Dual process theory of reasoning and recognition memory errors: Individual differences in a memory prose task

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Abstract

Cognitive factors can mediate the tendency to create false memory. We explored the role of the two systems of reasoning in the production of false memories. Such difference can be assessed through the Cognitive Reflection Test (CRT), a measure of the propensity to reflect rather than producing an intuitive response. By the use of a DRM-like paradigm in a prose recognition memory task, we measured CRT-related individual differences in producing false memories. We observed that intuitive thinkers are more likely to produce false memories.

Keywords: DRM, False memories, CRT, Dual process theory of reasoning.

Introduction

A long tradition of cognitive research has observed how people can develop false memories about past events (Bartlett, 1932; Deese, 1959; Loftus, 1975). This is a fundamental topic both from an applicative (e.g. eyewitness memory) and theoretical point of view (e.g. the nature of semantic knowledge, Collins & Loftus, 1975). The Deese-Roediger-McDermott paradigm (DRM) has become the standard way to investigate this phenomenon (Roediger & McDermott, 1995). In this paradigm, participants are presented with a list of semantically-related words constructed in a particular way. An initial word is chosen (for example, hospital) and then other semantically related words are selected (doctor, nurse, patient, etc). Such list of words (with the exception of the initial word) is presented for learning, followed by a recognition memory task. The key observation is that in the recognition task participants with high confidence report that the initial word "doctor" was actually in the list. Through such paradigm it is possible to observe how a false memory (a memory for an event that never occurred) can be created. This result is usually explained in terms of an associative model of memory. According to this perspective, the initial (and missing) word is strongly activated because is highly semantically correlated with the words presented in the list. However, specific theories (such as the fuzzy trace theory or the activation-monitoring theory) underlying false memory dynamics are still under debate (Brainerd & Reyna, 2002; Brainerd et al., 2001; Gallo & Roediger, 2002; Roediger, Balota, & Watson, 2001).

Many studies have examined how individual differences may influence the memory processes with regard to the false memory phenomena (Baird, 2001; Watson et al., 2005; Winograd, Peluso, & Glover, 1998). For example, a higher rate of false memory is observed in people with higher vividness of imagery (e.g. producing a photograph-like mental picture, Winograd et al., 1998) or with a higher expertise in the domain of the material to be learnt (Baird, 2001).

However, few studies have investigated individual differences based on thought and reasoning processes. Graham (2007) has investigated the role of the Need for Cognition (NFC) construct (Cacioppo & Petty, 1982) on false memories. The NFC consists of the tendency to engage and enjoy effortful cognitive activities. Some individuals consistently seek opportunities to engage in challenging cognitive activities whereas other individuals have little motivation and tend to avoid such tasks. Graham (2007) found that the NFC mediates false memories where high NFC individuals falsely recognized a greater amount of

semantic-related words than individuals with low NFC. Such result is explained in terms of high NFC individuals' tendency to greater elaboration of list resulting in stronger interconnections in memory (and thus an increase in the probability of activation of a word present in the same semantic network).

The NFC is somewhat related to the dual process theory of judgment (Epstein, 1994; Evans & Over, 1996; Sloman, 1996, 2014; Stanovich & West, 2000). Starting from the influential *Heuristics and biases* research program, many authors have sustained the distinction of two modalities of reasoning; A fast, effortless, associative, nearly-automatic reasoning process and a slow, resources-demanding, rule-base, controlled process. How to label those two processes and specific differences about their characteristics is still under debate. We will refer to the former as the intuitive system (Sloman, 2014) and to the latter as the analytical system. The Cognitive Reflection Test (CRT; Frederick 2005) is a predictive measure of the tendency to deliberate about the outputs of intuitive processes before responding in a cognitive task. The CRT is composed of three questions, each one has an (incorrect) obvious intuitive answer and a less accessible (correct) answer that needs some analytical system deliberation. In Sloman's (2014) view the slow and effortful analytical process attempts to inhibit (sometimes with success and sometimes not) the "obvious" response of the effortless and fast intuitive process. For example, given the Lily Pad problem of the CRT: *In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake?* The default, most obvious intuitive response that does not require a particular effort is 24; If 48 days is the time necessary for the patch to cover the entire lake, consequently 24 days should be intuitively the time necessary for half the surface. However, if the reader reflects a little bit more about the problem, can easily see that every day the patch doubles in size, so in the 47th day the lake was half covered and in the 48th and final day the lily pads finished to cover the entire surface. Such form of reasoning inhibits the obvious, intuitive response.

