Retrieval of analogs from long-term memory: Explaining the divergence between experimental and naturalistic studies

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Abstract

In contrast to the experimental tradition in the study of analogical retrieval, naturalistic studies in which participants have to retrieve their own source analogs suggest that retrieval does not require superficial similarities. However, two important limitations of naturalistic studies concern the unknown availabilities of close vs. distant matches in long-term memory and the use of retrieval measures vulnerable to report bias. In the present study we complemented the procedure followed in naturalistic studies with two additional controls: (1) a survey of naturally encoded sources available in Long-Term Memory prior to the experimental session, and (2) a measure of analogical retrieval less vulnerable to report bias. A comparison between the number of natural analogs that were available in memory and those that were retrieved during an analogy generation task demonstrated that retrieval of naturally encoded source analogs–just as retrieval of experimentally learned situations–is strongly constrained by superficial similarity.

Keywords: Analogy, retrieval, similarity.

Recuperación de análogos desde la memoria a largo plazo: explicando la divergencia entre los estudios experimentales y los naturalistas

Resumen

En contra de los estudios experimentales sobre recuperación analógica, aquellos estudios naturalistas en donde se permite a los participantes recuperar sus propias analogías parecen demostrar que la recuperación no requiere similitudes superficiales. Sin embargo, dos importantes limitaciones de estos estudios consisten en desconocer las cantidades de análogos base con y sin similitudes superficiales disponibles en la memoria de largo plazo de cada participante, y en usar medidas de recuerdo vulnerables a la selección consciente de los análogos recuperados. El presente estudio complementa el procedimiento de los estudios naturalistas con dos controles adicionales: un registro de los análogos naturales aprendidos por los participantes con anterioridad a la sesión experimental, y una medida de recuperación menos vulnerable a sesgos de selección. La comparación entre los análogos disponibles y aquellos que resultaron recuperados durante la tarea de generar analogías persuasivas demuestra que la recuperación de análogos naturales se apoya fuertemente en similitudes superficiales.

Palabras clave: Analogía, recuperación, similitud.

Two situations are analogous when they maintain *structural similarity*, that is, when their objects can be seen as connected by an identical system of relations at a certain level of abstraction (Gentner, 1983; Gentner & Markman, 2006; Holyoak & Thagard, 1995). This recognition usually allows transferring knowledge from a known situation (*source analog*: SA) to a novel situation (*target analog*: TA). In *interdomain* analogies, such as a comparison between the Irish debt and cancer, corresponding objects and relations are dissimilar. In *intradomain* analogies, as when comparing the Irish and the Argentine debts*,* matched objects and relations are similar, that is, they maintain *superficial similarity* (Gentner, 1989).

A series of experimental studies has demonstrated that superficial similarity represents a crucial precondition for retrieval (Gentner, Rattermann, & Forbus, 1993; Keane, 1987). The procedure employed in these studies involves two phases: an encoding phase, where participants receive one or more SAs interleaved with several distractors, and a retrieval phase, where participants are presented with TAs embedded in tasks for which retrieving the SA becomes crucial. Studies using this *reception paradigm*–as Blanchette and Dunbar (2000) termed it–show that intradomain retrieval is between two and three times more likely than interdomain retrieval, demonstrating a strong influence of superficial similarity on analogical retrieval.

Using an alternative procedure, Blanchette and Dunbar (2000) obtained results that challenged this assumption. After providing participants with a description of the zero-deficit strategy for reducing public debt, they asked them to generate their own persuasive analogies in favor of the convenience of adopting a zero-deficit strategy. This *production paradigm* elicited strikingly high relative and absolute amounts of interdomain analogizing, leading the authors to conclude that when people are allowed to use their own SAs in response to meaningful real-world situations, retrieval is not constrained by superficial similarity.

An important shortcoming of the production paradigm concerns the unknown availability of intra and interdomain SAs in each participant's long-term memory (LTM). As these quantities had not been established, the observed profusion of interdomain analogizing could simply reflect their greater prevalence in LTM. A proper assessment of the effect of superficial similarity requires knowing not only the quantities of intra and interdomain SAs that were retrieved, but also the number of instances that were available for retrieval (i.e., retrieval probability = number of retrieved sources/number of available sources). A second shortcoming of using proposed analogies as a measure of analogical retrieval is that it may miss a number of retrievals not finally included among analogical proposals. If it were the case that, once retrieved, interdomain SAs end up being reported relatively more often than intradomain retrievals, then the majority of interdomain analogies would not indicate that retrieval is superficially unconstrained (see, e.g., Trench, Oberholzer, Adrover & Minervino, 2009).

