Mammoth Cloning Reminds Us of "Jurassic Park" but Storm Replication Does Not: Naturalistic Settings Do Not Aid the Retrieval of Distant Analogs

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Abstract

After asking participants to propose analogies favoring a zero-deficit policy, Blanchette and Dunbar (2000) obtained a high proportion of base analogs lacking superficial similarities with the target, thus questioning the validity of a long experimental tradition demonstrating their centrality on retrieval. Through the use of culturally shared bases, we overcame two limitations in their study that preclude interpreting their results as evidence for superficially unconstrained retrieval: 1) a lack of discrimination between retrieved and invented bases, and 2) an assessment of the effect of superficial similarity based on counting superficially similar vs. superficially dissimilar bases, which disregards the number of available analogs of each kind. Our participants had to propose analogies that could be used to dissuade a person from pursuing certain objective. A movie seen in natural contexts could serve such a purpose. Whereas half of the participants had to retrieve it out of a superficially similar target, the other half had to retrieve it out of a superficially dissimilar target. In line with traditional findings, retrieval of superficially dissimilar sources was scarce and much lower than retrieval of sources maintaining such similarities. Results call into doubt the hypothesis that in natural settings analogical retrieval is less constrained by superficial similarity.

Keywords: analogy; retrieval; similarity

Introduction

Analogical reasoning plays a central role in activities as diverse as problem solving, decision making, and argumentation (Gentner, Holyoak, & Kokinov, 2001). The essence of analogy lies in acknowledging that two situations–more or less similar in appearance–can be considered comparable at a more abstract level of description (Gentner, 1983; Holyoak, 1984). Mapping is the mechanism of aligning elements (e.g., predicates and objects) that play similar roles in the compared situations (Gentner, 1989; Holyoak, 1984). Frequently, the established correspondences allow the transfer of knowledge from a better known situation (*base analog*: BA) to a less understood situation (*target analog*: TA) via inference generation. This subprocess entails the projection of source elements that are not initially present in the target, but can be hypothetically postulated in accordance with the correspondences provided by the mapping process (Gentner, 1989; Holyoak, Novick, & Melz, 1994).

Analogies vary in the extent to which the base elements maintain intrinsic similarities with corresponding elements in the target. Consider a situation in which a bussinessman, who was dating a beautiful lady, introduced her at a company's party to show her off, with the consequence that several of his employees spent hours trying to seduce her. This situation could be considered, in certain level of abstraction, analogous to another situation in which a professor, who had a pretty daughter, appeared with her at an university concert to brag about her, after which some of his students spent months attempting to invite her out. When two situations share an identical system of relations (in this example, somebody exhibits a close woman to boast about her beauty with the consequence that others tried to win her heart), they are said to maintain *structural similarities* (Gentner, 1989). As it occurs in this analogy, if target elements (i.e., objects, object attributes and relations) are intrinsically similar to their corresponding elements in the base (e.g., girlfriend ↔ daughter, beautiful ↔ pretty, introduce ↔ appear with), the compared situations are also said to maintain *superficial similarities* (Gentner, 1989). The following situation, although structurally similar to the first one, does not maintain superficial similarities with it: "Robbie, who got a new soccer ball, brought it for a match at his club in order to share it, but some of his friends tried hard to steal it from him". Even though this situation shares with the base story a system of relations (i.e., a person exposes something desirable, with the result that others attempt to possess it), its elements are less similar to the corresponding base elements than in the previous case (e.g., girlfriend ↔ soccer ball, beautiful ↔ new, show off ↔ share).

The process of retrieving BAs from long term memory (LTM) has received a great deal of attention within analogy research, as it is considered one of the most critical components of knowledge transfer (Gentner et al., 2009).