When considering the relationship between individual differences in CRT and the false memory phenomena, two possible predictions can be made. On the one hand, it is reasonable to predict that people who are more analytical on the CRT problems will tend to produce more false memories; people with high NFC tend to create more false memories and NFC has a significant (albeit small – about .22, Frederick, 2005) positive correlation with analytical responses on the CRT. However, Frederick (2005) says that CRT measures "the ability or disposition to resist reporting the response that first comes to mind" whereas the NFC measures the "tendency to engage in and enjoy thinking" (Cacioppo & Petty, 1982). Following this line of thought, a different prediction can be that high intuitive people on CRT (due to their inability to resist reporting the first response that comes to mind) will make more false memories because they are less effective in the inhibition of semantic-related words not present in the original list. Such prediction in a memory recognition task is also supported by the fact that high intuitive people on CRT can rely more on a familiarity-based judgment than an analytical more controlled strategy.

Experiment

We investigated individual CRT-related differences in a DRM-like paradigm employing a memory prose task. Participants read a brief story with ten target words and then answered a series of questions unrelated to this experiment. The filler tasks included the CRT. After ten minutes, the material was removed and an incidental recognition memory task was administered.

Method

Participants Two-hundred-fifty-three freshmen college students enrolled in the University of Florence (97 male) were recruited for course credits. The sample mean age (in years) was 22.9 (sd = 7.4).

Stimuli and procedure Two brief cover stories (in Italian) were developed on the basis of an Italian word database (Burani, Barca, & Saskia Arduino, 2001) reporting several measures (familiarity, imagery, concreteness, frequency of use). Two sets of ten target words were chosen (First Target Set: Mill, Magpie, Winter, Nun, Lead, Medal, Carpet, Table Cloth, Compass; Second Target Set: Swamp, Thrush, Autumn, Friar, Canvas, Novel, Tavern, Lamp, Soap, Tray). Employing the First Target Set of words, we wrote the text of Story A (target words are in bold): "*Alex passed through the **mill** pausing to watch a **magpie**. The **winter** was near. He continued for another quarter of an hour thinking about the **nun** met before and finally arrived. The atmosphere was quiet and immediately noticed that the **lead** was exactly where he had left it. Clutching the **medal** in his hand, he realized that something was wrong, but could not figure out what it was. He looked around for clues: The **lantern** on his right, the **carpet** on the floor, the **table cloth** fallen on the ground together with a shattered **compass**. Someone was here... he turned and saw his wife. Her face was worth a thousand words: It was then that he realized that he had become a millionaire*.". Story B was exactly the same (in particular from a syntactical and grammatical point of view), but the target words were substituted with the nouns from the Second Target Set in order to have a story with a similar meaning. In a preliminary experiment, we asked to a separate sample (n = 40) to rate the similarity of the target words to other lists of words (matched for the reported measures) in order to create two Related Sets of nouns (First Related Set: Thief, Wind, Cold, Church, Metal, Gold, Light, Dust, Lunch, North; Second Related Set: Mud, Bird, Leaf, The Habit, Painting, Book, Room, Light, Perfume, Silver). The Unrelated Sets of nouns were chosen

from the target words of the other scenario (Story B for Story A words and vice versa) and we verified that such words were judged dissimilar from the target words (a mean value less than 2.5 in a similarity Likert scale from 1 to 5). In the case of values higher than 2.5, we conducted another preliminary experiment. We select the words presented in the database that matched the Target words and we asked another group (n = 30) to rate their similarity with the Target words; the words with the least similarity values were chosen. To sum up, the First Unrelated Set was: Swamp, Dream, Music, Sandals, Canvas, Novel, Tavern, Living Room, Soap, Tray; the Second Unrelated Set comprised: Mill, Thief, Skis, School, Lead, Medal, Friend, Carpet, Table Cloth, Compass.

