*

Studies have shown that analogy-making relies on an abstract encoding of the objects (Green, Fugelsang, Kraemer, & Dunbar, 2008), the relations (Green, Fugelsang, & Dunbar, 2006) and the global schema or concept involved in the analogs (Gick & Holyoak, 1983).

Increasing evidence coming from the relational priming literature suggests that participants do encode common relations across superficially dissimilar situations. For instance, Estes and Jones (2006) have shown that the comprehension of a word pair (*e.g. gravel - road*) is facilitated when it is preceded by another word pair sharing the same relation in the absence of any semantic similarity between the objects of the pairs (*e.g. chocolate – cake*). Studies have further demonstrated that such relations could be integrated in LTM in a way that they can be later retrieved (Jones, Estes, & Marsh, 2008). Indeed, Popov, Hristova and Anders (2017) have shown that the initially presented pairs (*e.g. pipe – water*) induced false alarms in a recognition test when a pair of new word objects was sharing a similar relation (*e.g. artery – blood*). Critically, it has been shown that the relations between familiar objects (*e.g. tulips* and *daises* or *tulips* and *vases*) are automatically encoded, in a way that primes specific arithmetic operations that are *semantically aligned* with this relation (Bassok et al., 2008).

Further, research suggests that abstract concepts representing a complex arrangement of relations between objects are automatically activated during the processing of a situation. For instance, McRae, Nedjadrasul, Pau, Pui-Hei Lo and King (2018) showed that such abstract concepts (*e.g. discipline*, *helpful* or *thinking*) can be activated during the processing of a picture of a real-world situation in a way that primes a lexical decision on this concept label. In this line, findings in problem-solving show that a concept which is used in solving a problem from one domain (biochemistry) can be used in solving a problem from another domain (molecular genetics), even though the analogy is not consciously drawn (Schunn & Dunbar, 1996). Day and Goldstone (2011) also demonstrated how solutions can be unconsciously transferred from a source problem to an isomorphic one – sharing the same structure but differing on its surface features –, contrasting with the difficulty to spontaneously transfer a solution through an explicit mapping of the problems, as exposed above.

It has been demonstrated that differences in difficulty between isomorphic problems are essentially due to the encoding of the actions to apply the rules and reach the goal (Clément & Richard, 1997). The easier problems are those which solution path is congruent with everyday knowledge about the actions that are involved in the resolution process. For instance, in a lift-problem, conceiving the action of moving from the first floor to the third one without going through the second floor is quite difficult, whereas, in its isomorph, the well-known Tower of Hanoi, conceiving moving an object from one place to another without going through all the intermediate places is not. The authors interpreted the difference in difficulty between isomorphic move problems as the result of the encoding imported by the solver from his or her daily-life experiences. In this line, some studies demonstrate that a structure can be used to transfer a solution from a source to a target problem when this structure can be interpreted through familiar concepts from daily-life experiences (Bassok, 1996; Bassok, Wu, & Olseth, 1995). Indeed, analogical transfer between isomorphic problems depends on the similarity at the level of a meaningful interpreted structure - the one reflecting the objects' daily-life relations, as opposed to the similarity at the level of their deep structure, which does not refer to any familiar concept. In Bassok et al.'s (1995) study, participants learning to solve a combinatorial problem where computers are assigned to secretaries perform much better in transferring the solution to an isomorphic problem that also involves objects distributed to humans (*e.g. prizes* attributed to *students*) than the reverse (*e.g. students* attributed to *prizes*). Indeed, the attribution of objects to humans in the source problem would have induced the encoding of the familiar "*get*" relation usually observed between objects and humans in daily-life, constraining transfer to other isomorphic problems depicting a situation compatible with this induced structure. Even if the problem's deep isomorphic structure (*random attribution of elements from one set to another set*) is not encoded by participants who are not familiar with the concept of random attribution, a familiar relational structure –

sometimes congruent with the problem's deep structure and sometimes incongruent with it – still appears to be encoded. Accordingly, experts are more likely than novices to detect a deep structural similarity between two arithmetic word problems (Novick, 1988). These studies reflect the role of anterior knowledge during the encoding of the situations and suggest that abstract information from a situation is encoded, as long as it refers to familiar concepts.

## 1. 2. Investigating analogical retrieval processes: the experimental paradigms

### *1. 2. 1. Analogical problem solving*

A commonly used experimental design in the study of analogical retrieval in problem solving via analogical transfer is the source-target paradigm (Gentner et al., 2003; Gick & Holyoak, 1983; Holyoak & Koh, 1987; Keane, 1987; Ross, 1987, 1989). In this paradigm, after a problem and its solution are presented, an analog problem is proposed as a target cue. For instance, in the Duncker's (1945) well-known "Radiation problem" a doctor has to operate a stomach tumor with a powerful blast of radiation, but its use at high intensity would damage the healthy tissues in its way. To determine whether superficial similarity is a prerequisite for access, studies have sought to determine whether transfer occurs when the analog source problem is superficially dissimilar. In experiments using the radiation problem as the target cue, the "General army problem" may be used as a SDA source problem: a rebel general divides his army into small troops to attack a fortress surrounded by mines (Gick & Holyoak, 1980, 1983; Keane, 1987). According to the authors, the analogical transfer of the solution in which the doctor can point multiple low intensity rays at the tumor depends on the encoding of a *convergence* abstract schema that is common to both analogs. Results have shown that SDA source problems are hardly retrieved without any hint. They led to the conclusion that structurally-based access is a rare phenomenon (Gick & Holyoak, 1980, 1983; Keane, 1987). Indeed, studies using different materials, but comparable design, revealed that retrieval is high when superficial similarity is interleaved with structural similarity (Ross, 1987, 1989). For

instance, retrieval of the source problem which is analog to the radiation problem increases when it involves a surgeon operating on a cancer (Keane, 1987). Surface similarities would benefit from a privileged status in access since they would rely on preexisting connections between the objects of the target and the source in LTM, whereas structural similarities would require to establish new connections by holding the two situations active in working memory (Hummel & Holyoak, 1997). However, it does not necessarily mean that the impact of the structure in analogical retrieval is completely neglected. Holyoak and Koh (1987) attribute a certain role to structural similarity in access. In their experiment, they varied the structural and surface overlap between the radiation problem and a source analog problem in which the filaments of a lightbulb had to be repaired. The authors found that the preservation of both surface (using *lasers* rather than *ultrasounds* to act on the *filaments*) and structural aspects (requiring the *convergence* solution because the light bulb's glass is *fragile*, rather than because the lasers/ultrasounds are *not strong enough*) had an influence on spontaneous transfer. Other studies have shown that structural similarity can, under certain conditions, independently trigger retrieval: when two analog source problems are jointly presented and compared, their solving principle can be retrieved when faced with the target cue problem (Catrambone & Holyoak, 1989; Gentner et al., 2003). In a similar way, the comparison of two analog target cue problems can result in a *late analogical abstraction*, which reflects the extraction of an abstract schema, which, in turn, increases the likelihood of retrieving a SDA source problem and transferring its solution (Gentner, Loewenstein, Thompson, & Forbus, 2009, Experiment 5). It has also been demonstrated that transfer between SDA problems increases when participants are presented with an idealized representation of the target cue, impoverished in surface details contrasting with the one of the source problem (Trench, Tavernini, & Goldstone, 2017). Hence, most of the conclusions stemming from studies on

spontaneous transfer between analog problems emphasize a strong dependence of analogical retrieval on surface similarity.

*1. 2. 2. The story-recall paradigm*

Another widespread paradigm is the story-recall task (Catrambone, 2002; Gentner & Landers, 1985; Gentner et al., 1993, 2009; Wharton et al., 1994, 1996). Short source stories are presented before introducing the target cue stories, which share different types of similarities with source stories. In contrast to problem-solving paradigms in which the problems generally share the same structure, story-recall paradigms aim to implement source and target cue stories that exclusively share either the structure or either the surface (Gentner & Landers, 1985; Gentner et al., 1993, 2009). A target cue story shares either the same structure but a different surface (SDA, or *analogy-match* in Gentner's terminology), or a similar surface but a structure that is claimed to be different (SDD, or *mere-appearance match* in Gentner's terminology) with the source story, since the end of the story is not the same (the difficulty of experimentally dissociating surface from structural similarity will be exposed later). Results have generally supported the *surface dominance* hypothesis.

The weak impact of structural similarity in access is also supported by the lack of difference in response times when participants are asked to verify the coherence of the conclusion of a target cue story that was preceded or not by a SDA story presenting a similar conclusion (Seifert, McKoon, Abelson, & Ratcliff, 1986). In the same study, inciting participants to identify the similarity between the SDAs leads to a reduction of the time necessary to verify the conclusion of the target cue story. The role of comparing two analog target cues in promoting structurally-based retrievals through the abstraction of a schema, that has been demonstrated in problem-solving, has also been identified in story-recall studies (Gentner et al., 2009; Dekel, Burns, & Goldwater, 2017). Participants also better retrieve superficially dissimilar analogs when they have to produce analogies of the source stories

after reading them (Dunbar, 2001). Wharton et al. (1994) have shown that when two source stories are in competition, both of which share the surface similarity but only one of them also shares the structural similarity with the target cue, structural similarity is crucial in guiding access. Structural similarity also determines access when neither of the competing source stories shares surface similarity (Wharton et al., 1996), especially when those abstract features are predictive of future events (Johnson & Seifert, 1992). Hence, the advantageous role of structural similarity in access has solely been observed when only one of two source stories shares structural similarity and both share the same amount of surface similarity.