A number of experimental studies have demonstrated that the retrieval of BAs is highly dependent on the degree of superficial similarities maintained with the TA (e.g., Catrambone, 2002; Clement, 1994; Gentner, Rattermann, & Forbus, 1993; Holyoak & Koh, 1987: Keane, 1987; Ross, 1987; Spencer & Weisberg, 1987): Whereas retrieval of superficially dissimilar BAs rarely reaches 20% of the trials, superficially similar BAs are retrieved in more than 60% of the cases. The procedure followed in these studies, as in most memory research, consists of two distinct phases: Whereas in the first phase participants are presented with a series of BAs for study, during the second phase–on occasions contextually separated from the first one–participants receive the TAs framed in activities for which retrieving the BAs could be potentially useful, and experimenters assess to what extent the work with such TAs elicits retrieval of the critical BAs. Blanchette and Dunbar (2000) named this procedure the *reception paradigm*, as the BAs that participants are expected to retrieve are previously presented by the experimenters.

Using an alternative procedure, Blanchette and Dunbar (2000) obtained results that were interpreted as challenging the agreed upon centrality of superficial similarities on retrieval. After apprising participants of the consequences of large-scale public debts, the authors asked them to propose analogies that could be used to gather support for a zero-deficit program–including massive cuts in social services–, alleging that future cuts would otherwise be more dramatic. Blanchette and Dunbar named this procedure the *production paradigm*, on the grounds that participants had to retrieve their own BAs during the analogical persuasion task. The fact that in 80% of the analogies the BAs employed by participants did not maintain high degrees of superficial similarities with the TA led the authors to conclude that when meaningful target tasks are used, the retrieval of naturally encoded BAs is not constrained by superficial similarities. Dunbar (2001) proposed that the inconsistency between the reception and the production paradigms could be explained in terms of the different types of encoding they promote. As opposed to the shallow encoding induced by the tasks and materials used in most experimental situations (i.e., reception paradigm), both the encoding of BAs in natural settings and the task of generating persuasive analogies for a meaningful TA aid the highlighting of their structural features. As BAs and TAs are encoded in structural terms, retrieval of BAs from memory does not require superficial similarities. This way, Blanchette and Dunbar's results called into question both the ecological validity of more than two decades of experimental research, and the adequacy of the computational models developed to reproduce the observed centrality of superficial similarities in retrieval (e.g., MAC/FAC, Forbus, Gentner, & Law, 1994; ARCS, Thagard, Holyoak, Nelson, & Gochfeld, 1990; LISA, Hummel & Holyoak, 1997).

In our opinion, however, neither the interpretation that Blanchette and Dunbar (2000) gave to their data nor the conclusions they derived from their results are fully justified. A first limitation–related to the interpretation the authors gave to their data–resides in not implementing any means of distinguishing instances of analogical retrieval from instances of analogy fabrication (i.e., *ad hoc* invention of BAs). One possible way of overcoming the fabrication problem could consist, as in Gentner et al. (2009), of asking participants to state the source of the reported BAs, and having judges determine the authenticity of such episodes. However, as opposed to the highly trackable BAs proposed by participants in the Gentner et al. (2009) study (e.g., past-experience negotiation episodes), the extreme diversity of the sources elicited by the zero-deficit TA makes it difficult to decide about their origin, pushing judges' reliability to the limits of acceptability (see Trench, Oberholzer, & Minervino, 2009). A more stringent way of excluding invented BAs from the data analysis, as implemented in the present study, would consist in presenting targets that are analogous to culturally shared BAs, and restricting the analysis to whether or not these known BAs came to participants' minds while generating analogies for the presented targets. In this way, if a participant offers a complete and faithful description of, say, the twin towers episode, there would be no doubt that such episode has been retrieved from LTM, given the fact that it is highly unlikely that a person invents an episode identical to the one we all know.

A second shortcoming of Blanchette and Dunbar's (2000) study–related in this case to the conclusions they derived from their data–, concerns the fact that even if an effective way of excluding invented BAs were implemented, the observed prevalence of superficially dissimilar BAs among participants' proposals should not be readily taken as evidence that naturalistic retrieval in not constrained by superficial similarities. Such interpretation, just as in the well known ratio bias, implies disregarding the amounts of superficially similar and superficially dissimilar BAs available in LTM, and therefore the proportions that the retrieved BAs represent. A proper assessment of the role played by superficial similarities during naturalistic retrieval should be based upon calculating the likelihood of retrieving superficially similar BAs from LTM, and comparing it against the probability of retrieving superficially dissimilar BAs. In turn, calculation of each of the above probabilities requires considering not only the successful cases of retrieval, but also those cases in which potential BAs failed to be retrieved, so as to obtain the quotient between the number of retrieved BAs and the number of all available BAs (i.e., p = retrieved cases/available cases). As available BAs for the zero-deficit are highly idiosyncratic, it seems difficult to implement an effective way of detecting them in the context of the production paradigm implemented by Blanchette and Dunbar (see Trench et al., 2009). Just as in the case of the retrieval/fabrication indeterminacy, a possible way of adapting Blanchette and Dunbar's (2000) procedure to circumvent the problem of not knowing in which cases a naturally encoded BA failed to be retrieved would consist of selecting a small number of culturally shared episodes, whose availability in participants' LTM could be verified.

