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A process-dissociation analysis of semantic illusions ☆

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ABSTRACT

We examine semantic illusions from a dual-process perspective according to which the processes that go into failing or succeeding to detect such illusions can be decomposed into controlled processes (checking the facts in the sentence against the information in memory) and automatic processes (the impression of truth that comes from the semantic associations between the elements in the sentence). These processes, we argue, make largely independent contributions to truth judgments about semantic-illusory sentences. The Process Dissociation Procedure was used to obtain estimates of these two kinds of processes. In Study 1, participants judged whether sentences were true or false while under high or low cognitive load. Cognitive load increased the rate of semantic illusions by specifically affecting controlled processing but not automatic processing. In Study 2, a previous paired-associate learning task also increased the rate of semantic illusions, but it did so by specifically affecting automatic processing, not controlled processing.

1. Introduction

How many animals of each kind did Moses take in the ark? When asked this question, most people respond "two", failing to notice that it was Noah and not Moses who took animals in the ark (e.g., Erickson & Mattson, 1981; van Oostendorp & de Mul, 1990). Likewise, people fail to detect any anomaly in the sentence "The authorities had to decide where to bury the survivors" (Barton & Sanford, 1993). In these semantic illusions, people overlook the distortion when a term in a sentence is replaced with a semantically similar but incorrect term. Thus, people end up accepting as true sentences that sound true but that are nonetheless false. These illusions do not result from lack of knowledge, because when participants are asked, for example, who took the animals in the ark, they say correctly that it was Noah and not Moses. They are also not a result of conversational norms. Indeed, "a common reaction to (the Moses illusion) is that people are merely cooperating with the speaker" (Reder & Kusbit, 1991, p. 386), assuming that the speaker is being truthful (according to Grice's maxim of quality, 1975). However, conversational norms cannot account for semantic illusions, because making participants explicitly aware that there might be distortions in the text does not eliminate the errors (Erickson & Mattson, 1981; Reder & Kusbit, 1991; van Oostendorp & Kok, 1990). Rather, these semantic illusions work because something in the sentence gives it the impression that it is true, and people base their judgments on that subjective truth rather than checking their knowledge for whether the sentence is objectively true or not.

Semantic illusions have been studied mainly for their implications for the understanding of sentence comprehension (e.g., Barton & Sanford, 1993; Erickson & Mattson, 1981; van Oostendorp & de Mul, 1990; van Oostendorp & Kok, 1990). They are a powerful demonstration that sentences are not subjected to "exhaustive analysis and consistency checks during processing" (Erickson & Mattson, 1981, p. 541), contrary to what early models of sentence comprehension assumed (e.g., Just & Carpenter, 1980), and that "the semantic representations that get computed are shallow and incomplete" (Ferreira, Bailey, & Ferraro, 2002, p. 12), merely *good enough* representations (Ferreira et al., 2002). However, the processes that go into semantic illusions have been a matter of some debate (see Park & Reder, 2004, for a review) and are not yet fully understood.

In this paper, we look at semantic illusions from a dual-process perspective that has proven useful in explaining how we think and behave in several domains, including reasoning, judgment and decision-making (e.g., Epstein, 1994; Evans, 2006; Ferreira, Garcia-Marques, Sherman, & Sherman, 2006; Kahneman & Frederick, 2002; Sloman, 1996; Stanovich & West, 2000), stereotyping and prejudice (e.g., Devine, 1989; Payne, 2001), and memory (e.g., Jacoby, 1991; Jacoby, Toth, & Yonelinas, 1993), among others. According to this perspective, two distinct kinds of processes contribute to regulate our thoughts and behavioral responses. Several labels and attributes have been used to distinguish these two kinds of processes: controlled vs. automatic, deliberate or intentional vs. unintentional, analytical vs. heuristic, conscious vs. unconscious, rational vs. intuitive, resource-demanding vs. effortless, and slow vs. fast. In general, a fast intuitive response that is primed by the person's internal or external

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context may be accompanied or not by slower, more deliberate processing that is eventually capable of overriding the person's initial intuition.

In order to tease apart the two kinds of processes, research often uses conflict problems where one process suggests one response and the other suggests a different response. To give an example, in research on the *belief bias* on logical reasoning, it is common to use syllogisms where the believability of the conclusion is at odds with its logical necessity (e.g., Evans & Curtis-Holmes, 2005). Semantic illusions share this diagnostic property of pitting intuition against deliberation: the illusory sentences intuitively appear to be true, but upon careful deliberation, one realizes that they are false.

When performance in such conflict problems is compared to performance in problems where both processes concur on the response, it is possible to isolate the contributions of the two kinds of processes using the Process Dissociation Procedure (PDP; e.g., Ferreira et al., 2006; Jacoby et al., 1993). This was the goal of our research: to isolate and assess the contribution of the controlled and automatic processes involved in semantic illusions.

1.1. A dual-process approach to semantic illusions

From a dual-process perspective, a large part of human thinking is carried out in an intuitive and largely automatic processing mode that provides an answer that comes quickly and spontaneously to mind with no need for strategic deliberation. Such intuitive processing is highly competent in most cases of language comprehension as it allows perceivers to tolerate noise and imprecision in communication (e.g., mispronunciations, slips of the tongue; Budiu & Anderson, 2002). However, this highly efficient processing comes with a price: in certain circumstances, it suggests an incorrect answer, as in the case of semantic illusions.