Experimental studies that present source and target cue stories in the test phase have generally led to the conclusion that surface similarity has a major influence in guiding the retrieval of a situation, whereas structural similarity plays a secondary role, unless promoted by specific experimental settings. This view can be summed up in Gentner and Colhoun's (2010) words: "Relational retrieval can be said to be the Achilles' heel of our relational capacity. There is considerable evidence that similarity-based retrieval, unlike the mapping process, is more influenced by surface similarity than structural similarity."(p. 11). Thus, the retrieval process would rarely trigger past situations whose structure could be beneficial for understanding a new one if the situations did not share surface similarity.

### *1. 2. 3. Production paradigm*

In contrast with experiments investigating analogical reminding *in vitro* – laboratory – settings, Dunbar and Blanchette (Dunbar & Blanchette, 2001) were interested in analogies occurring *in vivo* – real-life – situations. Dunbar (1997) considered work-related discussions between biologists and identified a great number of analogies with considerable structural overlap, alongside with surface similarities, given that the source situations were generally taken from the same scientific domain as the target cue. Similar findings were obtained in the field of economics (Kretz & Krawczyk, 2014), management science (Bearman, Ball, &

Ormerod, 2007) and engineering (Christensen & Schunn, 2007), where group discussions reflected a high amount of structural analogies. Moreover, an important proportion of these *in vivo* generated analogies does not seem to involve surface similarity (Christensen & Schunn, 2007; Dunbar & Blanchette, 2001; Kretz & Krawczyk, 2014). The contrast between the findings from experimental studies and observations in natural settings led researchers to look for potential biases that orient participants towards retrievals based on surface similarity.

In analogical problem solving, the lack of familiarity and the short familiarization time were identified as the main factors contributing to a surface-level encoding (Blanchette & Dunbar, 2000; Hofstadter & Sander, 2013; Vosniadou, 1989). The absence of a goal motivating participants to focus on the deep features of the stories was also considered to engage participants in superficial processing (Blanchette & Dunbar, 2000; Dunbar & Blanchette, 2001). The shallow processing of such stories was also pointed out by Hammond et al. (1991). Their experiment revealed that the presentation of words from the target cue in a scrambled order leads to a similar pattern of results as the presentation of the original target cues. This indicates a potentially shallow processing of the stories in both conditions. Hence, the experimental conditions in *in vitro* contexts would prevent participants from encoding deep structures and favor the dominance of superficial cues over structural ones.

Combining the *in vivo* and *in vitro* methods, Blanchette and Dunbar (2000) aimed to bring more naturalistic parameters to an experimentally controlled environment. Following this direction, they asked participants to generate analogies from their own experience in order to convince people if a political strategy was well-founded or not. Focusing on the participants' analogies, the authors found a greater proportion of superficially dissimilar than superficially similar analogies. Building up on these results, the authors concluded that traditional experimental conditions, in which the analog situations were provided by the experimenter, are a bias that induces superficially-based retrievals (Blanchette & Dunbar,

2000). Analogical retrieval would hence be less constrained by surface similarity when one is given the possibility to rely on his or her own sources of analogies.

*1. 2. 4. Bridging the in vivo/in vitro gap?*

Trench and Minervino (2015) argued that Blanchette and Dunbar's (2000) experiment suffers from a lack of experimental control since the generated analog situations could have been *ad hoc* creations of analogs rather than retrievals of previously experienced situations. Moreover, they argued that the predominance of inter-domain analogical retrievals in Blanchette and Dunbar's (2000) study could have been influenced by a greater number of source analogs available in distant semantic domains rather than in the target's semantic domain - politics. To ensure that the source analogs used by the participants were not *ad hoc* creations but actual instances of analogical retrieval, Trench and Minervino (2015) focused on the retrieval of popular movies. The target cue was a SDA for one group of participants and a SSA for another group of participants. The presence of only one source analog (the source movie) was a way to control the number of SSA and SDA source situations. In the spirit of Blanchette and Dunbar's (2000) experiments, participants were asked to use analogies in order to dissuade someone from adopting an intended behaviour. For instance, one of the critical source analogs was the movie *Jurassic Park*, where a millionaire had cloned dinosaurs from fossil DNA to create a park open to the public, but finally lost control over his creations. The SSA target cue depicted the story of a businessman intending to reproduce mammoths from a frozen embryo to exhibit them in a closed park, and the SDA target cue described a scientist attempting to reproduce Martian storms in an experimental zone open to other scientists. The results showed that participants tend to retrieve the movie more often when the analog target had superficial similarity. The second experiment focused on the retrieval of autobiographic memories in order to directly address Hofstadter and Sander's (2013) claim that the abstract encoding that receive such episodes allows for the retrieval of SDAs. One of

the target cues involved a character who enjoys passion fruit so much that he is interested in incorporating it into cheesecakes, toppings, daiquiris, etc. The participants were instructed to use analogies with situations from their own experience to dissuade the character from performing his or her intended action (*e.g.* eating too much passion fruits). The SSA whose retrieval was considered concerned the memory of having consumed so much of a new food that the participant became disgusted by it. The SDA whose retrieval was taken into account was the memory of having played a new game so much that he or she got fed up with it. Contrasting with Blanchette and Dunbar's (2000) results, participants more often provided SSAs than SDAs.

*1. 2. 5. The confound effect of surface and structural similarities*

Studies using problem solving (Catrambone & Holyoak, 1989; Gick & Holyoak, 1983; Keane, 1987) and production tasks (Blanchette & Dunbar, 2000; Trench & Minervino, 2015) mainly aimed to investigate the influence of surface similarity in analogical retrieval. As previously presented, they mostly converged on the importance of surface similarity in analogical retrieval. However, the dominance of SSA over SDA retrievals led to conclusions beyond the scope of analogical retrieval since it has been used to address the question initially raised by Gentner et al.'s (1993) princeps study on the predominant role of the surface in retrieval. More precisely, the fact that source analogs are better retrieved when they share surface similarity rather than when they are only structurally similar led to the conclusion that surface similarity is the main determinant of such analogical retrievals. As an illustration of this thesis, Trench and Minervino (2015) assume that the results of their experiments concerning the predominance of SSAs retrievals over SDAs retrievals would "run counter to the claim that the dominance of superficial similarity in retrieval is rooted in the artificiality of the tasks and materials used in traditional experiments" (Trench & Minervino, 2015, p. 21). The authors suggest that "the proficient analogizer begins by including surface information

about the target in the working memory probe that will be used for retrieval (…)" (p. 23). This is congruent with the kind world hypothesis which states that SSAs can be retrieved thanks to a surface similarity-based retrieval that operates in a world where surface similarity is often associated with relational similarity (Gentner & Medina, 1998).

We argue that the assumption that surface similarity is the motor behind the retrievals of SSAs is not convincing, given that these situations also share a high amount of structural similarity. Even though comparing the retrieval preferences between SSAs and SDAs is necessary for understanding the role of surface similarity in analogical retrieval, it may not be suitable for studying the dominance of surface versus structural similarity in retrieval processes. Indeed, studies focusing on analogical retrieval do not test the retrieval of SSDs that the surface dominance would imply. Hence, the methodology on which such studies rely does not assess the influence of surface similarity independently from the influence of structural similarity.

As stated before, an attempt to introduce a situation sharing only surface and no structure with the target cue has been made in story-recall paradigms (Gentner & Landers, 1985; Gentner et al., 1993, Experiment 1A and 2). Yet, as noted by Hammond et al. (1991), when looking closer at the stimuli from the *Karla the hawk* set of stories (see Table 1), an important proportion of the SSD target cue story preserves the structure of the source story (*e.g. making a deal to avoid a bad situation*). Thus, the SSD target cue appears to be a literal match until the outcome of the stories differs (*e.g. betrayal* versus *respect* of this deal). This relational overlap between the stories could have been determinant in eliciting retrieval.

It has to be noted that a residual relational overlap between situations that are supposed to be only superficially similar is also present in experiments using different materials than the *Karla the hawk* set of stories. For instance, the stories involving *a big*

*country* and *two small countries* as objects both involve *a competition between two adjacent weak countries and the attempt of one of these countries to make a deal with a more powerful neighbor country*, although the structure of the target cue differs at the end of the story (the more powerful country finally overruns both weak countries in the source story, whereas a hurricane bankrupts the three countries at the end of the target cue story) (Gentner et al., 1993, Experiment 3). Thus, it remains unclear whether surface similarity alone would still overrun structural similarity alone in driving retrieval.