Experiment

In order to investigate to what extent naturalistic analogical retrieval is constrained by superficial similarities we carried out an experimental adaptation of the production paradigm that, while preserving the central features of the Blanchette and Dunbar (2000) procedure (i.e., assessing the retrieval of naturally encoded BAs during an argumentation task), affords overcoming the indicated shortcomings.

To that purpose we extracted the central episodes of four movies, in which the main character performed an action that ended up yielding negative results. Out of each BA we derived two structurally similar TAs in which the main character was planning to carry out an action that could engender negative consequences similar to those of the BA (whereas one of the two TAs maintained superficial similarities with the BA, the other did not). After reading one of the two TAs, participants were asked to generate analogies that could be used to dissuade the main character from performing the intended action, on the grounds that such action could end up bringing negative consequences. As we restricted the data analysis to the retrieval of the specific culturally shared BAs from which the TAs were derived, we were able to avoid the problem of not distinguishing between fabricated and retrieved BAs. At the same time, the employment of this kind of BAs allowed us to identify the cases in which a BA was available but not retrieved, making it possible to calculate (and ultimately compare) the likelihoods of retrieving superficially similar and superficially dissimilar BAs as quotients between the number of retrieved BAs and the number of available BAs. The employment of an experimental design allowed us to control for extraneous variables (e.g, that both TAs satisfy the restrictions of one-to-one correspondences and parallel connectivity to the same extent), something that is not possible in a non experimental implementation of the production paradigm, where natural comparable BAs which differ in similarity may also differ in other respects (see Trench et al., 2009).

Method

Participants and Design. A total of 372 students at Universidad Nacional del Comahue, Argentina, volunteered to take part in the experiment. The final sample consisted of 160 participants who demonstrated, through questionnaires presented after the analogy generation task, that: 1) they knew the critical BA, and 2) they were able to make the analogy between such BA and the TA. The degree of superficial similarity between each BA and its two corresponding TAs (high or low) received between-subjects manipulation. Out of the 40 participants that had seen the selected movie (one of the four employed) whose retrieval was being evaluated, half received a TA that maintained superficial similarities with the BA, and the other half received a TA that did not maintain such similarities with it. The dependent variable was the number of participants that retrieved the BA during the analogy generation phase.

Materials and Procedure. BAs consisted of the central episodes from "Spiderman", "Shrek", "Jurassic Park", and "The Secret in Their Eyes". For example, in Jurassic Park a millonaire has cloned dinosaurs from the Jurassic Period out of fossil DNA taken from a mosquito. Despite receiving expert advice about the impossibility of exerting total control over biological phenomena, the millionaire insists on opening a park to exhibit the dinosaurs to the public. Finally, dinosaurs break the security system of the park, and attack humans. Superficially similar TAs were generated substituing base objects and relations with similar ones. For instance, the superficially similar TA of "Jurassic Park" stated that a bussinessman had replicated pleistocene mammoths out of a frozen embryo found in a glacier. The TA ended up stating that the bussinessman persevered with his idea of inaugurating a zoo to expose mammoths to visitors. The participants' task consisted of dissuading the main character from pursuing the project, warning him that as animal behaviours are not completely manageable, mammoths could destroy the zoo cages, thus endangering people. Superficially dissimilar TAs were derived substituing base objects and relations with objects and relations less similar than in the above example. Continuing with the Jurassic Park set, the superficially dissimilar TA stated that an astrophysicist was imitating Martian storms out of digital images captured by a space probe. The TA ended up stating that the astrophysicist was planning to let his colleagues enter the experimental zone in order to study these storms. Participants had to dissuade the main character from pursuing his plan, explaining to him that, as extraterrestrial climatic phenomena are not well known, they could exert negative effects on his colleagues. In both conditions, the instructions enforced participants to recall known stories or situations that could be used as analogs to support the predicted outcome. The complete texts corresponding to the TAs derived from "The Secret in their Eyes" are shown in Table 1. In order to gather an independent measure of the effectiveness of our manipulation, we asked a separate group of 40 participants to assign similarity scores to pairs of concepts consisting of base concepts and their replacing concepts in the two TAs (e.g., dinosaur-mammoth vs. dinosaur-storm). Within each of the four sets of stories, the mean similarity scores received by the superficially dissimilar pairings were lower than those received by superficially similar ones. Due to the lack of enough space, the obtained data and their statistical analyses are not displayed.

