When Lighting a Candle Becomes a Superstition: Analogical Recategorization through the Application of Relational Categories

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Abstract

In this paper we proposed a new classification of analogical mechanisms of representational change and gathered evidence of the operation of one of the new ones that we proposed: recategorization of events. We carried out two experiments to assess whether an analogy can trigger the recategorization of a target analog (TA). More specifically, the experiments were designed to test whether a TA not initially regarded as a member of a schema relational category can be perceived as belonging to such category as a result of being paired with a base analog (BA) consisting of a typical exemplar of that category. Results in both experiments showed that having paired an atypical TA with a typical BA favored the use of the base category to describe the TA. Implications for traditional and future proposals of mechanisms of analogical representation change are discussed.

Keywords: analogy; mapping; re-representation, relational category

Introduction

Analogy serves several and diverse cognitive functions, such as problem solving, explanation, persuasion, decision making and learning (Holyoak, Gentner, & Kokinov, 2001). Two situations are analogous if they share a common pattern of relations among their constituent entities, even though the objects themselves may differ across situations. Through a mapping between the elements of a known situation (*base analog*: BA) and their corresponding elements in a less understood situation (*target analog*: TA), inferences can be drawn to enhance the representation of the latter. Hofstadter and FARG (1995) have argued that mapping and representational change run in an intrinsically related way, and can not be studied separately. During the past decade some experimental research has been done that focused on this interaction (see, e.g., Gentner & Kurtz, 2006; Kokinov, Bliznashki, Kosev, & Hristova, 2007; Kurtz, 2005).

Gentner and Wolff (2000) distinguished several kinds of representational change produced by metaphor and analogy. In the present paper we introduce some adjustments to their classification and postulate three new mechanisms of representational change. First, we propose a general distinction between two kinds of mechanisms: 1) *re-representational mechanisms*: processes that make the mapping possible but do not produce a substantial change in the representation of the analogs, and 2) *conceptual change mechanisms*: processes that change the perception of the analogs as an effect of the comparison. Within the first kind, we include Gentner and Wolff´s (2000) *re-representation of propositional elements*, and propose a new mechanism: *re-representation of events*. Within the second kind, we include Gentner and Wolff´s *highlighting*, *inference generation* and *restructuring*, and propose two further mechanisms: *recategorization of propositional elements* and *recategorization of events* (see Figure 1). We present the results of two experiments that gather evidence for the mechanism of recategorization of events.

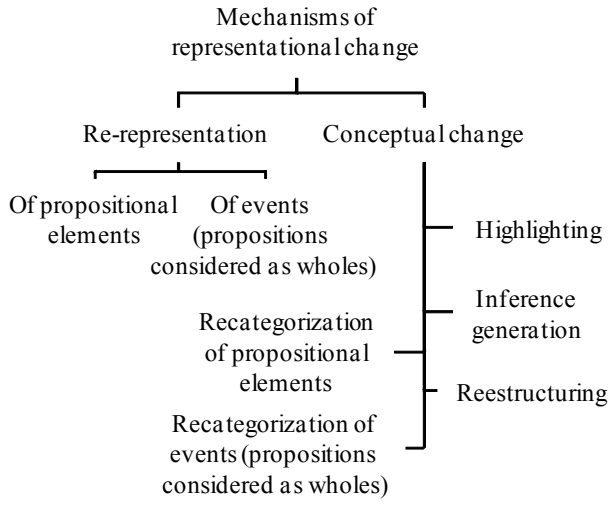

Figure 1. Analogical mechanisms of representational change.