Table 1: Example of Superficially Similar Disanalogs (SSDs) Gentner et al., 1993, Experiment 1 and 2).

| **Source story** |
| --- |
| Karla, an old hawk, lived at the top of a tall oak tree. One afternoon, she saw a hunter on the ground with a bow and some crude arrows that had no feathers. The hunter took aim and shot at the hawk but missed. Karla knew the hunter wanted her feathers so she glided down to the hunter and offered to give him a few. The hunter was so grateful that he pledged never to shoot at a hawk again. He went off and shot deer instead. |
| **Superficially Similar Disanalog target cue story (SSD)** |
| Once there was an eagle named Zerdia who donated a few of her tailfeathers to a sportsman so he would promise never to attack eagles. One day Zerdia was nesting high on a rocky cliff when she saw the sportsman coming with a crowsbow. Zerdia flew down to meet the man, but he attacked and felled her with a single bolt. As she fluttered to the ground Zerdia realized that the bolt had her own tailfeathers on it. |

In the present study, we put aside the question of the predominance of SSAs versus SDAs retrievals to focus on the original debate concerning the dominance of structural versus surface similarities in driving retrieval. As demonstrated, the superior retrieval of SDAs over SSDs is a more direct way of testing whether structural similarity overcomes surface similarity (the structure dominance hypothesis), and this rivalry constitutes the focus of this paper. To this end, we used a story-recall paradigm where surface and structural similarities were independently embedded in different source stories: a SSD and a SDA. Critically, the SSDs were designed so that structural overlap would be minimized in such a way that arguably their structures differ from the beginning of the stories.

## 2. Experiment 1A

The aim of Experiment 1A was to test the structure dominance hypothesis by assessing whether structurally similar situations are better retrieved than superficially similar situations. In this experiment, the SDA and the SSD were presented along with Superficially Dissimilar Disanalog source stories (SDDs) that hardly shared any of these features with the target cue story.

### 2. 1. Method

#### *2. 1. 2. Participants*

A total of 88 undergraduate students from the University Paris 8 (mean age = 21.3; females = 62) took part in the experiment during class.

#### *2. 1. 3. Materials*

Following Wharton et al. (1994, 1996), a competition was created between analog and disanalog source stories. Each participant received both types of source stories. Six stories were proposed before the target cue: four SDDs, one SSD and one SDA. The participants received one of the two versions (see Table 2) in which the SSD, the SDA and the target cue story were different. This was done to show that the predicted structural retrievals could rely on different structural similarities and overcome different surface similarities as long as the two types of similarities are isolated. In one version, the target cue was *Luigi and Lorenzo's story* and the SDA was *Julie and Victor's story*, both situations embodying the structure "*a competition ends when a rival helps the other in improving his or her signature ability*". The SSD was *Alessandro and Fabio's story* which structure widely differs from the analogs' one from the beginning of the story (the story is about two colleagues adopting an Italian style to sell more pizzas). In the second version, the target cue was *Elyse and Charles' story* and the SDA was *Paulo and Giorgio's story*, both sharing the same structure "*a circumstance compels someone to stay with a partner who has betrayed him or her*". The SSD was *Julie and*

Table 2: Stimuli with surface versus structural similarity used in each version of Experiment 1A (translated from French).

| Superficially Dissimilar Analog (SDA) source situations | Superficially Similar Disanalog (SSD) source situations | Target cue situations |
|---|---|---|
| | Version 1 | |
| Julie is in love with Victor, her classmate, and she is getting closer to him in order to seduce him. But Diane joins the class in the middle of the year and also has a crush on Victor. Julie notices that Diane is not very aware of her style and gives her some makeover advice, showing her fashion photos and taking her out for shopping. Diane now looks very cute and chic. Diane is so grateful that she tells Julie that she will stop flirting with Victor. | In a marketplace, a truck called « At Alessandro & Fabio's » has various choices of homemade pizzas. The important clientele that goes there is fond of the authentic atmosphere of the stand held by the two happy looking men in Italian traditional suits. However, once they leave from this marketplace, the two men will go to another one, but only after changing into German traditional clothes in order to sell special German sausages. The sign there displays « At Hans and Hendrich's ». | Luigi has a pizza truck in a very popular place. Lorenzo, another ambulant pizza chef, has placed his truck just beside Luigi's and is detrimental to his turnover. Luigi realizes that the dough of Lorenzo's pizzas is bland. Luigi spontaneously gives his personal recipe to Lorenzo so that he can improve the quality of his product. Since then, his pizza dough is amazingly tasty. The same evening, Lorenzo declares to Luigi that in order to show him how well-intended he found his act, he will move his truck in another sector, far from this one. |
| *Structure*: A competition ends when a rival helps the other in improving his or her signature ability<br>*Surface*: two lovers | *Structure*: simulating an authenticity to take advantage of a situation<br>*Surface*: two pizzaiolos | *Structure*: A competition ends when a rival helps the other in improving his or her signature ability<br>*Surface*: two pizzaiolos |
| | Version 2 | |
| Paulo and Giorgio have had great success with their pizza truck. Now they intend to fulfil their dream of getting a real Italian restaurant. One day, while looking through their books, Paulo discovered that Giorgio has always hidden the real amount of their profits, and that he actually keeps much more than half of it. Infuriated, Paulo decides to put an end to their collaboration. But since his wages depend on the collaboration with Giorgio, he changes his mind and finally continues working with him. | Julie is in love with Victor, her classmate, and she is getting closer to him in order to seduce him. But Diane joins the class in the middle of the year and also has a crush on Victor. Julie notices that Diane is not very aware of her style and gives her some makeover advice, showing her fashion photos and taking her out for shopping. Diane now looks very cute and chic. Diane is so grateful that she tells Julie that she will stop flirting with Victor. | Elyse and Charles are very happy since they got married. They have many projects and, since the birth of their first son Antoine, are considering selling their apartment to buy a house with more space. However, while using Charles' phone, Elyse found out that he has been meeting with another woman. Shocked, Elyse rushes and fills a suitcase with her clothes and leaves the house. After reflecting, she finally realizes that she has no other choice than to stay and take care of her little Antoine. |
| *Structure*: a circumstance compels someone to stay with a partner who has betrayed him or her.<br>*Surface*: two pizzaiolos | *Structure*: a competition ends when a rival helps the other in improving his or her signature ability<br>*Surface*: two lovers | *Structure*: a circumstance compels someone to stay with a partner who has betrayed him or her.<br>*Surface*: two lovers |

*Victor's story,* whose structure (exposed above) differs from the beginning of the story.

*2. 1. 3. Procedure & Design*

After providing their informed consent, participants were given a booklet with the materials and the full instructions. The participants were first asked by the experimenter neither to turn the pages in advance nor to come back to a previous page (this was also indicated in the headline of the first page of the booklet). They were then invited to read the instructions presented on the first page of the booklet. The first two pages of the booklet presented the six source stories, then a blank page separated them from the last page containing the target cue story. The stories were listed in a semi-randomized order. Participants were asked to rate each source story for imageability (*i.e.* the ease with which they could imagine the scene while reading it) right after reading it on a five-points scale. This procedure was replicated from previous story-recall studies (Wharton et al., 1994; Wharton et al., 1996), including those which demonstrated the predominant role of surface similarity (Catrambone, 2002). The last page, which presented the target cue situation, instructed the participant that they have to indicate whether the present situation remind them of one of the six previously read situations (in line with Gentner et al., 1993). If it was the case, they had to quote any element they could remember from this situation. The participants were told that the task usually takes about 10 minutes to complete but that no time limitation was imposed. Participants were then verbally debriefed about the aim of the study.

**2. 2. Results and discussion**

For each participant, a score of 1 was attributed to the source story for which word content was recalled. Synonyms were accepted, for instance when the participants reported a "cooperation" between "two cooks" instead of a "collaboration" between "two pizzaiolos", as literally mentioned in the text. If no such word content could lead to a clear identification of the source recalled, or if no retrieval was reported by the participant, the response was

classified as a non-retrieval. As responses reporting the retrieval of several source stories which share different types of similarity with the target cue could not help determining which similarity is preponderant for access, they were excluded from the analyses. Among the 85 participants which response could lead to a clear identification of at least one retrieved source story, four were excluded for this purpose (all reported both the SDA and the SSD).

The analysis focused on the number of participants retrieving either the SSD, the SDA or one of the SDDs. As illustrated in Fig. 1, the analysis indicates that participants most often retrieved the SDAs (81.5%) and marginally retrieved the SSDs (18.5%). No SDD were retrieved. A Chi square test was performed on the number of retrievals of SSDs and SDAs and revealed a significant difference ($\chi^2$ (1, $N$ = 80) = 32.10, $p$ < .01)[1].