Each participant was randomly assigned to one of the two Stories. After reading the story, participants were required to respond to a series of questions about the emotional valence of the story. After this series of questions, participants were required to do other tasks for an unrelated experiment. Those tasks also included the CRT (Frederick, 2005). The three problems were administered in a free response format with a limit of two minutes to complete each problem. The three problems were: 1) Bat and Ball problem *A bat and a ball cost 1.10 Euros in total. The bat costs 1.00 Euro more than the ball. How much does the ball cost? 2)* Machine Problem *If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets? 3)* Lilly Pad problem *In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake?*

After about ten minutes from the moment in which the text with the story was taken away, participants were invited to open a closed envelope and to complete the recognition memory task inside it. The recognition memory task was composed of 30 words (Target, Related and Unrelated words associated to the corresponding Story, A or B) arranged in a random order. For each word, participants were required to say if they have read it in the story (yes or not).

Data Analysis For each participant, we computed three scores. A Target Score, a Related Score and an Unrelated Score were calculated giving one point for each word recognized respectively in the Target, Related and Unrelated set of words; each score had a minimum of 0 and a maximum of 10 points. With regard to the CRT score, in a first phase, each response was coded as an intuitive response or a normative response. Following Frederick (2005), for the Bat and Ball problem the intuitive response is 10 and the analytical response is 5, for the Machine problem the intuitive response is 100 and the analytical response is 5, and for the Lilly Pad problem the intuitive response is 24 and the analytical response is 47. Participants that gave other kinds of responses (or that left blank) were discarded (17 participants). The CRT score was computed giving 1 point for each intuitive response and 0 points for each analytical response, resulting in a score ranging from 0 (all three problems solved with the analytical strategy) and 3 (all the problems solved with the intuitive strategies). On the basis of the CRT score, four groups were created: The Intuitive Group (participants with a total of 3 points in the CRT score, n = 62), the Mild Intuitive Group (participants with a total of 2 points in the CRT score, n = 61), the Mild Analytical Group (participants with a total of 1 point in the CRT score, n = 56), and the Analytical Group (participants with a total of 0 points in the CRT score, n = 57).

Story-related differences for the three scores (Target, Related and Unrelated) were compared by means of a mixed-model two-way ANOVA with CRT as a 4-level between-subjects variable (Intuitive, Mild Intuitive, Mild Analytical, and Analytical Group), scores (Target, Related, Unrelated) as a 3 level within-subjects variable and recognition score (number of words) as dependent variable. Given a significant result of the ANOVA, Fisher's Least Significant Difference post hoc tests were conducted to compare measures among the groups.

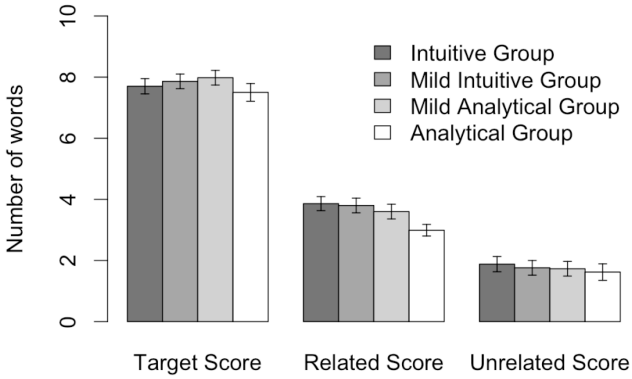

Figure 1: Mean scores of recognized Target, Related and Unrelated words of the four groups (Intuitive, Mild Intuitive, Mild Analytical, and Analytical Group).

Results

No statistically significant differences between the two Stories were found for Target Score, Related Score and Unrelated Score, so data were collapsed across the two texts.