Participants received a booklet with the materials and tasks. The first two pages of such booklet consisted of instructions on the use of analogy in persuasion, together with two examples in which the BAs were real stories (one of them superficially similar to its TA and the other one dissimilar), and two examples in which the BAs were fictional stories (again, one of them superficially similar to its TA and the other one dissimilar). This way, we tried to avoid biasing memory search neither in favour of fictional vs. real BAs, nor in favour of superficially similar vs. superficially dissimilar ones.

Table 1: An example of a natural base analog and its derived target analogs.

BA: "The Secret in their Eyes"	Superficially similar TA	Superficially dissimilar TA
Some time ago a *murderer killed Ricardo's wife*.	Some time ago *an assailant lamed Sonia's father*.	Some time ago *Romania defrauded* the *Government of Bulgaria*.
A *US Marshal said* to Ricardo that the murderer *would be in jail* for *life*.	A *State's Attorney told* Sonia that the assailant *would be in prison* for *25 years*.	A *UN diplomat assured* Bulgaria that Romania *would be kept under a trade embargo* for *10 years*.
However, due to *irregular procedures*, the *murderer* was *set free* soon afterwards.	However, due to *non-official mechanisms*, the assailant was *released* soon afterwards.	However, due to *complex negotiations the embargo on* Romania *was lifted* soon afterwards.
Since then, Ricardo's *only obsession* was having the murderer *serve* the *original sentence*.	Since then, Sonia's *sole preoccupation* is having the assailant *fulfill* the *prestablished penalty*.	Since then, Bulgaria's *main interest* is having Romania *undergo* the *stipulated restriction.*
For years, Ricardo has *locked* the murderer himself.	Sonia is planning to *shut* the assailant by herself.	Bulgaria is planning to *boycott* Romania on its own.
This has led Ricardo to *give up* important *personal ambitions*, such as *making* a *couple*.	You are a close friend of Sonia's, and you are concerned about her situation. You believe that pursuing her plan would lead Sonia to *withdraw* her *individual aspirations* such as *building a family*. You should evoke analogous situations or stories that you know, and that could be used to convince Sonia that executing such plan will entail giving up her own goals.	You are a political consultant of Bulgaria, and you are concerned about its situation. You believe that pursuing its plan would lead Bulgaria to *delay* its own *political programmes*, such as *undergoing economic reform*. You should evoke analogous situations or stories that you know, and that could be used to convince Bulgaria that executing such a plan will entail giving up its owns goals.

Note. The BA represents central episodes of the "Secret in their Eyes" that are relevant for establishing an analogy with the TAs. The exact wording of the base is arbitrary, since the abstract representations stored in memory may not be specified at a lexical level. Italized words in the base indicate objects (e.g., wife), object attributes (e.g., original) and relations (e.g., kill) that were replaced with either very similar concepts (superficially similar TA) or with less similar concepts (superficially dissimilar TA), also in italics.

