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Is comprehension necessary for error detection? A conflict-based account of monitoring in speech production

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ABSTRACT

Despite the existence of speech errors, verbal communication is successful because speakers can detect (and correct) their errors. The standard theory of speech-error detection, the perceptual-loop account, posits that the comprehension system monitors production output for errors. Such a comprehension-based monitor, however, cannot explain the double dissociation between comprehension and error-detection ability observed in the aphasic patients. We propose a new theory of speech-error detection which is instead based on the production process itself. The theory borrows from studies of forced-choice-response tasks the notion that error detection is accomplished by monitoring response conflict via a frontal brain structure, such as the anterior cingulate cortex. We adapt this idea to the two-step model of word production, and test the model-derived predictions on a sample of aphasic patients. Our results show a strong correlation between patients' error-detection ability and the model's characterization of their production skills, and no significant correlation between error detection and comprehension measures, thus supporting a production-based monitor, generally, and the implemented conflict-based monitor in particular. The successful application of the conflict-based theory to error-detection in linguistic, as well as non-linguistic domains points to a domain-general monitoring system.

1. Introduction

The fact that we survive and even thrive in spite of the error-prone nature of our cognitive systems makes the study of error processing crucial to the understanding of human cognition. Most probably,

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the reason that we function well despite erring often is that we have the ability to detect our own errors and counteract their effects, either by correcting them or by catching them before they cause trouble. It is the error-detection process that we target in this paper.

There are two types of errors (Reason, 1990) with distinct properties. The first type, classically labeled as "mistakes", comprises errors that result from the lack of information necessary to arrive at the correct response (e.g., you might call a yellow-jacket a bee if you do not know the difference between the two). In contrast, some errors result from a hasty response or a momentary lapse of attention, rather than lack of knowledge (e.g., when you confuse left and right when giving someone directions to your home). This second type of errors, referred to as "slips", is particularly important, because slips are common, correctable, and in principle preventable.

In the current paper, we address the question of error detection in speech, by adults who are using their native language. These errors are thus most likely to be "slips" in Reason's terminology, although we often use the term "error" to label them. Our goal is twofold: for one, we review the problems with the existing account of error detection in speech production and propose an alternative account, which does not suffer similar criticisms. To develop our model we use the similarity between speech errors and slips in other tasks, which brings us to the second goal of the paper: to provide support for a central, generic error detection system (e.g., Miltner, Braun, & Coles, 1997) by showing that a central mechanism that had previously been shown to explain error detection in forced-choice response tasks is equally plausible and effective when applied to a natural task such as speech production.

We start by discussing the "perceptual loop" theory (Levelt, 1983, 1989), the most widely-accepted account of speech monitoring. We review the evidence against this theory and introduce a new account, in which conflict (Botvinick, Braver, Carter, Barch, & Cohen, 2001; Yeung, Botvinick, & Cohen, 2004) is used as a signal for error detection. We then implement our theory in the interactive two-step model of word production (Dell & O'Seaghdha, 1991) and establish its predictions with two computational simulations. Next, we assess the explanatory power of our account against the perceptual loop theory by analyzing the error-detection performance of a group of aphasic patients. We conclude by proposing the conflict-based model as the default mechanism of error-detection in language production and discuss the similarities between this account and the monitoring of motor movements, thus pointing to the possibility of a domain-general monitoring mechanism.

1.1. The perceptual loop account of monitoring

The perceptual loop theory (Levelt, 1983, 1989) is an elegant account of speech monitoring because it assumes no specialized device or mechanism for error detection. According to this theory, speakers detect errors in their speech by listening to themselves. Error detection then boils down to comprehending that the produced utterance is different from the intended one. Since humans need the comprehension system to process the speech of others anyway, using this system for self-monitoring sounds plausible and is parsimonious. Similar to detecting errors in other people's speech by listening to them, speakers can detect errors in their own speech through an "external channel" (implying that the spoken utterance is processed by the auditory system).

There is some support for the perceptual loop theory's claim that error detection in self and others' speech is similar. Although normal speakers (as well as Broca's aphasia patients) detect more errors in others' speech than in their own (Oomen, Postma, & Kolk, 2001), the *relative* detectability of different error types is similar in monitoring self and others' speech. An equal proportion of semantically-related errors (e.g., "dog" for "cat"), as well as form-related errors (e.g., "mat" for "cat"), is detected by people when they monitor their own speech (when auditory feedback is not blocked by noise; Postma & Noordanus, 1996) and when they monitor the speech of others, at least under conditions where the intended meaning is known to both the speaker and the listener (Oomen & Postma, 2002; but see Tent & Clark, 1980). Such similarity in the pattern of error detection can be taken as evidence that a similar mechanism underlies the detection of both self and others' speech errors.

However, the external channel is not sufficient to explain all the empirical findings concerning error detection. An important finding in this regard is the timeline of detection. We show this using the classic example of the corrected error "v-horizontal" (Levelt, 1989), where the production of the word "vertical" is halted as soon as the first phoneme is produced. The latency between the initiation of the