The three scores were statistically different ($\chi^2(1) = 7.76$, $p = 009$). In particular, the Target Score was significantly higher than the Related Score ($\chi^2(1) = 13.25$, $p < .001$) and the Unrelated Score ($\chi^2(1) = 15.27$, $p < .001$). Moreover, the Related Score was statistically higher compared to the Unrelated Score ($\chi^2(1) = 10.22$, $p = .001$). No CRT-related differences were found for Target Score ($\chi^2(1) = 1.25$, $p = .264$) and Unrelated Score ($\chi^2(1) = 1.12$, $p = .291$). With regard to the Related Score, we found CRT-related

differences ($\chi^2(1) = 4.32$, $p = .038$). In particular, the Related Score for the Intuitive Group was significantly higher compared to the Normative Group ($p = .023$). Moreover, the Mild Intuitive Group scored higher than the Normative Group ($p = .041$).

Discussion

The aim of the present study was to explore the CRT-related individual differences on false memories. We found that those who scored high on the CRT (individuals who adopted an intuitive thinking style) created more false memories than those who scored low (individuals who adopted an analytical thinking style).

Given that the CRT measures mainly the ability to inhibit the first response that comes to mind, our findings can be explained in terms of a reduced tendency to inhibit the obvious response of recognizing an absent semantic-related word. Moreover, since the CRT intuitive responses are strictly associated with the use of heuristic reasoning (Toplak, West, & Stanovich, 2011), it can be hypothesized a stronger tendency to employ a familiarity heuristic to decide if a word was previously presented. Both interpretations can account for observed data. Further manipulations are needed to disambiguate these explanations. In particular, it may be desirable to measure false memories in a recognition task as well a free recall task and compare them with the CRT and an impulsivity test, such as the Barratt Impulsiveness Scale (BIS 11; Patton & Stanford, 1995). Following this procedure, it could be possible to observe if there is an interaction between the CRT individual differences and the type of task (recognition or free recall) where the use of a familiarity heuristic will induce more false memories only in the recognition task. At the same time, it could be interesting to explore the relationship between impulsivity, dual process of reasoning and false memories.

Moreover, it's important to note that the observed relationship between false memories and CRT is rather weak and it's necessary to better assess the role of potential confounding variables in future investigations. Indeed, an alternative explanation of our results is that the relationship between CRT and false memories is mediated by working memory capacity (Watson et al., 2005). Working memory capacity is correlated with analytical thinking and they positively correlate with the use of recollection processes (instead of familiarity) in memory retrieval. Thus it can be hypothesized that individuals who adopt an analytical thinking style may more rarely use familiarity processes producing less false memories. So, future research must include also a working memory capacity measure.

Contrary to the expectations based on the correlations among NFC, CRT and false memories, we find that people who adopted an analytical thinking style did not make more false memories. Such result is in line with the idea that individuals with both high and low NFC make use of their intuition. Research suggests that intuitions can influence judgments with a variable amount of thought effort. For example, an individual with high NFC will incorporate the intuition output together with other thoughts that are generated (so, the final judgment will be the result of a mediation between intuition and other thoughts). On the contrary, an individual with a low NFC will use the intuition output in a straightforward and direct way, where the final judgment will be determined almost completely by intuition. So, we can have false memories induced by the tendency to do greater elaboration of the material and false memories determined by the tendency to employ more intuitive thinking. Future research should measure both the NFC construct and the CRT in conjunction with a DRM task, in order to assess if there is an interaction between these two factors.

In conclusion, our work suggests that the ability to repress an intuitive response (as defined by the dual process theory of reasoning) is an important cognitive factor that may influence false memories.

Acknowledgments

Many thanks to Giacomo Fini, Alessio Petroni, Alessia Riela and Daniele Lari for collecting data. The English language was reviewed by Michela Gronchi. We thank the editor and three anonymous reviewers for their constructive comments, which helped us to improve the manuscript.

