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# Does naming accuracy improve through self-monitoring of errors?

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ABSTRACT

This study examined spontaneous self-monitoring of picture naming in people with aphasia. Of primary interest was whether spontaneous detection or repair of an error constitutes an error signal or other feedback that tunes the production system to the desired outcome. In other words, do acts of monitoring cause adaptive change in the language system? A second possibility, not incompatible with the first, is that monitoring is indicative of an item's representational strength, and strength is a causal factor in language change. Twelve PWA performed a 615-item naming test twice, in separate sessions, without extrinsic feedback. At each timepoint, we scored the first complete response for accuracy and error type and the remainder of the trial for verbalizations consistent with detection (e.g., "no, not that") and successful repair (i.e., correction). Data analysis centered on: (a) how often an item that was misnamed at one timepoint changed to correct at the other timepoint, as a function of monitoring; and (b) how monitoring impacted change scores in the Forward (Time 1 to Time 2) compared to Backward (Time 2 to Time 1) direction. The Strength hypothesis predicts significant effects of monitoring in both directions. The Learning hypothesis predicts greater effects in the Forward direction. These predictions were evaluated for three types of errors – Semantic errors, Phonological errors, and Fragments – using mixed-effects regression modeling with crossed random effects. Support for the Strength hypothesis was found for all three error types. Support for the Learning hypothesis was found for Semantic errors. All effects were due to error *repair*, not error detection. We discuss the theoretical and clinical implications of these novel findings.

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## 1. Introduction

Speech monitoring is a complex cognitive skill that operates largely beneath the surface of awareness. Intuition suggests that auditory comprehension is important for self-monitoring, and evidence shows this to be so. For example, monitoring suffers when healthy speakers are asked to detect their errors in the presence of noise (Lackner and Tuller, 1979; Oomen et al., 2001; Postma and Noordanus, 1996). On the other hand, the linguistic signatures of monitoring – self-interruption, editing terms ("uh-", "no"), and repairs – often happen too rapidly for auditory feedback to have plausibly played a role (Levelt, 1983). Either the comprehension system monitors speech before, as well as after, articulation (inner-speech monitoring; Hartsuiker and Kolk, 2001; Levelt, 1983), or the mechanisms of monitoring are internal to the production system (Nozari et al., 2011; Postma, 2000).

From a functional communication perspective, speech self-monitoring plays an important role in keeping speech errors in check and the dialogue on track (Pickering and Garrod, 2004). We wondered if it might also play a role in use-dependent, incremental language learning (e.g., Damian and Als, 2005; Oppenheim et al., 2010). That is, might error detection or repair constitute an error signal or other feedback that tunes the production system to the desired outcome? We explored this novel hypothesis through an analysis of spontaneously monitored naming errors in participants with aphasia.

### 1.1. Speech monitoring in aphasia

Generally speaking, people with aphasia (PWA) produce higher than normal rates of error in speech and naming and show less evidence of monitoring (e.g., Schlenck et al., 1987). PWA who routinely fail to monitor their speech errors tend to carry a more severe diagnosis, (e.g., jargon aphasia or Wernicke's aphasia) and have poorer therapy outcomes (Fillingham et al., 2006; Marshall et al., 1994; Marshall and Tompkins, 1982; Wepman, 1958). A link between monitoring and recovery was demonstrated 20 years ago by Marshall and colleagues (Marshall et al., 1994). They studied 30 PWA 1 – 6 months post onset and just prior to a 3-month program of general aphasia therapy. Before and during therapy, the participants performed a 40-item picture naming test, which was scored for spontaneous "self-correction effort" (what we here call

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*error detection)* and "self-correction success" (here, *error repair).* A key finding was that comprehension and production outcomes of therapy correlated positively with the rate at which naming errors were detected, though not with the rate of repair. This important study does not appear to have generated much follow-up. This may be because the findings left open the possibility that monitoring plays no causal role in recovery but simply indexes a language system that is less impaired and thus more likely to recover. Our study addressed that possibility along with the more interesting possibility that acts of monitoring actively promote adaptive change, i.e., learning, in the damaged system.

### 1.2. Cognitive accounts of monitoring and monitoring deficits

The monitoring deficit in aphasia has been investigated in relation to cognitive models of naming. Comprehension-based monitoring models predict a positive correlation between PWA's ability to comprehend and their ability to monitor. Contrary to this, Nickels and Howard (1995) reported that the rate at which PWA detected their phonological naming errors did not correlate with their scores on auditory speech processing measures. They also observed no correlation between phenomena indicative of pre-articulatory monitoring (self-interrupted naming attempts, such as/bi-/for *banana)* and tasks requiring the parsing of inner-speech (e.g., selecting two homophones from a triad of pictures). Several other investigations into the relationship between monitoring and auditory comprehension status in PWA were similarly negative (Marshall et al., 1998, 1985; Nozari et al., 2011; Schlenck et al., 1987; see also Oomen et al. (2001)).