Re-representation mechanisms

Dominant theoretical accounts of the mapping process rely heavily on the existence of semantic similarity between the propositional elements to be mapped (e.g., Gentner & Markman, 2006; Hofstadter & FARG, 1995; Holyoak & Thagard, 1989; Hummel & Holyoak, 1997). Even though there is agreement regarding the fact that two dissimilar predicates or entities can be put in correspondence in order to improve an ongoing global mapping if they can be re-represented as similar, there is still debate as to the exact mechanisms through which this re-representational process takes place. Falkenhainer's (1990) method of *minimal ascension* could re-represent initially dissimilar concepts such as *buy* and *take* via identification of a common superordinate (e.g., *obtain*). In a similar way, the first version of the multiconstraint theory allowed alignments between non identical elements by providing the mapping engine (ACME) with similarity scores among the elements being compared (Holyoak & Thagard, 1989). The criterion underlying such similarity scores reflected intuitive taxonomic IS-A criteria (see Holyoak & Thagard, 1995). In this way, as *cat* and *dog* are encompassed by the immediate superordinate *mammal*, they are assigned a higher similarity score than would be assigned to the pair *cat* and *tuna*, since the common superordinate of these last concepts (i.e., *animal*) occupies a higher position in the hierarchy. A more recent proposal for re-representing similar but not identical relations, advanced by the structure-mapping theory as an extension of SME (Falkenhainer, Forbus, & Gentner, 1989), is *semantic decomposition*. This mechanism consists of identifying the subcomponents that encode the meaning of dissimilar relations, so as to reveal identity matches among these subcomponents (Yan, Forbus, & Gentner, 2003). If a means of finding an identity between initially dissimilar predicates like UNLOCK (house) and UNCORK (bottle) were needed, applying decomposition to the above predicates could eventually lead to re-represent them as CAUSE [UNLOCK (house), OPEN (house)] and CAUSE [UNCORK (bottle), OPEN (bottle)], respectively. In this way, the decomposition mechanism reveals that *unlock* and *uncork* share the common subcomponent *open*. In a similar vein, the last computational implementation of the multiconstraint theory (i.e., LISA; Hummel & Holyoak, 1997, 2003) achieves a sort of decomposition by resorting to distributed representations of meaning. LISA operates on conceptual units that are permanently linked to a collection of primitives that represent their semantics. Within LISA's architecture, two non-identical elements can be put in correspondence as a result of sharing semantic primitives–a mechanism akin to semantic decomposition (Gentner & Kurtz, 2006). The processes described so far constitute re-representation mechanisms, to the extent to which they do not imply substantial changes in the perception of one or both analogs as an effect of the comparison, being their main function to complete an ongoing mapping. On the other hand, they operate computing the similarity between pairs of propositional elements considered in isolation.

In order to gather experimental evidence for the existence of re-representation at the level of propositional elements, Gentner and Kurtz (2006) used both online and offline measures to assess if participants re-represented non identical relations when asked to give judgments of analogical relatedness. In this study, participants were asked to give timed answers to whether a BA (e.g., *John bought the candy*) was analogous to TAs in which the base relation was substituted with other relations of varying degrees of semantic similarity with the base relation. Sticking to the above BA, whereas in the synonymous verb condition the TA was *John purchased the candy*, in the near verb condition the TA was *John took the candy*. Finally, in the far condition the TA was *John stepped on the candy*. Processing times for synonymous pairs were shorter than those for near pairs. With regards to ratings of analogical acceptance, analogs with synonymous verbs were nearly always considered analogous. At the level of semantically similar but distinct predicates, in more than half of the trials the compared facts were judged as analogous, providing striking evidence of human flexibility in re-representing predicates in order to place two situations in correspondence. In their second experiment, Gentner and Kurtz introduced an analogical acceptance justification task aimed at assessing whether participants would mention an underlying semantic commonality that could provide supporting evidence for a re-representation process. Their results showed that participants effectively used novel language redescriptions to refer to the analogical relations, especially for near and far substitutions. An interesting result was that when participants had to justify the analogical relation between far objects they did not only redescribe the noun but also the verb, which was the same across the BA and the TA. This data is not consistent with approaches that conceive re-representation processes as operating via the identification of similarities between propositional elements considered in isolation.