References

Baird, R. R. (2001). Experts sometimes show more false recall than novices: A cost of knowing too much. *Learning and Individual Differences, 13*(4), 349-355.

Bartlett, F. C. (1932). *Remembering: An experimental and social study*. Cambridge: Cambridge University Press.

Burani, C., Barca, L., & Saskia Arduino, L. (2001). Una base di dati sui valori di età di acquisizione, frequenza, familiarità, immaginabilità, concretezza, e altre variabili lessicali e sublessicali per 626 nomi dell'italiano. *Giornale Italiano di Psicologia, 28*(4), 839-856.

Brainerd, C. J., & Reyna, V. F. (2002). Fuzzy-trace theory and false memory. *Current Directions in Psychological Science, 11*(5), 164-169.

Brainerd, C. J., Wright, R., Reyna, V. F., & Mojardin, A. H. (2001). Conjoint recognition and phantom recollection. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 27(*2), 307.

Cacioppo, J. T., & Petty, R. E. (1982). The need for cognition. *Journal of Personality and Social Psychology*, *42*(1), 116.

Collins, A. M., & Loftus, E. F. (1975). A spreading-activation theory of semantic processing. *Psychological Review, 82*(6), 407-428.

Deese, J. (1959). On the prediction of occurrence of particular verbal intrusions in immediate recall. *Journal of Experimental Psychology, 58*(1), 17-22.

Epstein, S. (1994). Integration of the cognitive and the psychodynamic unconscious. *American Psychologist, 49*, 709-724.

Evans, J. St. B. T., & Over, D. E. (1996). *Rationally and reasoning*. Hove, UK: Psychology Press.

Frederick, S. (2005). Cognitive reflection and decision making. *Journal of Economic Perspectives, 19*, 25-42.

Gallo, D. A., & Roediger, H. L. (2002). Variability among word lists in eliciting memory illusions: Evidence for associative activation and monitoring. *Journal of Memory and Language, 47* (3), 469-497.

Graham, L. M. (2007). Need for cognition and false memory in the Deese–Roediger–McDermott paradigm. *Personality and Individual Differences, 42*(3), 409-418.

Loftus, E. F. (1975). Leading questions and the eyewitness report. *Cognitive Psychology, 7*(4), 560-572.

Patton, J. H., & Stanford, M. S. (1995). Factor structure of the Barratt impulsiveness scale. *Journal of Clinical Psychology, 51*(6), 768-774.

Roediger, H. L., Balota, D. A., & Watson, J. M. (2001). Spreading activation and the arousal of false memories. In H. L. Roediger, J. S. Nairne, I. Neath, & A. M. Surprenant (Eds.), *The nature of remembering: Essays in honor of Robert G. Crowder* (pp. 95-115). Washington DC: American Psychological Association.

Roediger, H. L., & McDermott, K. B. (1995). Creating false memories: Remembering words not presented in lists. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 21*(4), 803-814.

Sloman, S. A. (1996). The empirical case for two system of reasoning. *Psychological Bullettin, 119*(1), 3-22.

Sloman, S. A. (2014). Two systems of reasoning, an update. In J. Sherman, B. Gawronski, & Y. Trope (Eds.). *Dual process theories of the social mind*. New York: Guilford Press.

Stanovich, K. E., & West, R. F. (2000). Individual differences in reasoning: implications for the rationality debate. *Behavioural and Brain Sciences, 23*, 645-726.

Toplak, M. E., West, R. F., & Stanovich, K. E. (2011). The Cognitive Reflection Test as a predictor of performance on heuristics-and-biases tasks. *Memory & Cognition, 39*(7), 1275-1289.

Watson, J. M., Bunting, M. F., Poole, B. J., & Conway, A. R. (2005). Individual differences in susceptibility to false memory in the Deese-Roediger-McDermott paradigm. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 31*(1), 76-85.

Winograd, E., Peluso, J. P., & Glover, T. A. (1998). Individual differences in susceptibility to memory illusions. *Applied Cognitive Psychology, 12*(7), 5-27.