The present study complemented Blanchette and Dunbar's production paradigm with a series of controls designed to overcome the above limitations. In order to assess the probability with which intra and interdomain natural SAs get retrieved during an analogy generation task, we checked the availability of a predefined set of intra and interdomain SAs in the LTM of each participant, and tracked their eventual retrieval during the analogy generation task. To that end, we included an *availability questionnaire* comprising generic descriptions of 20 common situations that were analogous to the zero-deficit problem. Participants had to indicate whether or not they knew instances of such situations from their autobiographic memories. After the analogy generation task, and in order to obtain a measure of analogical retrieval less vulnerable to report bias, we presented the same set of 20 common situations, with the instruction to indicate whether or not an instance of such situation had come to mind during such task (the *retrieval questionnaire*). A comparison between answers given by each participant to both

questionnaires afforded calculating the retrieval probabilities of intra and interdomain SAs as quotients between the number of retrieved and available sources of each type.

Method

Participants

Thirty Psychology students at University of Buenos Aires volunteered to participate in the study.

Procedure and Materials

After reading an explanation on the use of analogies in persuasion illustrated with two examples (one intra and one interdomain), participants were presented with the zero-deficit strategy for controlling public spending, which consisted in drastic cuts in education, health services and social programs. Participants were asked to write down as many analogies as they could to convince the population of adopting such strategy, on the grounds that future cuts would otherwise be even more dramatic. They were allotted a maximum of 1 hr for the task, but after 20 min experimenters allowed those who had ran out of ideas to begin the next phase. During the second phase, participants were handed the retrieval questionnaire, which listed 20 common situations that were analogous to the deficit problem (6 intradomain and 14 interdomain) –found to be more prevalent among this population according to a previous study (e.g., "A situation in which a person allowed the balance of his or her credit card to accumulate, with the result that later payment was more expensive than would have been otherwise"; see Table I for other examples). Upon reading each situation, they had to indicate whether or not a known instance of such situation had come to mind, albeit briefly, during the previous phase, regardless of whether or not such situation was included among the analogical proposals. They were asked to describe them exactly as they were recalled during the analogy generation phase. Participants were given 20 min to complete the retrieval questionnaire. After a 5 min break, participants were handed the availability questionnaire containing the same items, but preceded by an instruction to mark those situations they had encountered prior to the experimental session (be it through personal experience, heard from others, or whatever source), regardless of whether they had described them during the previous tasks. Participants were asked to describe in detail each situation marked as "known". The order of presentation of the items was counterbalanced.

TABLE I
Examples of the schematic situations included in the availability and retrieval questionnaires

Intradomain items	Interdomain items
1. A person allowed the balance of his credit card to accumulate, with the result that later payment was more expensive than would have been otherwise.	1. A person postponed undergoing cancer treatment, with the result that later treatment was longer than would have been otherwise.
2. A country let the public debt to grow too big, with the consequence that later payment entailed more drastic cuts than would have been required otherwise.	2. A person allowed the grass to grow too high, with the consequence that later cutting was more complicated than would have been otherwise.
3. A person allowed the annual payments of his or her loan to accumulate, with the result that later cancellation was more effortful than would have been otherwise.	3. A person took too long to check a noise in his car engine, with the consequence that the damage got worse than would have been otherwise.

Data analysis

Two judges were handed the answers to the availability questionnaire with the instruction to decide if they were instances of their corresponding schema. They were also handed the answers to the retrieval questionnaire with the instruction to determine if any instance described by a participant under a given schematic situation of the availability questionnaire also appeared in the retrieval questionnaire. For each participant, an available instance of a schematic situation was coded as "retrieved" if it matched an instance reported in the retrieval questionnaire. Finally, judges had to assess in which cases an instance retrieved by a participant was included among the analogical proposals written by that participant during the analogy generation task. As in the previous case, a retrieved instance of a schematic situation was coded as "used" if it matched any of the situations proposed during the analogy generation phase. Judges' agreement on the above tasks reached 82%, 92%, and 78%, respectively, with cases of disagreement being solved by open discussion.

Results

Retrieval of source analogs

The available intradomain items (M = 5.13; SD = 0.62) were retrieved in 44.80% of the cases during the analogy generation task (M = 2.30; SD = 0.71). In contrast, the available interdomain items (M = 10.83; SD = 1.43) were retrieved only in 12.30% of the cases during persuasive analogy generation (M = 1.33; SD = 0.79). These values resemble those obtained by studies using a reception paradigm (e.g., Catrambone, 2002; Gentner et al., 1993), and show a clearly detrimental effect of semantic distance between the SA and the TA on its likelihood of being retrieved, $\chi^2(1, N = 479) = 60.94, p < .001$. Results thus reveal that retrieval under a production paradigm–just like retrieval under a reception paradigm–is highly constrained by superficial similarity.

Use of retrieved sources

Whereas intradomain SAs were used in the 18.84% of the cases, retrieved interdomain SAs were employed in the 77.50% of the cases, a difference that shows a clear effect of semantic distance between a retrieved SA and the TA on its probability of being finally included among the analogy proposals, $\chi^2(1, N = 109) = 33.80, p < .001$. These results show that the sole analysis of the proposed analogies, as a measure of analogical retrieval, grossly overestimates the relative proportion of interdomain retrievals.