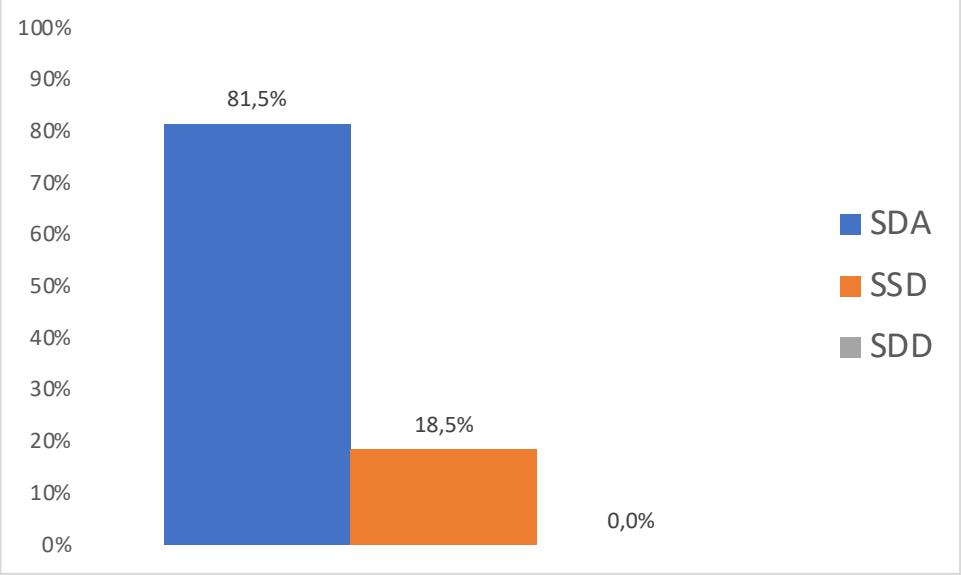


Figure 1: Proportion of retrievals of the source stories according to the type of similarity shared with the target cue story in Experiment 1A.

In accordance with the structure dominance hypothesis, the results demonstrate that structural similarity surpasses surface similarity in retrieval when the two types of similarity

[1] This difference was significant both in the version where the target cue situation is Luigi and Lorenzo's story ($\chi$2 (1, N = 43) = 7.36, p < .01) and in the version where the target cue situation is Elyse and Charles' story ($\chi$2 (1, N = 36) = 29.43, p < .01).

are presented in different source stories. They suggest that the structural similarity was itself sufficient so that participants focused on abstract features when retrieving a source story. While the high frequency of SSAs retrievals has been widely documented (Dunbar, 1997; Gick & Holyoak, 1983; Trench & Minervino, 2015), our results demonstrate that superficially similar situations lose their advantage over SDAs in driving retrieval when they are deprived of structural similarity. Hence, the high frequency of SSA retrievals reported in the literature cannot be imputed to the dominance of surface similarity in retrieval. These results further comfort the idea that the preponderance of SSDs retrievals in previous story-recall studies (Gentner & Landers, 1985; Gentner et al., 1993) may have been due to the fact that an important proportion of the target cue story shares a structural similarity with the source story (*e.g. making a deal to avoid a bad situation*), before the stories come to different endings (*e.g. respect* or *betrayal of this deal*). Experiment 1B was designed in order to provide an objective measure of whether an important proportion of the target cue stories shares structural similarity with the corresponding source stories in the case of the SSDs used in previous story-recall studies, whereas it is not the case of the SSDs which are used in the present study.

## 3. Experiment 1B

Previous research has shown that one way of assessing the structural overlap between two situations is to task participants with judging the *soundness* of the correspondence between them (Gentner & Landers, 1985; Gentner et al., 1993). More specifically, the soundness rating task is adequate to assess the presence of partial structural overlap between two stories (Johnson & Seifert, 1992). In this line, we adapted the soundness rating task to determine which proportion of the text depicting a SSD target cue story, if any, is judged by the participants as structurally similar to the corresponding source story. In order to better control the structural overlap between different SSDs, participants were asked to indicate if and until where the correspondence was sound between different pairs of SSDs: the SSDs

used in Gentner & Landers (1985) and Gentner et al. (1993) (Experiment 1 and 2), the SSDs used in Gentner et al. (1993) (Experiment 3), and the SSDs used in the present study. For the sake of clarity, the SSDs will be referred as with the terminology that was adopted in the original study where they were used (Mere Appearance (MA) matches, Object-Only (OO) matches for Gentner and collaborators' studies and SSDs for the current study).

### 3. 1. Method

#### *3. 1. 1. Participants*

27 undergraduate students (mean age = 30.1; females = 22) took part in the experiment during a class at the University of Cergy-Pontoise.

#### *3. 1. 2. Materials*

The materials were composed of two pairs of MA matches, two pairs of OO matches and two pairs of SSDs (Table 3). The two pairs of MA matches were taken from the materials presented in Gentner and Landers (1985) and Gentner et al. (1993). The two pairs of OO matches were the ones that are exposed in Gentner et al. (1993). The two pairs of SSDs were the ones used in the first experiment of the present study. Because one of the two stories of a pair (*e.g.* MA matches) could be used in another pair (*e.g.* OO matches), two versions of the task were elaborated where a story could only be presented in one pair. Thus, each version was composed of one pair of MA matches, one pair of OO matches and one pair of SSDs.

#### *3. 1. 3. Procedure and Design*

The participants first gave their informed consent before participating in the study and were debriefed about its aim at the end of the experiment . Fourteen participants received the first version of the task and 13 other participants received the second one. The first page of the booklet contained the instructions which started by the explanation of what a sound match is, in an identical form as the one that was provided by Gentner and Landers (1985) and Johnson and Seifert (1992). The next paragraph indicated to the participants that they will

Table 3: MA and OO matches (Gentner et al., 1993) used in experiment 1B

| Source stories | Target cue stories |
|---|---|
| *Mere-Appearance (MA) matches* | |
| Version 1 | |
| Percy the mockingbird spent the whole warm season chirping and twittering. When it began to get colder Percy visited a squirrel and sang a song for her, expecting to get some of the squirrel's sunflower seeds in return. However, the squirrel was very disappointed in him.<br>"You are a terrible singer!" she yelled. "I'm not giving you any of my wheat."<br>A tear rolled down Percy's cheek, and he vowed to give up singing for good. | A magpie named Sam sang all summer. When winter came he paid a visit to a chipmunk. However, the chipmunk was not at all pleased with Sam.<br>"You have wasted the summer while I have been hard at work!" she said. Sam performed a ballad for her hoping she would give him some nuts in return. But she was still not pleased. "I will not give you any of my nuts!" she exclaimed. |
| Version 2 | |
| Karla, an old hawk, lived at the top of a tall oak tree. One afternoon, she saw a hunter on the ground with a bow and some crude arrows that had no feathers. The hunter took aim and shot at the hawk but missed. Karla knew the hunter wanted her feathers so she glided down to the hunter and offered to give him a few. The hunter was so grateful that he pledged never to shoot at a hawk again. He went off and shot deer instead. | Once there was an eagle named Zerdia who donated a few of her tailfeathers to a sportsman so he would promise never to attack eagles. One day Zerdia was nesting high on a rocky cliff when she saw the sportsman coming with a crowsbow. Zerdia flew down to meet the man, but he attacked and felled her with a single bolt. As she fluttered to the ground Zerdia realized that the bolt had her own tailfeathers on it. |
| *Object-Only (OO) matches* | |
| Version 1 | |
| Two small countries, Bolon and Salam, were adjacent to a large, warlike country called Mayonia. Bolon decided to make the best of the situation by taking over Salam. Salam started looking for aid from other strong countries but soon Bolon succeeded in taking it over. Then victorious Bolon proposed to make a treaty with its warlike neighbor Mayonia. Bolon proposed to give Mayonia control over Salam in exchange for a guarantee that Bolon would remain independent. Mayonia responded by overrunning both Bolon and Salam. Bolon was so buy maintaining control of Salam, it could do nothing to stop Mayonia. Thereupon Mayonia installed puppet governments in both Bolon and Salam and took over the newspapers and radio stations. | Two weak nations, Lincoln and Moreland, bordered each other. Both countries relied heavily on the tourist trade to keep their economies afloat. They competed with each other over which one of them would get the most tourists. Meanwhile, another nearby nation, Chad, had a very strong economy with a thriving tourist trade. Tourist cruises flocked into its harbors and planes full of visitors were constantly landing in its airport. Because of this, Moreland tried to join forces with Chad in its new advertising campaign to entice still more tourists. Unfortunately a hurricane hit the coast and bankrupted all three nations. |
| Version 2 | |
| Percy the mockingbird spent the whole warm season chirping and twittering. When it began to get colder Percy visited a squirrel and sang a song for her, expecting to get some of the squirrel's sunflower seeds in return. However, the squirrel was very disappointed in him.<br>"You are a terrible singer!" she yelled. "I'm not giving you any of my wheat."<br>A tear rolled down Percy's cheek, and he vowed to give up singing for good. | One unusually warm spell in February Sam the magpie thought "This is my chance." He stood up on the edge of his nest and trilled proudly. His song was so loud and cheerful that it woke a nearby chipmunk. The chipmunk asked for another song. He was so moved by Sam's talents that he forgot it was still winter and decided to go looking for nuts to store. |

Note: The stories were translated in French for the experiment. SSDs from Experiment 1A were also presented in Experiment 1B (see Table 2).

have to draw a marker in the text of the second story, where what follows does not have a sound correspondence with the first story. They were told that the marker could be placed (i) before the first word of the second story if they thought that it does not have a sound match with the first story from the beginning, or (ii) between two words of the second story if they thought the match is sound before their marker but not sound anymore after it, or (iii) after the last word of the story if they thought that the second story has a sound match with the first one until the end. We first predicted that more participants would place the cursor before the first word of the target cue story in front of the SSDs than when they would be faced with the MA matches and the OO matches. Indeed, the SSD target cue stories should be considered as structurally different from the beginning of the text more often than the MA and the OO target cue stories, which should be considered as structurally similar (at least) at the beginning of the texts. A second prediction concerned the mean proportion of the target cue story texts that would precede the cursor placed by the participants. It was predicted that a more important proportion of the target cue story text should precede the cursor for MA and OO matches than for SSDs.

