

Research Report

Testing the limits of the semantic illusion phenomenon: ERPs reveal temporary semantic change deafness in discourse comprehension

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Abstract

In general, language comprehension is surprisingly reliable. Listeners very rapidly extract meaning from the unfolding speech signal, on a word-by-word basis, and usually successfully. Research on ‘semantic illusions’ however suggests that under certain conditions, people fail to notice that the linguistic input simply doesn’t make sense. In the current event-related brain potentials (ERP) study, we examined whether listeners would, under such conditions, spontaneously detect an anomaly in which a human character central to the story at hand (e.g., “a tourist”) was suddenly replaced by an inanimate object (e.g., “a suitcase”). Because this replacement introduced a very powerful coherence break, we expected listeners to immediately notice the anomaly and generate the standard ERP effect associated with incoherent language, the N400 effect. However, instead of the standard N400 effect, anomalous words elicited a positive ERP effect from about 500–600 ms onwards. The absence of an N400 effect suggests that subjects did not immediately notice the anomaly, and that for a few hundred milliseconds the comprehension system has converged on an apparently coherent but factually incorrect interpretation. The presence of the later ERP effect indicates that subjects were processing for comprehension and did ultimately detect the anomaly. Therefore, we take the absence of a regular N400 effect as the online manifestation of a temporary semantic illusion. Our results also show that even attentive listeners sometimes fail to notice a radical change in the nature of a story character, and therefore suggest a case of short-lived ‘semantic change deafness’ in language comprehension.

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1. Introduction

Under normal circumstances, the human language comprehension system works amazingly fast, and amazingly well. One of the key features of the system that allows for its usually excellent performance is incrementality. Psycholinguistic experiments have shown that listeners and readers immediately relate the meaning and grammar of each incoming word to the context, whether this context consists of an isolated sentence (e.g., [28,51]), the global discourse

(e.g., [17,29,43–45]), or a non-linguistic visual scene (e.g., [3,37]).

But immediate analysis does not necessarily mean that linguistic information is always interpreted to the fullest degree possible. For instance, there are quite a few reports of incomplete semantic analysis or underspecification (e.g., [4,10]; for review, see [12,36]). Particularly striking are semantic illusions, which indicate that sometimes the full meaning of a word is not incorporated into the interpretation of a sentence, with people happily accepting an incorrect interpretation based on semantic heuristics instead. A well-known example is the “Moses illusion” [10], in which participants routinely fail to notice the anomaly in the

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question ‘How many animals of each sort did Moses put on the ark?’, despite knowing it was Noah instead of Moses. Similarly, after reading a story about a plane crash and confronted with the sentence ‘The authorities had to decide where to bury the survivors’, participants regularly do not perceive the coherence break [4].

The available evidence suggests that the probability of detecting a semantic anomaly decreases if the impostor word (e.g., “Moses”) is semantically related to the correct word (“Noah”; [10]), as well as if the impostor word is strongly associated with the global scenario suggested by the discourse (e.g., “survivors” in a plane crash scenario; [4]). Furthermore, we know that impostor words are more easily detected when they are brought into focus (e.g., as in ‘It was Moses who put two of each kind of animal on the ark. True or False?’, [5]), indicating that semantic illusions are partially dependent on the misdirection of focus. To account for these phenomena, Sanford and Sturt [36] have proposed that if a word fits the global situation very well or when it is out of focus, it will receive incomplete semantic analysis, to such an extent that the actual input can be misconstrued and a semantic anomaly can pass undetected.

On the one hand, the existence of semantic illusions is perhaps not that amazing. After all, the heavy cognitive demands imposed by processing speech or written text at a rate of several words per second makes it very unlikely that people always exploit every single bit of relevant information to the fullest degree. We know that in other domains of cognition, our brain often employs plausibility strategies, so that it can get where it needs to be quickly, while maintaining sufficient accuracy [34]. In decision making, for instance, our brain makes heavy use of heuristics that usually work well but inevitably go wrong from time to time (e.g., [20]). As evidenced by many classic visual illusions, even our highly esteemed visual system sometimes gets it wrong. Recent demonstrations of visual ‘change blindness’ (e.g., [38]), in which observers fail to notice a change to central objects in a scene even when looking for it, forcefully illustrate the fact that our input systems are not designed to consistently deliver full and complete representations of the input they encounter. Language comprehension may be no different. In fact, semantic illusions in language comprehension have recently been related to the use of a plausibility heuristic, which biases the system towards semantic analyses that are most consistent with world knowledge (e.g., [12,36]).

From another perspective, however, the existence of these illusions is actually very surprising. After all, story characters are central to situation models, and readers appear to be intensively engaged in keeping track of such ‘protagonists’ during comprehension [54]. If so, then why do people allow Moses to replace Noah without a blink, and allow survivors to replace protagonists who actually died? If protagonists are so central to the situation model, wouldn’t one expect that listeners always immediately notice a protagonist being replaced by an entirely different entity,

even if the anomalous impostor word is out of prosodic focus and it fits a scenario very well?

This raises the issue of just how far we can stretch the limits of the semantic illusion phenomenon. For instance, would listeners, given the above mentioned conditions, fail to notice cases in which a salient human story character (e.g., a tourist) engaged in conversation with another human being (say, a check-in desk clerk) is suddenly replaced by a non-living entity (e.g., a suitcase) that happily continues the conversation? Animacy is a core semantic feature that lies at the heart of our understanding of the world around us. In fact, the animate–inanimate distinction is often considered to be an innate organizing principle of cognition (e.g., [14,34]), with different neural mechanisms subserving each of the two categories [7]. Even if an inanimate impostor word such as “suitcase” would be prosodically unfocused, scenario-relevant, and semantically related to the animate character being replaced, it does lack a core semantic feature required in this context, namely, being alive. Would even such a flagrant violation remain undetected?

We explored this issue in the present event-related brain potential (ERP) study by investigating whether participants would detect a discourse anomaly of the type just outlined under conditions that have been reported to induce semantic illusions. Participants listened to short narratives portraying a man and a woman engaged in a conversation about some inanimate object (see Table 1). The inanimate object and the man were semantically related to each other (e.g., ‘diver’ and ‘harpoon’, ‘coachman’ and ‘whip’). A replacement occurred in the fifth and following sentences: Either the woman would continue her conversation with the man as usual (*coherent continuation*) or she would suddenly address the inanimate object instead and continue her conversation with this entity (*anomalous continuation*). Equivalent to the coherent continuation, the anomalous continuation was prosodically de-accented, and as such did

Table 1
Example story (approximate translation from Dutch)

Introduction

A tourist wanted to bring his huge suitcase onto the airplane. However, because the suitcase was so heavy, the woman behind the check-in counter decided to charge the tourist extra. In response, the tourist opened his suitcase and threw some stuff out. So now, the suitcase of the resourceful tourist weighed less than the maximum twenty kilos.

Coherent continuation

Next, the woman told the *tourist* that she thought he looked really trendy. The tourist grabbed the woman’s hand and eagerly asked her for a date. But the woman reprimanded the tourist for being pushy and told him to just get on the plane right away.

Anomalous continuation

Next, the woman told the *suitcase* that she thought he looked really trendy. The suitcase grabbed the woman’s hand and eagerly asked her for a date. But the woman reprimanded the suitcase for being pushy and told him to just get on the plane right away.

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