Minervino, Oberholzer and Trench (2008) have argued that a limitation of all available accounts of the role played by semantic similarity on analogical mapping resides in confining its treatment to the level of propositional elements (i.e., objects, object properties and relations), and argued for the need of broader construals in the treatment of similarity. In the present paper, we propose an alternative re-representation mechanism that operates on propositions as wholes and not at the level of propositional elements. Such mechanism consists of searching for a schema relational category (Markman & Stilwell, 2000) for which the compared facts constitute instances. We refer to this mechanism as *recategorization of events*.

Instead of sharing a set of probabilistic features and feature correlations, members of relational categories such as *assassination* share a relational structure like, say, KILL (murder, means, victim), which can be instantiated by many apparently different exemplars, such as *Fred thrust a knife into Gina's heart*, *Mary had Bob drink poison*, or *The surgeon disconnected the patient's oxygen supply* (Gentner & Kurtz, 2005). Let's consider the following analogs:

BA: Dolores hung garlic on the door
TA: Mary brought a rabbit leg to the stadium

If participants in an experiment had to decide if these situations are analogous and try to find superordinates for the pairs *hang-bring*, *garlic-rabbit leg* and *door-stadium*, they would only find very abstract ones, giving place to a trivial superordinate description like "Someone takes an object to a place", probably leading participants to decide that the compared facts are not analogous. A similar result would be obtained when attempting to discover latent identities via decomposition:

BA: Dolores hung garlic on the door →
CAUSE [HANG (dolores, garlic, door), MOVE (dolores, garlic, door)]

TA: Mary brought a rabbit leg to the stadium →
CAUSE [BRING (mary, rabbit leg, stadium), MOVE (mary, rabbit leg, stadium)]

In cases like the described above, where element-to-element re-representational mechanisms fail to reveal an identity between the compared situations, we postulate a re-representational mechanism, consisting of a search for a schema relational category (in this case, *superstition*) for which the to-be-mapped situations could be considered instances. According to our proposed classification, this last process should be included among re-representation mechanisms, on the grounds that the perception of the situations does not change as an effect of the analogical comparison.

Minervino et al. (2008) conducted two experiments to show that sometimes people disregard element-to-element similarities and favor similarity between events described by whole propositions in their judgments of analogical relatedness. Participants had to choose between two TAs (e.g., TA1: *John offered a deodorant to Mary*; TA2: *John wrote a poem to Mary*) for a certain BA (e.g., *John gave a perfume to Mary*)–all the analogs being structurally identical. The only difference was that whereas the elements of the TA1 were semantically close to the elements of the BA, the elements of the TA2 were semantically more distant. Results showed that participants frequently passed over element-to-element similarities between the BA and the TA1 and chose instead the TA2, which shared a common schema relational category with the BA (e.g., *act of seduction*).

As we have said, re-representation mechanisms do not imply substantial changes in the perception of the analogs. In the case of the two considered mechanisms this can be explained as follows: since the base and target elements or events constitute typical instances of the superordinate category evoked to place them in correspondence, the analogy does not induce a categorization different from the one each analog would have received by it itself.

Conceptual change mechanisms

It is possible that in some cases one of the analogs (e.g., the BA) constitutes a typical exemplar of a schema relational category but the other (the TA) one does not, admitting the application of more accessible alternative categories. If the typical BA promotes a relatively improbable categorization of the TA, that categorization could be taken as a case of conceptual change rather than a case of re-representation. Consider the following analogs:

BA: Dolores hung garlic on the door.
TA: Mary lighted a candle in the basement

In cases like this, people are likely to categorize the BA as an exemplar of a superstitious behavior (since it is a typical example of that relational category), and then evaluate if the TA could be considered an instance of such category. This kind of representational change is likely to occur for schema relational categories, since the exemplars of these categories usually receive many and diverse categorizations (some of them not mutually exclusive), as compared to exemplars of entity categories (Gentner & Kurtz, 2005) (e.g., *Mary lighted the candle in the basement* could be categorized as an act of illumination, an attempt to improve the smell of the basement, etc.). If the BA represents a typical exemplar of a schema relational category, it may favor the application of such category to the TA in order to reveal the similarity between the base and the target. We refer to this kind of conceptual change as *recategorization of events*.