After reading the instructional material for 7 min, participants were allotted 15 min to read the TA and write down as many analogies as they could generate to dissuade the character of the TA from carrying out his plan, warning him about a possible negative consequence of such plan (for examples of specific instructions see Table 1). Once this time had elapsed, participants had to answer a questionnaire aimed at detecting whether or not they had retrieved the critical BA despite not having included it among their final proposals. To that end they were asked whether they had been reminded of any movie during the analogy generation activity. In case they had, they were asked to indicate which movie or movies they were reminded of, and to state exactly which parts of such movie or movies they remembered at that time. Participants then answered a questionnaire to determine in which cases the participant knew the specific facts about the BA that were required to establish an analogy with the TA. They were asked in the first place if they had seen the critical movie (those answering "no" finished the experiment right away). In case they had seen it, they went on to the next page where they had to answer 10 multiple choice questions about the BA, with four options each. Finally, the last page of the booklet consisted of a final task aimed at evaluating if participants were able to make the analogy between the BA and the TA. The right column of a 2-column table listed the six central actions of the TA. Participants had to fill in the fields of the left column with the corresponding episodes of the BA. As the calculation of the retrieval probabilities entails taking the quotient between the number of successful retrieval attempts and the total number of cases in which an adequate representation of the BA was available for retrieval, the retrieval calculation was limited to participants that got right 9 of the 10 questions of the availability questionnaire. In a similar vein, as retrieval trials should exclude the cases where a participant cannot make the analogy even when asked to do so, the analysis was limited to cases in which a participant got right at least 5 of the 6 fields in the final analogy-making task. Participants were run individually until completing 8 groups of 20 participants that, for the particular BA whose retrieval had

been evaluated, demonstrated having an adequate representation of such BA in memory and being able to establish its analogical relation with the TA. In four of these groups participants received TAs that were superficially similar to the BA they were expected to retrieve, and in the remaining four groups participants received TAs that were superficially dissimilar from such BA.

Results and Discussion

A BA was scored as retrieved in the cases where the participant: 1) employed the BA and their relevant facts among the proposed analogies, or 2) reported having been reminded of the critical movie and its analogy-relevant facts despite not having included them among their proposals. Two independent judges, who were instructed in the six critical facts of each of the four movies, had to decide in which cases participants included at least four of such facts in either their initial arguments or in their answer to the retrieval questionnaire. Judges reached 81% agreement, solving the cases of disagreement by open discussion. Results showed that whereas superficially similar BAs were retrieved in 70% of the trials, superficially dissimilar BAs were retrieved in only 15% of the cases, demonstrating a strong effect of superficial similarities on naturalistic retrieval of BAs, χ^2 (1, 160) = 47.29, p < .001 (88% of the retrieved BAs were used in the argumentation task). This pattern of results holds for each of the four BAs employed (see Figure 1). The plot of "The Secret in their Eyes" was retrieved in 75% of the cases after a TA with which it maintained superficial similarities, and in only 10% of the cases after a TA without such similarities, χ^2 (1, 40) = 14.73, p < .001. In turn, "Shrek" was retrieved in 75% of the trials after a superficially similar TA, and in 15% of the trials after a superficially dissimilar TA, χ^2 (1, 40) = 12.22, p < .001. "Spiderman" was retrieved in 60% of the cases after a superficially similar TA, and in 20% of the cases after a superficially dissimilar TA, χ^2 (1, 40) = 5.10, p < .05. Finally, "Jurassic Park" was retrieved in 70% of the trials after a superficially similar TA, and in 15% of the trials after a superficially dissimilar TA, χ^2 (1, 40) = 10.23, p < .001.

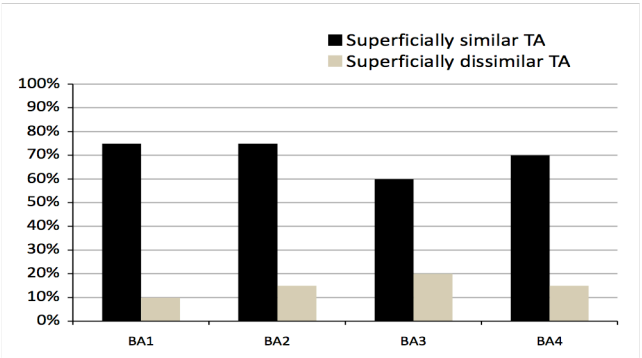

Figure 1: Retrieval of naturally encoded base analog (BAs) after a superficially similar or a superficially dissimilar target analog (TA). BA1: "The Secret in their Eyes", BA2: "Shrek", BA3: "Spiderman", BA4: "Jurassic Park".

