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Research report

Target/error overlap in jargonaphasia: The case for a one-source model, lexical and non-lexical summation, and the special status of correct responses

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ABSTRACT

We present three jargonaphasic patients who made phonological errors in naming, repetition and reading. We analyse target/response overlap using statistical models to answer three questions: 1) Is there a single phonological source for errors or two sources, one for target-related errors and a separate source for abstruse errors? 2) Can *correct* responses be predicted by the same distribution used to predict errors or do they show a completion boost (CB)? 3) Is non-lexical and lexical information summed during reading and repetition? The answers were clear. 1) Abstruse errors did not require a separate distribution created by failure to access word forms. Abstruse and target-related errors were the endpoints of a single overlap distribution. 2) Correct responses required a special factor, e.g., a CB or lexical/phonological feedback, to preserve their integrity. 3) Reading and repetition required separate lexical and non-lexical contributions that were combined at output.

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We present a study of target/response overlap in the spoken output of three jargonaphasic patients using data from reading, naming and repetition. We use statistical models to address three related questions. The first question concerns the striking phenomenon that gives jargonaphasia its name. Jargonaphasic patients sometimes make errors that are clearly related to the target word (target-related errors: e.g., strawberry > strewberry), but they also make errors that seemingly bear little relationship to the target (neologistic errors: e.g., suitcase > teligom). We ask if these errors have two sources—one for related errors, based on successful access to word forms, accompanied by occasional minor segmental errors, and a second, for abstruse errors, based on a failure to gain access word forms. In its clearest form, two sources would produce a bimodal distribution of overlap. The

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alternative, a single segmental source, would predict that some words will be relatively untouched by errors and others will be completely altered, but the majority will fall continuously between these extremes.

Our second question is related, but involves correct responses, which have not been a traditional concern of jargonaphasic studies. We ask if correct responses are predictable from the level of overlap that characterizes errors, as would be expected if correct responses are just those where all segments escape the error generating process unscathed.

Our third question concerns whether spoken responses are based on combining lexical and non-lexical information. There is extensive debate in the neuropsychological and modeling literature over the most appropriate architecture for the reading process and a more limited discussion of the same issues for repetition (e.g., see reading discussion in Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001; for repetition see: Hanley, Dell, Kay, & Baron, 2004; Hanley & Kay, 1997; Hanley, Kay, & Edwards, 2002; Harm & Seidenberg, 2004; Zorzi, Houghton, & Butterworth, 1998 and associated references). We test the hypothesis that there are lexical and non-lexical routes to repetition and reading and that these sources sum together to produce a response (Alario, Schiller, Domoto-Reilly, & Caramazza, 2003; Bi, Han, Weekes, & Shu, 2007; Funnell, 1996; Hanley & Kay, 1997; Hanley et al., 2002; Hillis & Caramazza, 1991, 1995; Howard & Franklin, 1988; Miceli, Capasso, & Caramazza, 1994; Tree, Kay, & Perfect, 2005; Ward, Stott, & Parkin, 2000).

We test these theoretical alternatives by formalizing them in a hierarchically related set of mathematical models that predict the distribution of shared phonemes in targets and responses. We evaluate our set of models using formal model selection. Our case series, as a result, has methodological, as well as empirical implications. Formalising models and using model selection methods can be a good way to explore specific quantitative consequences of theories and to confront theories and data. Our results will illustrate a point that others have made before, most frequently in the domains of statistical theory and biological modelling (see, specifically, Burnham & Anderson, 2002): Model selection, which emphasizes the relative ability of a collection of models to account for data, and the interpretation of the values of the parameters required to fit the data, is a more appropriate perspective for comparing theories than winner-take-all methods based on hypothesis testing, where binary decisions sometimes reflect relatively minor differences in fit.

To situate our results in relationship to the existing psycholinguistic and neuropsychological literature, we will use terms and levels defined by a large literature on speech production (e.g., Caramazza, 1997; Dell, 1986; Garrett, 1980; Kempen & Huijbers, 1983; Levelt, 1989; Levelt, Roelofs, & Meyer, 1999; Rapp & Goldrick, 2000), but abstracting away from some of the details that differ between accounts. In common with most neuropsychological and psycholinguistic architectures, we assume there is a semantic/conceptual level that accesses a distinct level where words are represented as unitary items (Caramazza & Hillis, 1990; Dell, Schwartz, Martin, Saffran, & Gagnon, 1997; Howard & Gatehouse, 2006; Levelt et al., 1999). This is the level of *word selection*. A unitary word level is needed to account for whole word errors in speech production (Garrett, 1975) and for effects of grammatical processes that apply to words and not their component parts (e.g., effects of grammatical class, gender, number: Badecker, Miozzo, & Zanuttini, 1995; Bock & Miller, 1991; Caramazza & Miozzo, 1997; Garrett, 1975; Henaff Gonon, Bruckert, & Michel, 1989; Miozzo & Caramazza, 1997a, 1997b; Vigliocco, Antonini, & Garrett, 1997). In some accounts there are two unitary word levels, connected to syntactic and phonological information (lemma and lexeme, respectively; Levelt et al., 1999; Vigliocco et al., 1997). In other accounts there is a single level (lexeme; Caramazza, 1997; Caramazza & Miozzo, 1997; Vigliocco et al., 1997). Our data do not speak to this issue, so we will refer to a unitary word level without prejudging whether a syntactic level is accessed *before* the level that is linked to phonemes (i.e., lemma before lexeme). Unitary word representations are connected, at the next level, to corresponding phonological segments. This is the level of *phoneme selection*. These are abstract phonemes, not completely specified for production, but specified for contrastive features (e.g., Voicing, which differentiates/p/and/b/in English would be specified, but not aspiration, which is not contrastive in English. The/p/would not have aspiration specified at this level). Finally, there is a level where all phonetic dimensions are specified for articulation. These distinctions are widely shared in linguistics and psycholinguistics (Anderson, 1974; Goldrick & Rapp, 2007; Laganaro, 2012).

We assume that the connections between semantic information and word nodes, the word nodes themselves, and their connections with phonemes constitute the lexical representation of a word. We also assume that the abstract phoneme level that is part of the lexical representation is also addressed by non-lexical conversion processes for reading or repetition through independent connections.

Our architecture for speech production is diagrammed in Fig. 1. This is identical to the architecture described by Goldrick and Rapp (2007) except that they assume that lexical and non-lexical information converge later, at the level of *phonetic encoding*. In the interest of parsimony, we assume that summation occurs at the first available level (*phoneme selection* in Fig. 1), so that phonetic encoding is not duplicated in lexical and non-lexical routes. One consequence is the phoneme level is accessed by both lexical and non-lexical processes in our architecture. To avoid the confusion that could result from giving this a lexical label (e.g., *lexical phonology*), we refer to this level as *phoneme selection* following Romani, Galluzzi, Bureca, and Olson (2011).

Note that there is some disagreement in the literature over what is considered *post-lexical* that is, naturally, related to which levels are considered to be part of lexicon. Some people do not consider the connections between word nodes and phonemes to be part of lexical representations, and, therefore consider phonological encoding to be a post-lexical level. We consider, instead, this level to be part of lexical representations because a word is characterized by its sequence of phonemes as much as by its meaning (see also, Goldrick & Rapp, 2007). To avoid potential confusion, we will not use the term *post-lexical* and, instead, use the term *post-access* to identify the levels after which a word node has been correctly activated/selected. We will describe the question of the locus