Kurtz (2005) carried out two experiments in which the primary question was whether comparing a pen with a bottle (a typical exemplar of *container*) could influence the recategorization of a pen (an atypical case of *container*) as an instance of that category. This was evaluated directly using a yes/no question: "Can a pen be a container?" Kurtz (2005, Experiment 1) included two control conditions: while in one of them the critical question was not preceded by a comparison task, in the other one participants had to compare a pen to a base object (key) that was not an exemplar of container (this second group is necessary to confirm that the causal factor is the comparison with the bottle and not just any process of comparison). The bottle/pen condition but not the key/pen condition gave more "yes" answers than the pen/only condition.

The Kurtz's (2005) study was aimed at investigating analogical recategorization of objects. We developed a first experiment to determine whether presenting a typical exemplar of a schema relational category can trigger the recategorization of a TA describing an event that is less representative of the same relational category. Let's suppose that a group of people read *Dolores hung garlic on the door*. If they were asked how they would categorize that situation, they might answer that Dolores is carrying out a superstitious action. Now, if they read that *Dolores lighted a candle in the basement*, most of them would probably say that Dolores is trying to illuminate the basement, and may be that only a few would say that she is being superstitious.

But how would people describe the TA when paired with the BA in the context of an analogy? In this case we ventured that many of them would describe lighting a candle in the basement as a case of superstition. If this actually happened, we would count with some evidence concerning the fact that analogies could favor the recategorization of events.

Experiment 1

Participants in the analogy group read a typical BA and an atypical TA (e.g., *Peter gave a bottle of perfume to Mary* and *Peter played a joke on Mary*) and were asked to categorize the situation described in the TA considering that it was analogous to the one described in the BA (e.g., "How would you describe Peter's second behavior considering that it is analogous to his first action?"). Participants in the no-analogy group read the TA after reading a non analog (i.e., a case that doesn't belong to the critical category; e.g., *Peter lodged a complaint against Mary*). Then they were asked to categorize the second situation (e.g., "How would you categorize Peter's second behavior?"). The categorizations of the TAs were compared between the analogy and no-analogy groups.

Method

Participants Fifty three undergraduate students from the University of Buenos Aires participated in the experiment for course credits. Participants were randomly distributed between the two conditions: the analogy group (26) and the no-analogy group (27).

Materials. Twelve sets of materials were used. Each set consisted of a typical analog, an atypical analog and a non analog (NA). All of the analogs and NAs consisted of simple daily life situations (e.g., *Peter played a joke on Mary* or *Dolores lighted a candle in the basement*). We made a preliminary study to produce our materials. Participants (27) in an independent group had to categorize and rate on a 7-point Likert scale the analogs and non analogs of 33 sets, considered as isolated cases and presented in a random order. To choose the sets we adopted the following criteria: 1) the typical analogs were cases in which more than 60% of the participants used the critical category to classify the situation, and on the Likert scale their median value was 6 or more (e.g., *Hang garlic on the door*, a typical example of superstition); 2) the atypical analogs were cases in which less than 15% of the participants selected the critical category to classify the situation, and on the Likert scale their median value was 3 or less (e.g., *Light a candle in the basement*, a non-typical example of *superstition*); 3) the NAs were cases where nobody applied the critical category and their median value was 1 (e.g., *Forget a coat in the garden*, not a case of *superstition*). In the analogy condition participants read six critical analogies (i.e., a typical case as the BA and an atypical case as the TA) and six filler analogies (i.e., an atypical case as the BA and a typical case as the TA). The aim of the filler analogies was to prevent participants in the analogy group from discovering the logic of the recategorization of the TA in terms of the BA. In the no-analogy condition participants read six critical non analogies (i.e., NA plus an atypical TA), and six filler non analogies (i.e., NA plus a typical TA). In this way, participants in both groups had to categorize and rate typical and atypical cases. The order of presentation of the sets was counterbalanced in both conditions. See Table 1 for examples of the sets employed in Experiment 1.