An independent source of judgment may come from a different, more controlled processing mode, in this case, careful deliberation about whether the information conveyed in the sentence is really consistent with one's knowledge. Indeed, in studies on semantic illusions, there is always a substantial amount of correct detections of the inconsistencies in the sentences, which indicates that controlled processing of the information can work to override the intuitive answer put forward by automatic processing and suggest a different answer. The ability to engage in such deliberate processing and override prepotent dominant responses is a central feature of human executive functions (Miyake & Friedman, 2012) and it has been shown to be well captured by the controlled component of the PDP (Payne, 2005).

While it is not always clear where exactly previous accounts of semantic illusions fall in the dimension of single- vs. dual-process models, a dual-process approach shares a substantial amount of features with several of those previous accounts.

van Oostendorp and colleagues (van Oostendorp & de Mul, 1990; van Oostendorp & Kok, 1990) distinguished between conceptual cohesion, the relatedness in memory of the concepts and facts involved in a sentence, which they assume readers monitor continuously in an automatic fashion, and semantic coherence, the appropriateness of the specific relations, which they assume is more demanding and time-consuming to assess. They suggested that sentences with high conceptual cohesion may be subjected to incomplete processing and, therefore, the semantic incoherence in semantic illusions would go undetected.

van Oostendorp and colleagues (van Oostendorp & de Mul, 1990; van Oostendorp & Kok, 1990) based their ideas on early models of sentence comprehension and question answering that, to a more or less explicit degree, already had a dual-process flavor. Reder (1982), for example, suggested that people do not always judge the truth of statements by retrieving the facts in memory and comparing them to the sentence. Rather, they often simply infer truth from the plausibility of the sentence, because it is an efficient strategy. According to her model of strategy selection in question answering (Reder, 1987), what determines which strategy is used is an initial automatic evaluation of knowledge relevant to the question, and the higher the relatedness of the concepts in the question, the less likely a person is to perform a careful memory search for a specific fact.

More recently, Park and Reder (2004) discussed semantic illusions in terms of "familiarity-based heuristics" vs. "careful matching operations" (p. 283), and argued that, "distortion detection involves a two-pass process—the first to flag a potential mismatch and the second to invoke a careful inspection that might confirm an erroneous term in the question" (p. 282). When there is a sufficient match between the incorrect and the appropriate names, due to their semantic overlap, the illusory sentence gets past the first stage unnoticed.

All these perspectives seem to be in line with the assumption that largely automatic processes are typically used in achieving sentence comprehension, which is a pre-condition to judge its truthfulness. But what specific psychological mechanisms have been proposed to account for semantic illusions?

Partial matching is the mechanism that is usually considered in the literature on semantic illusions (Park & Reder, 2004; Reder & Kusbit, 1991). The semantic overlap between the incorrect name in the illusory sentence and the correct name for which the former is mistaken (the fact that Moses and Noah share several semantic features) creates a good fit between the information in the sentence and the information stored in memory, and this good fit will bias the person to judge the sentence as true.

When semantic overlap is lowered, as in the cases where the incorrect name, although thematically associated with the sentence, is a worse representative than the correct name (e.g., How many animals of each kind did Ezekiel take in the ark?), the match is poor and people more readily detect the illusion (Erickson & Mattson, 1981).

A related reason why semantic overlap helps the illusion to fly under the radar of sentence processing is that it makes the sentence easy to process. This *processing fluency* will further contribute to the appearance of truth of the statement.

Several lines of research have shown how processing fluency is used as a heuristic cue to make several kinds of judgments including judgments of truthfulness (for a review, see Herzog & Hertwig, 2013). Perceptual fluency in particular has been shown to affect susceptibility to semantic illusions: people are less likely to detect the Moses illusion when the sentence is presented in an easy-to-read font than when it is harder to read (Song & Schwarz, 2008).

Conceptual fluency resulting from the ease of processing of a target word that comes from its continuity of meaning with other words that provide the context (Parks & Toth, 2006; Whittlesea, 1993) may also contribute to semantic illusions. In agreement with the present dual-process approach, it has been shown that conceptual fluency acts as a regulator of whether automatic or controlled processes are called for. Using reasoning and judgment tasks, Alter, Oppenheimer, Epley, and Eyre (2007) showed how disfluency leads people to second-guess their intuition and engage in deliberate reasoning. And even though fluency is a bad advisor in the case of semantic illusions, it is generally a valid cue to infer the truth in a statement. Because fluency and truth are positively correlated in real-world environments, people learn to use fluency as cue for truth (Reber & Unkelbach, 2010; Unkelbach, 2007).

On the other hand, consistent with the idea that the correct detection of semantic illusions is an effortful process, in the study of van Oostendorp and de Mul (1990), participants took longer to make an accurate judgment and reject the illusory sentence when the true word and the distorted word were highly related than when semantic overlap was low. Interpreting this finding from a dual-process perspective, in the latter condition, the automatic assessment of relatedness would suffice to produce a fast rejection, whereas in the former condition, automatic processing would not detect a distortion and only the controlled, slower process of checking the sentence against the knowledge stored in memory would enable the detection of the illusion. The role of controlled processes in the detection of semantic illusions is further attested by demonstrations that instructions that stress accuracy increase detection rates (van Jaarsveld, Dijkstra, & Hermans, 1997). Also