**3. 2. Results and discussion**

First, the number of words that preceded the cursor was coded for each response to each stories pair. We calculated the proportion of participants who placed the cursor before the first word of the target cue story for each type of stories pair. The proportion of each target cue story text that shares structural similarity with the source story was also computed. It was obtained by dividing the number of words that preceded the cursor by the total number of words of the target cue story. A mean proportion was calculated for each type of stories pair (MA matches, OO matches and SSDs). When a participant did not provide any answer or drew more than one cursor in a stories pair, the protocol was excluded from the analysis. Two participants were excluded for these reasons.

As regards the proportion of participants who placed the cursor before the first word of the target cue story, 8.0% of the participants did so when faced with the MA matches, 24.0% of the participants did so when faced with the OO matches and 64.0% of the participants did so when faced with the SSDs. A chi square test was performed to compare the number of participants who placed the cursor before the first word of the target cue story between the MA match and SSD conditions, as well as between the OO match and the SSD conditions. It revealed that a significantly higher number of participants placed the cursor before the first word when they were faced with the SSDs rather than with the MA matches ($\chi^2$ (1, $N$ = 24) = 10.88, $p$ < .001) or with the OO matches ($\chi^2$ (1, $N$ = 24) = 4.55, $p$ < .05). Further, the results revealed that 65.4% of the MA target cue stories text was considered to have a sound correspondence with its corresponding source story. This was also the case of 43.7% of the OO target cue stories text. Conversely, only 8.6% of the SSD target cue stories text was judged as having a sound match with their source story. A paired-sample t-test was conducted to compare these mean proportions. The difference between MA and SSD target cue stories was significant ($t$(24) = 7.51, $p$ <.001), as well as the one between OO and SSD target cue stories ($t$(24) = 4.78, $p$ <.001).

Experiment 1B demonstrated that participants perceive that an important proportion of each type of target cue stories, which was constructed in previous experiments so as to share surface but not structural similarity (MA matches and OO matches), still preserves structural similarity with their corresponding source story. In contrast, it appears that the SSDs that were used in Experiment 1A are considered as structurally different since the beginning of the stories. Together with the results from Experiment 1A, the results from Experiment 1B support the claim that some residual structural similarity may have been influential in the retrievals of the source situations which were considered to share only surface similarity in previous experiments.

As noted by Wharton et al. (1994), most experiments conducted on this topic, just like Experiment 1A, provided only one source story sharing surface features with each target cue situation (*e.g.* Catrambone, 2002; Gentner et al., 1993). However, in natural settings one has generally encountered more than a single situation that shares a surface similarity with a target cue situation. As an illustration, it is very likely that one has several memories involving *pizzaiolos* when they go to a pizza restaurant. Experiment 2 was conducted in order to assure more ecological validity regarding the competition of source stories.

## 3. Experiment 2

As analogies with SDAs are known for being particularly useful when little is known about the target domain, it can be argued that the experimental condition where only one semantically similar source story is stored promotes the retrieval of the SDA. Following Hammond et al. (1991), "When there are few examples in memory that share content features, abstract similarities may be expected to play a larger role in reminding" (p. 127). In other words, the structural dominance could be attenuated in real-life conditions where one often has more knowledge (more exemplars of superficially similar source stories) about the domain of the target cue.

However, the structure dominance hypothesis predicts that SDAs are still predominantly retrieved when there is more than a single superficially similar situation in memory, as long as the latter do not preserve the structure of the target cue situation (*i.e.* as long as they are SSDs). In Experiment 2, several SSDs were put in competition with the SDA and with SDDs. We predicted that the SDA would still be retrieved more often than all the SSDs taken together, since the former is the only one that preserves the structure of the target cue story.

## 3. 1. Method

### *3. 1. 1. Participants*

A total of 76 undergraduate students (mean age = 22.1; females = 52) from the University Paris 5 and Paris 8 accepted to take part in the experiment in university libraries. All of them provided their informed consent prior to the experiment.

### *3. 1. 2. Materials*

The target cue stories, the SSDs and the SDAs, were the same as the ones used in the two versions of Experiment 1A. In each version (see Table 4), the four SDDs were replaced by two SSDs (sharing surface features with the target cue story and the SSD from Experiment 1A) and two alternative SDDs (sharing surface features with the SDA in order to respect a symmetry with superficially similar ones, but not sharing its structure). In the version where

Table 4: Summary of all the stories used in Experiment 2

| First version | Second version |
|---|---|
| **Target cue stories** | |
| Luigi and Lorenzo's story | Elyse and Charles' story |
| **Source stories** | |
| *Superficially Similar Disanalogs (SSDs)* | |
| Claudio and Franco's story | Arnaud and Zoe's story |
| Alessandro and Fabio's story | Claire and Quentin's story |
| Paulo and Giorgio's story | Julie and Victor's story |
| *Superficially Dissimilar Analogs (SDAs)* | |
| Julie and Victor's story | Paulo and Giorgio's story |
| *Superficially Dissimilar Disnalogs (SDDs)* | |
| Arnaud and Zoe's story | Claudio and Franco's story |
| Claire and Quentin's story | Alessandro and Fabio's story |

the target cue is Luigi and Lorenzo's story and the SDA is Julie and Victor's story, the two SSDs that were introduced dealt with pizzaiolos and the two alternative SDDs described

lovers. The two new SSDs depicted lovers and the two alternative SDDs involved pizzaiolos in the version presenting Elyse and Charles' story as the target cue and Paulo and Giorgio's story as the SDA. All in all, three SSDs and three superficially dissimilar source stories (one SDA and two SDDs) were presented before the target cue story.

*3. 1. 3. Procedure and Design*

The procedure and design were replicated from Experiment 1A.

**3. 2. Results and discussion**

Following the same coding procedure as in Experiment 1A, five of the 72 participants who mentioned a retrieval were excluded from the analyses for having reported both one of the SSDs and the SDA.

We compared the number of participants retrieving one of the SSDs, the SDA or one of the SDDs. As Fig. 2 illustrates, the analyses showed that a substantial majority of participants retrieved the SDA (79.1%), a marginal proportion retrieved one of the SSDs (13.4%) and few proposed one of the SDDs (7.5%). A chi square test was performed on the number of participants retrieving one of the SSDs and the number of participants retrieving the SDA. The difference was significant ($\chi^2$ (1, $N$ = 61) = 31.23, $p < .01$)[2].

These results are in line with the ones obtained in Experiment 1A concerning the preponderance of structurally-based over superficially-based retrievals. They show that the structure dominance hypothesis still holds in settings where several SSD source stories are involved.

It could be objected that the structural dominance observed in Experiment 1A and Experiment 2 was due to the successive presentation of the source stories and the target cue story. In many experiments bearing on retrieval processes (*e.g.* Catrambone, 2002; Gentner et

[2] This difference was significant both in the version where the target cue is Luigi and Lorenzo's story ($\chi$2 (1, N = 33) = 11.76, p < .01) and in the version where the target cue is Elyse and Charles' story ($\chi$2 (1, N = 27) = 20.57, p < .01).

al., 1993, 2009; Wharton et al., 1994, 1996), participants' attention is generally moved away from the source stories before the target cue story is presented (introducing a temporal delay or using a filler task). It could also be criticized that, contrary to experiments that present participants with a high number of source stories (Gentner et al., 1993), our first two experiments, presenting participants with six source stories, allowed them to engage in a mapping of the target cue story with each source story, instead of engaging in a retrieval process. Experiment 3 was designed in order to control for these parameters, by introducing a filler task and increasing the number of source stories.