Procedure Participants in the analogy group read a definition of analogy and four examples of analogies and non analogies. They also received an explanation and examples of the categorization task. Then they had to perform four training tasks. After that, they read six critical analogies and six filler analogies, and they were asked to categorize the TA of each of them on the supposition that it was analogous to the BA. In this categorization task, they were allowed to provide one or more descriptions of the TA. Participants in the no-analogy group read the same instructions as participants in the analogy condition, except for the fact that the explanation about analogy was removed. After that, they read six critical non analogies and six filler non analogies, and they performed the categorization task. The experiment was individually administrated in computers and each session lasted approximately 30 min. On one screen appeared the pair of situations and the categorization task.

Table 1: Examples of sets

Category	Typicality	Situation
Seduction	Typical	Juan gave a perfume to María
	Atypical	Juan played a joke on María
	Non analog	Juan lodged a complaint to María
Marital infidelity	Typical	Ariel closed the chat when his wife arrived
	Atypical	Ariel arranged the bed when his wife arrived
	Non analog	Ariel blew his nose when his wife arrived
Teaching	Typical	Martín explained an equation to his brother
	Atypical	Martín made the bed of his brother
	Non analog	Martín asked for a refreshment to his brother

Results and Discussion

Two independent judges evaluated if the participants used the critical category to describe the TA. They were instructed to consider as hits only those cases in which the exact critical concept or a very close synonym was

employed (e.g., *witchcraft* or *ritual* instead of *superstition*). Judges agreed in 87% of the trials. Cases of disagreement were solved by open discussion. Participants in the no-analogy group used the critical category in 7% of the TAs' descriptions. In contrast, in the analogy-group participants used the critical category to refer to the TAs in 48% of the trials, $\chi^2(1, 318) = 66.58$, $p < .0001$. Results showed that when paired with a typical BA, there was an increased probability of describing the TA as an instance of the schema relational category that corresponds to the BA. This evidence suggests that the presence of a typical BA can have an influence on the recategorization of the atypical TA.

Experiment 2

In Experiment 1 participants in the analogy group were not given the chance to judge if the compared situations were analogous or not. Instead, they were prompted to categorize the TA on the supposition that it was analogous to the BA. This may have determined the relative high number of times that the critical category was employed. In Experiment 2 we introduced a variation that allowed us to evaluate a spontaneous categorization instead of a forced one. To that end, we introduced a yes/no answer question about the analogical relation prior to the categorization task. Participants read two situations and then they where asked if they were analogous ("Do you consider that these two situations are analogous?"). Since, as we will see, all participants were confronted not only with analogies but also with non analogies, the chances of "no" and "yes" answers were balanced. After that, they had to categorize the second situation (e.g., "Then, how would you categorize the second situation?"). We compared the number of times the critical category was selected between the analogy sets and the no-analogy sets.

Method

Participants Forty undergraduate students from the University of Buenos Aires participated in the experiment for course credits.

Materials We used the same materials as in Experiment 1. As all participants were confronted with analogies and non analogies, we were able to implement an intrasubject manipulation of the independent variable (presence or absence of a typical BA followed by an atypical TA). Thus, participants were confronted with both critical and filler analogies and critical and filler non analogies. The order of presentation of the sets was counterbalanced. In this way, for each participant that received the critical analogy version of, say, Set 1, another participant received the critical non analogy version of the same set.