Discussion

A long tradition of experimental studies employing a reception paradigm has shown that interdomain retrieval is low both in absolute terms and in comparison to intradomain retrieval. The standard interpretation of these results is that analogical retrieval rests heavily on superficial similarity between the analogs. Using a production paradigm, Blanchette and Dunbar (2000) obtained a contrasting pattern of results, and called into question the ecological validity of the experimental tradition as well as the adequacy of the computational models engineered to simulate their typical pattern of results (see, e.g., Forbus & Gentner, 2011 for a review)

We have pointed out that two limitations in the production paradigm–as implemented by Blanchette and Dunbar (2000)–should prevent interpreting the observed ratio of intra vs. interdomain analogical proposals as evidence for superficially unconstrained analogical retrieval. One of them had to do with having employed the raw proportion of intra vs. interdomain analogical proposals as a basis for making inferences about retrieval tendencies of the system, since participants could differentially favor the

report of intra or interdomain SAs that were successfully retrieved. The second limitation concerned the unknown availability of both types of sources in the LTM of participants. We have argued that even if a more sensitive measure of analogical retrieval were devised, the absolute numbers of intra and interdomain SAs retrieved by participants would only be informative about the mechanisms of analogical retrieval if experimenters had some means of assessing what proportions of the available intra and interdomain SAs stored in LTM such absolute numbers represent.

In the present study we adapted Blanchette and Dunbar's (2000) procedure with the aim of overcoming these two limitations. As in their study, our participants received an explanation of the zero-deficit strategy for eliminating public deficit, and were asked to generate as many analogies as they could to persuade citizens of the urgency of supporting such policy. However, we complemented this task with two questionnaires: one intended to detect a number of SAs that were potentially available in the LTM of participants, and the other directed to detect which of those SAs were recalled during the analogy generation task, even if they were not used. Results showed that the probability of reporting a retrieved source is more than three times higher when such source is interdomain, as compared to when such source is intradomain, thus confirming that the raw count of analogical proposals–as implemented by Blanchette and Dunbar–is both insensitive and superficially biased as a measure of analogical retrieval. Most importantly, results demonstrated that the probability of retrieving a naturally encoded SA is three times higher when such source is intradomain, as compared to when it is interdomain. These results demonstrate that under a production paradigm–just as under a reception paradigm–the retrieval of a naturally encoded SA is highly constrained by superficial similarity.

And what about Dunbar's (2001) more general thesis that in natural settings–as opposed to laboratory conditions–people do not rely on superficial similarity? Blanchette and Dunbar (2001), for instance, observed that 80% of the analogies used by journalists prior to the referendum on the independence of Quebec were taken from domains different from politics. However, rereading this naturalistic evidence in light of the present results suggests that the post-access selection processes implied in such activities could have led to the rejection of intradomain retrievals, as it occurred in the present study. Finally, evidence coming from Dunbar's (1997) study of molecular biologists as they work in their laboratories directly compromises the thesis that naturalistic retrieval is superficially unconstrained. The fact that 97 out of the 99 analogies produced in such meetings linked the target organism with either the same or a similar organism suggests a strong effect of superficial similarity on retrieval. In sum, if there really is dissociation between how artificial and natural settings affect analogical retrieval, the available evidence does not seem to be the right source of support for it.

References

BLANCHETTE, I. & DUNBAR, K. (2001). Analogy use in naturalistic settings: The influence of audience, emotion, and goals. *Memory & Cognition, 29*, 730-735.

BLANCHETTE, I. & DUNBAR, K. (2000). How analogies are generated: The roles of structural and superficial similarity. *Memory & Cognition, 28*, 108-124.

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.

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

FORBUS, K. & GENTNER, D. (2011). Computational models of analogy. *WIREs Cognitive Science, 2,* 266-276

GENTNER, D. (1983). Structure-mapping: A theoretical framework for analogy. *Cognitive Science, 7,* 155-170.

GENTNER, D. (1989). The mechanisms of analogical transfer. In S. Vosniadou & A. Ortony (Eds.), *Similarity and analogical reasoning* (pp. 199-242). Cambridge, UK: Cambridge University Press.

GENTNER, D., & MARKMAN, A. B. (2006). Defining structural similarity. *The Journal of Cognitive Science*, *6,* 1-20.

GENTNER, D., RATTERMANN, M. J. & FORBUS, K. D. (1993). The roles of similarity in transfer: Separating retrievability from inferential soundness. *Cognitive Psychology*, *25*, 431-467.

HOLYOAK, K. J. & THAGARD, P. R. (1995). *Mental leaps: Analogy in creative thought*. Cambridge, MA: The MIT Press.

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

TRENCH, M., OBERHOLZER, N., ADROVER, F., & MINERVINO, R. (2009). La eficacia del paradigma de producción para promover la recuperación de análogos interdominio. *Psykhé, 18*, 39-48.