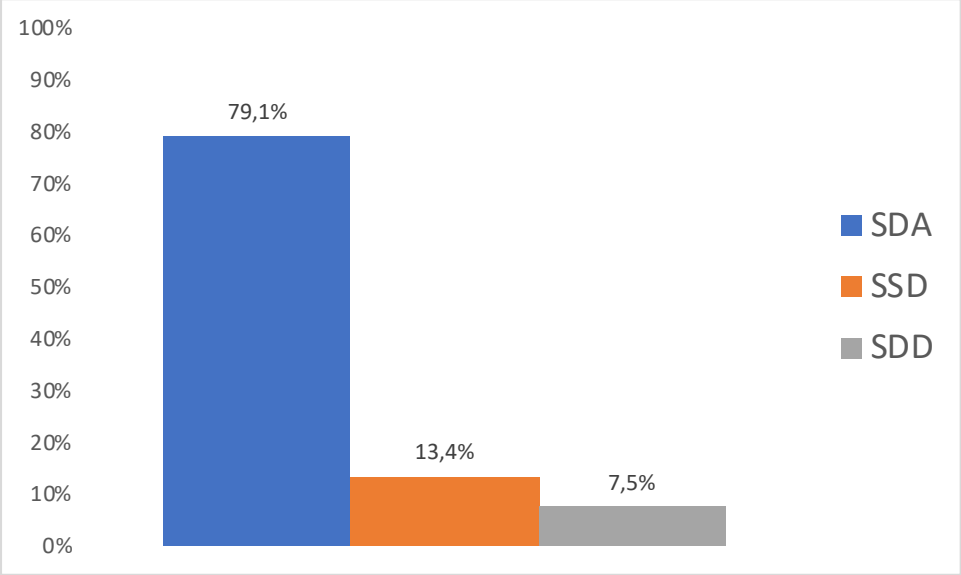


Figure 2: Proportion of retrievals of the source stories according to the type of similarity shared with the target cue story in Experiment 2

## 4. Experiment 3

### 4. 1. Method

#### *4. 1. 1. Participants*

92 participants (mean age = 22.4; females = 56) took part in the experiment at the libraries of University Paris 5 and Paris 8.

*4. 1. 2. Materials*

In line with Wharton et al. (1994, 1996), a five minutes filler task was introduced as a distractor between the encoding and the retrieval phases. For fulfilling this task, participants had to write down a maximum of alternative uses that could be made of different objects.

Given that previous studies pointed to a shallow processing induced by story-recall paradigms (Blanchette & Dunbar, 2000; Hammond et al., 1991), the presentation of an excessively high number of source stories may dissuade participants to get involved in a deep understanding of each story, and might induce a superficial encoding. Thus, besides the filler task, two SDDs were added to the source stories set from Experiment 1, so as to make the reactivation-mapping of each source story even less likely to be processed than in the two previous story-recall experiments, while not discouraging participants to pay attention to each story. In the present experiment, eight source stories were presented to the participants since the SSD and the SDA were presented along with six SDDs.

*4. 1. 3. Procedure and Design*

The procedure and design were replicated from Experiments 1A and 2.

**4. 2. Results and discussion**

Ninety participants reported at least one retrieval. Among them, responses of 14 participants were not analysed because they reported several retrievals (10 retrieved both the SSD and the SDA, 2 retrieved a SSD and a SDD, 2 retrieved a SDA and a SDD).

Again, we compared the number of participants retrieving the SSD, the SDA or one of the SDDs. The results are in accordance with Experiments 1A and 2 (Fig. 3). SDAs were predominantly retrieved (71.8%) whereas SSDs were marginally retrieved (26.9%). Only one participant retrieved a SDD (1.3%). A chi square test revealed that the difference between the

number of retrievals of SDAs was significantly higher than the number of retrievals of SSDs ($\chi^2$ (1, $N$ = 76) = 15.91, $p$ < .01)[3].

Results from Experiment 3 support once again the structure dominance hypothesis. They also strengthen the conclusion that the greater amount of SDAs retrievals observed in Experiment 1A and 2 was due to a retrieval process being predominantly oriented toward structural similarity.

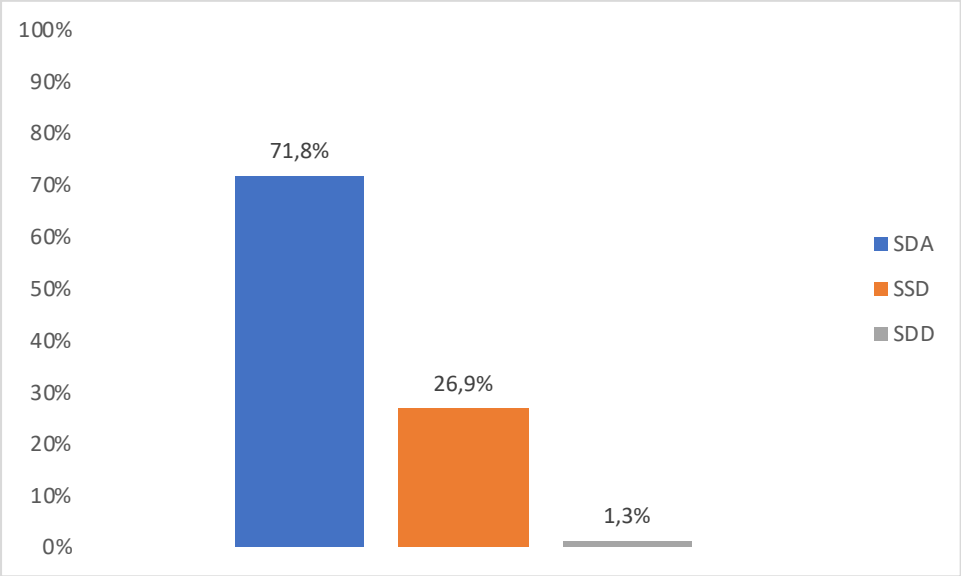


Figure 3: Proportion of retrievals of the source stories according to the type of similarity shared with the target cue story in Experiment 3

## 5. General Discussion

When analogical retrieval became the focus of experimental research, it has mostly been claimed that superficial similarity is the predominant factor for accessing a situation stored in memory (Catrambone, 2002; Gentner et al., 1993, 2009; Hummel & Holyoak, 1997; Trench & Minervino, 2015). Some studies have credited structural similarity with a modest role (Gentner et al., 1993, 2009; Gick & Holyoak, 1983) while others have attributed to it an important influence in access (Holyoak & Koh, 1987; Kretz & Krawczyk, 2014; Wharton et

[3] This difference was significant both in the version where the target cue situation is Luigi and Lorenzo's story ($\chi$2 (1, N = 40) = 5.49, p < .05) and in the version where the target cue situation is Elyse and Charles' story ($\chi$2 (1, N = 35) = 11.11, p < .01).

al., 1994, 1996), and certain studies even proposed that it can surpass the influence of surface similarity (Blanchette & Dunbar, 2000; Dunbar & Blanchette, 2001; Hofstadter & Sander, 2013). Nevertheless, the recent additional demonstration that surface similarity plays an important role in the retrieval of structurally similar situations from the participants' own experience was taken as an evidence supporting the surface dominance in retrieval (Trench & Minervino, 2015).

In the present study, we tested the structure dominance hypothesis by using story-recall tasks where the source stories sharing surface similarity did not share structural similarity, and where the source stories sharing structural similarity did not share surface similarity. In Experiment 1A, the competing SSD and SDA were presented among four SDD stories. The results demonstrated that surface features are only marginally used as retrieval cues, whereas structural similarity elicits near perfect retrievals. In Experiment 1B, a soundness rating task was used as a mean to assess the difference of structural overlap between the stories that were constructed so as to share surface but no structural similarity in previous studies and in our experiments. Participants rated a great proportion of the text of the MA and the OO target cue stories (Gentner & Landers, 1985; Gentner et al., 1993) as sharing structural similarity with their respective source story, whereas the SSDs used in the present experiments appeared from the beginning of the text as structurally different. Experiment 2 was aimed to assess whether the structure dominance hypothesis is also predictive of retrieval in the cases where one has encountered several exemplars sharing surface similarity with the target cue. Structurally-based retrievals remained preponderant when several SSDs were introduced in the pool of source stories. These data suggest that the retrieval of SDAs is preferred as long as superficially similar source stories do not share a significant part of the target cue's structure, even when more exemplars sharing surface features compete. In order to rule out the possibility that our results were due to a reactivation of all source stories one after another,

and a mapping of each of them to the target cue story, a third experiment was conducted with the introduction of eight source stories and a five minutes filler task. Structural dominance was still observed after these controls have been implemented. It could be argued that the implementation of a mapping process is still made possible by the presentation of a limited number of source stories (eight source stories) in the same experimental session as the presentation of the target cue story. However, it should be noted that in previous experiments, participants who were presented with seven source stories (Gentner et al., 2009, Experiment 4), as well as participants who were presented with the source and target cue stories during the same experimental session (Catrambone, 2002) still predominantly retrieved SSDs rather than SDAs. Hence, the contrast between the results obtained in these studies and the present study appears to be better explained by the absence of any structural similarity among the stories sharing surface similarity.

### 5. 1. Structural focus and surface erosion in analogical retrieval

Our results demonstrate that SDAs are better retrieved than SSDs. Trench and Minervino's (2015) results reveal that SSAs are predominantly retrieved over SDAs. Together, these data suggest that structurally-based retrieval is preferentially oriented towards SSAs, but that when SSAs are lacking, surface similarity is put aside and leaves place to the retrieval of SDAs. The central role of structure in the situation’s encoding may allow a situation sharing high, moderate or no surface similarity to be retrieved, as long as it remains structurally similar.