A wealth of experimental studies using the reception paradigm (e.g., Catrambone, 2002; Gentner et al., 1993) has demonstrated that the superficial similarity between BAs and TAs plays a central role in the retrieval of BAs. Contrary to this long tradition, Blanchette and Dunbar (2000) presented the results obtained with the production paradigm as evidence that when participants generate their own analogies for realistic TAs and tasks, retrieval is less constrained by superficial similarity than was previously thought. These results called into question the validity of more than two decades of experimental research on analogical retrieval, as well as the accuracy of several computational models that were designed to simulate this pattern of behavioral results. We have pointed out that a series of methodological shortcomings of the production paradigm, as implemented by Blanchette and Dunbar (2000), should preclude interpreting the profusion of superficially dissimilar BAs among participants' proposals as evidence for retrieval processes that are not constrained by superficial similarities. In first place, their study did not distinguish between cases of analogical retrieval and cases of analogy fabrication. In the present experiment we overcame this limitation by employing culturally shared BAs, requiring very detailed descriptions of those BAs in order to score them as retrieved, and restricting our analysis to these BAs. A second limitation of Blanchette and Dunbar's study for determining the weight of superficial similarities on retrieval resides in the fact that it only allows computing the instances of superficially similar and superficially dissimilar BAs that were retrieved. As we have pointed out, to calculate (and ultimately compare) the probabilities of retrieving these two kinds of BAs it is also necessary to know in which cases an available BA failed to be retrieved from LTM. As with the retrieval/fabrication indeterminacy, the solution we found to circumvent this last limitation consisted of employing culturally shared BAs, whose availability in LTM could be checked for each participant after the analogy generation task.

Having remedied these insufficiencies detected in Blanchette and Dunbar's (2000) study, results showed that superficial similarities exert a strong and possitive effect on the retrieval of naturally encoded sources during persuasive analogy generation, a pattern of results that is aligned with those traditionally obtained in studies where artificial BAs are provided to participants during the experimental session. Since both the naturalistic encoding of our BAs and the alleged meaningfulness of our persuasive analogy generation task are precisely those aspects of the production paradigm that, according to Dunbar (2001), underpin their observed profusion of purely structural retrievals, our results run counter to Blanchette and Dunbar's (2000) claim that prior failures to elicit purely structural retrieval are rooted in the artificiality of most experimental tasks and materials. It should be taken into account that the BAs used in our experiment were the central aspects of movies that had had great impact on the public. In spite of this, they were only retrieved in 15% of the cases after superficially dissimilar TAs.

Working with less structurally encoded BAs–perhaps more representative of the BAs derived by laypeople out of everyday life situations–would yield even lower retrieval rates than those reported here. In the opposite direction, working with natural BAs whose structural features have been highlighted will most likely elicit higher retrieval rates than in the present experiment (e.g., Chen, Mo, & Honomichl, 2004), a phenomenon for which there is also supporting evidence coming from studies where BAs are provided by the experimenters (e.g., Catrambone & Holyoak, 1989). What seems ungranted is the supposition that naturally encoded situations receive, in general, a structural processing that gives them an edge over experimental materials, as Dunbar (2001) suggests.

The fact that Blanchette and Dunbar (2000) have derived somewhat contentious conclusions from their results, in our opinion does not undermine their more general claim that psychological studies of analogy can benefit from adopting a more naturalistic approach. For instance, participants in their study proposed almost 10 BAs during the analogy generation task–most of them superficially dissimilar to the TA. Whatever the reasons underlying this level of performance, the number of superficially dissimilar analogies that people can propose after certain TAs is undoubtedly higher than would be predicted based on the results of traditional experimental studies. Naturalistic studies can therefore bring a more complete and realistic picture of analogical thinking than the one offered by laboratory experiments, albeit sometimes at the expense of losing the controls that characterize the latter, and that are mandatory for extracting certain kind of conclusions.

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