A recent study (Nozari et al., 2011) explored the relationship between error monitoring and *production* abilities in aphasia, with more promising results. It has long been appreciated that some PWA selectively monitor their semantic errors, others their phonological errors (Alajouanine and Lhermitte, 1973; Marshall et al., 1985; Stark, 1988). Nozari et al. analyzed PWA's error monitoring in relation to the semantic-phonological version of Dell's interactive two-step model of naming (Foygel and Dell, 2000; Schwartz et al., 2006). The model postulates that the proximal cause of semantic errors in PWA is heightened conflict between the target and related words, due to lesion-induced weakness in the semantic (s) weights (see Fig. 1). The proximal cause of phonological (nonword) errors is heightened conflict among phonemes, due to weak phonological (p) weights. Nozari et al. (2011) ran a simulation study showing that in the normal (unlesioned) model, conflict at either the word or phoneme level reliably predicted errors at that level. They argued for a general-purpose conflict-monitoring system (Yeung et al., 2004) that reacts to such conflict within the production system by signaling the occurrence of an error.

Now consider aphasia: a basic premise of Dell's model is that lesion-induced weakness in s- or p-weights heightens conflict at that level, resulting in errors. Nozari et al. (2011) hypothesized that

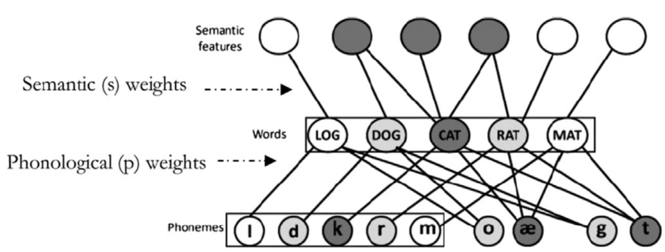


**Fig. 1.** The interactive two-step model of word production. Boxes indicate the places where conflict was measured during simulated normal naming: the word level at the end of step 1; the phoneme level at the end of step 2 (reprinted from Nozari et al. (2011)).

a further consequence of heightened conflict at a given level might be to lessen the reliability of the conflict signal, causing error monitoring to suffer. They tested this hypothesis with naming and monitoring data from 29 PWA. First, each individual's naming response distributions (proportions of correct responses and several error types) were entered into the model for the fitting of s- and p-weights for that individual (Foygel and Dell, 2000). Then, the naming data were analyzed trial-by-trial for evidence that an error was detected, and the individual's rate of detection for semantic errors and phonological (nonword) errors was calculated. In the final step, participants' semantic and phonological error detection rates were correlated with their model-fitted s-and p-weights, and, for comparison purposes, with 8 measures of auditory input processing. Positive correlations were found between semantic error detection and strength of the s-weights ($r=.59$, $p=.001$) and between phonological error detection and strength of the p-weights ($r=.43$, $p=.021$). Reversing the pairings (e.g., semantic error detection with fitted p-weights) yielded negative correlations. Thus, as predicted, lower weights at a particular level of the production system correlated with lower detection rates for errors only at that level. In contrast, detection rates and auditory input measures were uncorrelated across the group and doubly dissociated at the level of individual participants (see also Marshall et al. (1998)).

Nozari et al.'s (2011) correlations and modeling data support a production-based, conflict-centered account of semantic and phonological error detection in aphasia. Their study did not deal with error repair. However, assumptions common to most monitoring accounts – whether comprehension- or production-based – is that repair of speech errors takes place under central control and typically involves restarting or re-programming the speech act (Levelt, 1983; Postma, 2000).[1]

### 1.3. The present study

Like Nozari et al. (2011), the present study analyzed the spontaneous self-monitoring of a heterogeneous group of PWA during performance of a naming task. As noted, our goal was to explore a possible link between monitoring and incremental learning, and to this end, we measured the impact of monitoring *at the level of individual items*. We also analyzed detected and repaired items separate from those detected without repair.

The specific question we asked was whether targets of errors that are spontaneously monitored are at an advantage on retest, relative to unmonitored errors. There are at least two possible reasons why this might be the case. The first is that detecting or repairing an error constitutes a *learning event*, which causally impacts later performance on that item (Learning hypothesis). The second possibility is that detection and repair simply index item strength, and stronger items have a higher probability of being named correctly on another occasion (Strength hypothesis). It is important to note that the Strength and Learning hypotheses are not mutually exclusive; both can be true.

Table 1 shows how the present study went about testing the Strength and Learning hypotheses. In broad outlines, we administered a very large naming test twice, in separate sessions, without extrinsic feedback. On both administrations, each trial was scored for the type of naming response (correct, error) and whether the accompanying verbalizations qualified as evidence of

[1] Postma (2000) suggests that central control is not necessarily involved in the repair of response execution errors, such as those involving faulty placement of the tongue or jaw during articulation. Such errors may be corrected through online peripheral adaptations and need not involve reprogramming. The typical speech error is an error of *selection* (lemma or phoneme), and these, as a class, are repaired under central control.

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