Some authors have claimed that the frequent retrievals of SSAs that has been reported in the literature (Bearman et al., 2007; Dunbar, 1997; Trench & Minervino, 2015) are due to the conjunction of a surface similarity-based access and the fact that a set of surface features generally correlates with some structural features (the kind world hypothesis; Gentner & Medina, 1998). In other words, the structural blindness in retrievals would be compensated by

the kind nature of the world in which similar structures underlie similar surfaces. In contrast, our results suggest that the retrieval of structurally similar situations may not fully depend on probable but not systematic associations between surface similarity of two situations and their structural similarity. Conceiving retrieval as a process that is mainly based on structural similarity which is set at a moderate level of abstraction may provide a more accurate explanation for the reason why SSAs are more often retrieved than just any SSD.

One can still wonder why surface similarity seems to modulate the retrieval of an analog (Trench & Minervino, 2015) whereas it only marginally promotes the retrieval of a disanalog. As noted by Vosniadou (1989), two analogs belonging to a similar semantic domain can share an important structural similarity. It can be argued that the preponderance of retrievals of SSAs over the retrievals of SDAs is due to the fact that two analogs with surface similarity generally share a higher proportion of relevant abstract similarities than two SDAs. This explanation can be exemplified with the similarities existing between the target cue depicting someone that is consuming so much new food that he or she gets disgusted by it and the SSA or the SDA which retrieval was considered in Trench & Minervino (2015). The SSA may contain relevant abstract information, such as the fact that the character may have a sweet tooth or that he or she risks to put on weight or to get sick, which the SDA, such as playing too much of a video game with the consequence of getting fed up with it, may not preserve.

The results raise an additional question on the kind of analogies that are used when pursuing different types of goals, which is not circumscribed to the issue of retrieval processes. Even though participants may consider SSAs as more reliable while making predictions (Trench & Minervino, 2015), it may also be the case that alternative goals are better achieved through the use of a SDA (Blanchette & Dunbar, 2000). For instance, when pursuing the goal of illustrating and explaining a target situation, providing a SSA that shares

many features with it may weaken the emphasis on the relevant ones, whereas a SDA restricts similarity to what is essential. In this line, observational studies suggest that experts frequently refer to SDAs while seeking to illustrate a concept (Christensen & Schunn, 2007; Kretz & Krawczyk, 2014; Richland, Holyoak, & Stigler, 2004). Further studies are needed to understand more precisely how contexts and purposes influence the use of an analog that shares or does not share surface similarity.

**5.2. Why were SDAs so rarely retrieved in previous experiments?**

Previous studies have shown that SDAs retrievals are rare. Research in problem-solving has revealed that the solution from a source problem is rarely transferred to a SDA target cue problem. As familiarity with the analog situations is central in allowing one to encode and use a structural similarity to drive retrieval (Vosniadou, 1989), it may be the case that the low familiarity with the problems prevents the participants from accessing SDA problems. Indeed, participants are better able to retrieve based on structural similarity when they are familiar with the schema underlying the SDAs (Gentner et al., 2003; Gick & Holyoak, 1983; Seifert et al., 1986).

The unfamiliarity account for the rare occurrence of SDAs retrievals can appear to be in contradiction with Trench and Minervino's (2015) results, demonstrating that even SDAs from the participants' own experiences (*e.g.* the *Jurassic Park* movie) are rarely retrieved. Indeed, the authors conclude from their results that even the structure of familiar events is rarely used alone to drive retrieval. However, the familiarity with a source situation may not imply that it will be retrieved when faced with a target cue situation sharing a structure at any level of abstraction. Familiarity may not allow the participant to encode the situations at the most abstract level (at which the *Jurassic Park* movie and *the Martian Storm* scenario are similar), but, it may allow the participant to create an abstract category which abstraction is determined by the knowledge he or she has about the situation (Hofstadter & Sander, 2013). It

is possible that the participants' knowledge about the *Jurassic Park* movie led them to create an abstract category, such as a *risky attempt to recreate fascinating creatures*, that does not cover the *Martian Storm* scenario, although the category could contain other SDAs sharing a structural similarity at a less abstract level. Contrasting with the *Martian Storm* scenario, the *Mammoths* scenario would be a good fit of the category, which could explain why it elicits more frequent retrievals of *Jurassic Park*. It should be noted that the category extracted from the *Jurassic Park* movie already requires a slight abstraction in order to be extended to the *Mammoths* scenario, since it necessitates to both detect common structural features and to bypass a certain degree of surface dissimilarity (*mammoths* are not *dinosaurs*, *frozen embryos* are not *mosquito fossils*, etc). The sharp contrast in frequency of SDAs retrievals that lies between Trench and Minervino's (2015) results and the ones reported in the present study suggests that some SDAs may be harder to retrieve than others, due to the fact that they share a structural similarity at a higher level of abstraction. Whereas the present study provides evidence for the dominance of structural similarity in analogical retrieval, further studies are needed to determine at which level of abstraction the structural similarity which is set between the SDAs stops being the preponderant factor guiding retrieval.

Together, the findings obtained in the experiments reported in this study contribute to better understand the role of surface and structural similarities in the retrieval of past-events. They demonstrate that the widely documented superiority of surface similarity over structural similarity is not reproduced when structural similarity is neutralized among superficially similar situations. The contrast between the present results and the failures to retrieve SDAs in previous experiments also suggests that the participants knowledge must be considered when assessing the ability to encode structural features and to subsequently use them as retrieval cues.

## Appendix

SSDs used for the two versions of the task in Experiment 2 (translated from French)

| First version | Second version |
|---|---|
| Julie is in love with Victor, her classmate, and she is getting closer to him in order to seduce him. But Diane joins the class in the middle of the year and also has a crush on Victor. Julie notices that Diane is not very aware of her style and gives her some makeover advice, showing her fashion photos and taking her out for shopping. Diane now looks very cute and chic. Diane is so grateful that she tells Julie that she will stop flirting with Victor. | In a marketplace, a truck called « At Alessandro & Fabio's » has various choices of homemade pizzas. The important clientele that goes there is fond of the authentic atmosphere of the stand held by the two happy looking men in Italian traditional suits. However, once they leave from this marketplace, the two men will go to another one, but only after changing into German traditional clothes in order to sell special German sausages. The sign there displays « At Hans and Hendrich's ». |
| Today, Arnaud has invited Zoé to have a drink in a fancy bar downtown. Just yesterday, he was telling to his mate Pierre that he really likes her, while proudly claiming he was absolutely sure he would close with her tonight. At the end of their date, he came near and tried to kiss her, but Zoé, very surprised, pushed him away. On his way back, Arnaud meets Pierre, his friend, and tells him that anyway, he never meant to go further with that ugly and disgraceful girl he never pint his hope in. | Every day, Claudio and Franco wake up early to prepare pizzas in their food-truck. From sunset to sunrise, they run the streets restlessly in order to sell a maximum of pizzas a day. Exhausted, Claudio confesses to Franco that he cannot bear this routine anymore, which is as exhausting as gloomy. Franco tells he is fed up too. At this moment, a bright idea came to them : they would convert the truck into an RV with their savings and go abroad to see new horizons. |
| When she gets to the office, Claire sometimes meets Quentin whose company is set at the upper floor. She starts to charm him and to show interest in him by making eyes to him. Quentin, who had initially no hidden agenda, and who adopted a perfectly cordial attitude with her, progressively succumbs to her charm and credits her with an increasing attention. After she stated that Quentin was paying more and more attention to her, Claire finally ignored him and started seducing Gabriel, the server of the cafeteria. | Paulo and Giorgio have had great success with their pizza truck. Now they intend to fulfil their dream of getting a real Italian restaurant. One day, while looking through their books, Paulo discovered that Giorgio has always hidden the real amount of their profits, and that he actually keeps much more than half of it. Infuriated, Paulo decides to put an end to their collaboration. But since his wages depend on the collaboration with Giorgio, he changes his mind and finally continues working with him. |

Note : as in Experiment 1A, the target cue was Luigi and Lorenzo's story in the first version and Elyse and Charles' story in the second version.

## References

Bassok, M., Wu, L. L., & Olseth, K. L. (1995). Judging a book by its cover: Interpretative effects of content on problem-solving transfer. *Memory & Cognition*, *23*, 354-367.

Bassok, M. (1996). Using content to interpret structure: Effects on analogical transfer. *Current Directions in Psychological Science*, *5*, 54-58.

Bassok, M., Pedigo, S. F., & Oskarsson, A. T. (2008). Priming addition facts with semantic relations. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *34*, 343-352.

Blanchette, I., & Dunbar, K. N. (2000). How analogies are generated: The roles of structural and superficial similarity. *Memory & cognition*, *28*, 108-124.