Procedure Participants read a definition of analogy, four examples of analogies and non analogies, and an explanation and examples of the categorization task. After completing four practice trials, they read twelve pairs of situations. Each participant received three critical analogies, three critical non analogies, three filler analogies and three filler non analogies. In each of them they were asked to determine if the two situations were analogous. Following that task, they had to categorize the TA, being allowed to produce one or more descriptions.

Results and Discussion

Two independent judges evaluated, following the same criteria applied in Experiment 1, if the participants used the critical category to describe the TA. Judges agreed in 89% of the trials. Cases of disagreement were solved by open discussion. When participants read the critical non analogies they used the critical category in 3% of the TAs' descriptions. In contrast, within those trials in which participants were confronted with critical analogies and accepted the analogy (82 cases), they evoked the critical category in 41% of the cases, $\chi^2(1, 192) = 42.86$, $p < .0001$. Although in this experiment we gave participants the possibility of evaluating if the two situations were analogous or not, results replicated those obtained in Experiment 1. The data showed that when the analogical relation with the typical BA was identified, there was a higher probability of applying the critical category to the atypical TA than when it was paired with a NA. To sum up, the data support the idea that analogical mapping triggered a recategorization of the TA as an instance of the critical base category.

General Discussion

In this paper we presented a new classification of mechanisms of representational change. We propose a distinction between mechanisms that make the mapping possible but do not lead to a substantial change in the perception of the analogs (i.e., mechanisms of re-representation) and mechanisms that lead to a substantial change in the representations as an effect of the analogical comparison (i.e., mechanisms of conceptual change). Three new mechanisms are proposed and two of them have a couple of differences with the mechanisms previously proposed in the field. First, in some situations the re-representation and the conceptual change operate considering the propositions (i.e., the events that they describe) as wholes and not the propositional elements in isolation. Second, they contemplate the use of relational categories (Gentner & Kurtz 2005) that have not received enough attention by theories of analogical mapping.

Most theories of analogical mapping accept that two situations can be considered analogous even when their corresponding elements are not initially represented as having identical meaning (Gentner & Kurtz, 2006). They require, however, that some kind of identity between initially similar (but non-identical) propositional elements could be identified, and they propose several mechanisms of re-representation to find those identities, like searching for superordinates in IS-A networks (Falkenhainer, 1990; Holyoak & Thagard, 1989) or decomposition (Hummel &

Holyoak, 1997; Yan, Gentner & Forbus, 2003). Sometimes, these propositional element comparisons may lead to disregard similarities that can be captured using alternative re-representation mechanisms. In this study we proposed that the employment of schema relational categories (Markman & Stilwell, 2000) could be a means of considering similarities between propositions considered as wholes. The members of relational categories share a relational structure that can be instantiated by many and diverse exemplars (Gentner & Kurtz, 2005). For example, *aggression* could be instantiated by insulting someone, pointing defects to someone, making an ironic comment about someone, etc. In these cases, the activation of an appropriate relational category could lead to discover the analogical relations between the exemplars. If the base and target situations constituted typical exemplars of the schema relational category, it would be a case of re-representation of events, since the representational change does not imply viewing one of the analogs in a novel manner as an effect of the comparison with the other one. In contrast, if a typical BA promoted an improbable categorization of the TA, it would be a case that we classified as recategorization of events. In this study we carried out two experiments to gather evidence for the use of this last mechanism.

The results of Experiment 1 showed that a relational category triggered by a typical BA influenced the categorization of an atypical TA in terms of the base category. This finding was replicated in situations where participants spontaneously identified the analogical relation between the base and target analogs. A common shortcoming of the new mechanisms proposed and the traditional ones is that they all assume the existence of taxonomic hierarchies such as IS-A networks. We consider that in many cases the identification of analogical relations supposes the creation of *ad hoc* categories that are not available in conceptual networks of general purpose. It would be interesting that future studies investigated the role that ad hoc schema relational categories play in the analogical mapping.

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