Bearman, C. R., Ball, L. J., & Ormerod, T. C. (2007). The structure and function of spontaneous analogising in domain-based problem solving. *Thinking and Reasoning*, *13*, 273-94.

Catrambone, R., & Holyoak, K. J. (1989). Overcoming contextual limitations on problem-solving transfer. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *15*, 1147-1156.

Catrambone, R. (2002). The effects of surface and structural feature matches on the access of story analogs. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *28*, 318-334.

Chalmers, D. J., French, R. M., & Hofstadter, D. R. (1992). High-level perception, representation, and analogy. *Journal for Experimental and Theoretical Artificial Intelligence*, *4*, 185-211.

Christensen, B. T., & Schunn, C. D. (2007). The relationship of analogical distance to analogical function and pre-inventive structure: The case of engineering design. *Memory & Cognition*, *35*, 29–38.

Clément, E., & Richard, J-F. (1997). Knowledge domain effects in problem representation: the case of the Tower of Hanoi Isomorphs. *Thinking and Reasoning*, *3*, 133-157.

Day, S. B., & Goldstone, R. L. (2011). Analogical transfer from a simulated physical system. Journal of Experimental Psychology: *Learning, Memory, and Cognition*, *37*, 551–567.

Dekel, S., Burns, B. D., & Goldwater, M. B. (2017). Leaping across the mental canyon: Analogical retrieval across disparate task domains. In G. Gunzelmann, A. Howes, T. Tenbrink, & E. Davelaar (Eds.), *Proceedings of the 39th annual conference of the cognitive science society* (pp. 1908-1913). Austin, TX: Cognitive Science Society.

Dietrich, E. S. (2010). Analogical insight: Toward unifying categorization and analogy. *Cognitive Processing*, *11*, 331-345.

Dunbar, K. N. (1997). How scientists think: Online creativity and conceptual change in science. In T. B. Ward, S. M. Smith, & S. Vaid (Eds.), *Creative thought: An investigation on conceptual structures and processes* (pp. 461–493). Washington, DC: APA Press.

Dunbar, K. N. (2001). The analogical paradox: Why analogy is so easy in naturalistic settings yet so difficult in the psychological laboratory. In D. Gentner, K. J. Holyoak, & B. N. Kokinov (Eds.), *The analogical mind: Perspectives from cognitive science* (pp. 313–334). Cambridge, MA: MIT Press.

Dunbar, K. N., & Blanchette, I. (2001). The in *vivo/in vitro* approach to cognition: The case of analogy. *Trends in cognitive sciences*, *5*, 334-339.

Duncker, K. N. (1945). On problem solving. Psychological Monographs, 58, Whole No. 270.

Estes, Z., & Jones, L. L. (2006). Priming via relational similarity: A copper horse is faster when seen through a glass eye. *Journal of Memory and Language*, *55*, 89–101.

Festinger, L. (1957), *A Theory of Cognitive Dissonance*, Stanford, CA: Standford University Press.

Gentner, D. (1983). Structure-Mapping: A Theoretical Framework for Analogy. *Cognitive Science*, *7*, 155-170.

Gentner, D., & Colhoun, J. (2010). Analogical processes in human thinking and learning. In B. Glatzeder, V. Goel, & A. Müller (Eds.), *Towards a theory of thinking* (pp. 35-48). Berlin, Germany: Springer Berlin Heidelberg.

Gentner, D., & Landers, R. (1985). Analogical reminding: A good match is hard to find. *Proceedings of the International Conference on Systems, Man, and Cybernetics* (pp. 607-613) Tucson, NY.

Gentner, D., Loewenstein, J., & Thompson, L. (2003). Learning and transfer: A general role for analogical encoding. *Journal of Educational Psychology*, *95*, 393–408.

Gentner, D., Loewenstein, J., Thompson, L., & Forbus, K. D. (2009). Reviving inert knowledge: Analogical abstraction supports relational retrieval of past events. *Cognitive Science*, *33*, 1343-1382.

Gentner, D., & Medina, J. (1998). Similarity and the development of rules. *Cognition*, *65*, 263-297.

Gentner, D., Rattermann, M. J., & Forbus, K. D. (1993). The roles of similarity in transfer: Separating retrievability from inferential soundness. *Cognitive Psychology*, *25*, 524-575.

Gick, M. L., & Holyoak, K. J. (1980). Analogical problem solving. *Cognitive Psychology*, *12*, 306–355.

Gick, M. L., & Holyoak, K. J. (1983). Schema induction and analogical transfer. *Cognitive Psychology*, *15*, 1-38.

Green, A. E., Fugelsang, J. A., & Dunbar, K. N. (2006). Automatic activation of categorical and abstract analogical relations in analogical reasoning. *Memory & Cognition*, *34*, 1414-1421.

Green, A. E., Fugelsang, J. A., Kraemer, D. J., & Dunbar, K. N. (2008). The micro-category account of analogy. *Cognition*, *106*, 1004-1016.

Goldstone, R. L., Medin, D. L., & Gentner, D. (1991). Relational similarity and the non-independence of features in similarity judgments. *Cognitive Psychology*, *23*, 222-262.

Hammond, K. J., Seifert, C. M., & Gray, K. C. (1991). Functionality in analogical transfer: A hard match is good to find. *The Journal of the Learning Sciences*, *1*, 111-152.

Hampton, J. A. (2003). Abstraction and context in concept representation. *Philosophical Transactions of the Royal Society of London: Biological Sciences*, *358*, 1251–1259

Hofstadter, D., & Sander, E. (2013). *Surfaces and essences: Analogy as the fuel and fire of thinking*. New York: Basic Books.

Holyoak, K. J., & Koh, K. (1987). Surface and structural similarity in analogical transfer. *Memory & Cognition*, *15*, 323-340.

Hummel, J. E., & Holyoak, K. J. (1997). Distributed representations of structure: A theory of analogical access and mapping. *Psychological Review*, *104*, 427–466.

Johnson, H. M., & Seifert, C. M. (1992). The role of predictive features in retrieving analogical cases. *Journal of Memory and Language*, *31*, 648–667.

Jones, L. L., Estes, Z., & Marsh, R. L. (2008). An asymmetric effect of relational integration on recognition memory. *The Quarterly Journal of Experimental Psychology*, *61*, 1169-1176.

Keane, M. (1987). On retrieving analogues when solving problems. *The Quarterly Journal of Experimental Psychology*, *39*, 29-41.

Kretz, D. R., & Krawczyk, D. C. (2014) Expert analogy use in a naturalistic setting. *Frontiers in Psychology. 5*, 1333.

McRae, K., Nedjadrasul, R. P., Lo, B. P-H., & King, L. (2018). Abstract concepts and picture of real-world situations activate one another. *Topics in Cognitive Science*. 1-15.

Novick, L. R. (1988). Analogical transfer, problem similarity, and expertise. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *14*, 510-520.

Popov, V., Hristova, P., & Anders, R. (2017) The Relational Luring Effect: Retrieval of Relational Information during Associative Recognition. *Journal of Experimental Psychology: General*, *5*, 722–745.

Richland, L. E., Holyoak, K. J., & Stigler, J. W. (2004). Analogy Use In Eighth-Grade Mathematics Classrooms. *Cognition and Instruction*, *22*, 37-60.

Ross, B. H. (1987). This is like that: The use of earlier problems and the separation of similarity effects. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *13*, 629.

Ross, B. H. (1989). Distinguishing types of superficial similarities: Different effects on the access and use of earlier problems. Journal of Experimental Psychology: *Learning, Memory, and Cognition*, *15*, 456.

Schank, R. C. (1982) *Dynamic memory*. New York: Cambridge University Press.

Schunn, C. D., & Dunbar, K. N. (1996). Priming, analogy, and awareness in complex reasoning. *Memory & Cognition*, *24*, 271–284.

Seifert, C. M., McKoon, G., Abelson, R. P., & Ratcliff, R. (1986). Memory connections between thematically similar episodes. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *12*, 220-231.

Trench, M., & Minervino, R. A. (2015). The role of surface similarity in analogical retrieval: Bridging the gap between the naturalistic and the experimental traditions. *Cognitive Science*, *39*, 1292-1319.

Trench, M., Tavernini, L. M., & Goldstone, R. L. (2017). Promoting spontaneous analogical transfer by idealizing target representations. *Proceedings of the 39th Annual Conference of the Cognitive Science Society*. (pp. 1206-1211). London, England: Cognitive Science Society.

Vosniadou, S. (1989). Analogical reasoning as a mechanism in knowledge acquisition: A developmental perspective. In S. Vosniadou & A. Ortony (Eds.), *Similarity and analogical reasoning* (pp. 413–437). New York: Cambridge University Press.

Wharton, C. M., Holyoak, K. J., Downing, P. E., Lange, T. E., Wickens, T. D., & Melz, E. R. (1994). Below the surface: Analogical similarity and retrieval competition in reminding. *Cognitive Psychology*, *26*, 64-101.

Wharton, C. M., Holyoak, K. J., & Lange, T. E. (1996). Remote analogical reminding. *Memory & Cognition*, *24*, 629-643.