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Research report

Linking language and categorization: Evidence from aphasia

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ABSTRACT

In addition to its use in communication, language appears to have a variety of extra-communicative functions; disrupting language disrupts performance in seemingly non-linguistic tasks. Previous work has specifically linked linguistic impairments to categorization impairments. Here, we systematically tested this link by comparing categorization performance in a group of 12 participants with aphasia and 12 age- and education-matched control participants. Participants were asked to choose all of the objects that fit a specified criterion from sets of 20 pictured objects. The criterion was either “high-dimensional” (i.e., the objects shared many features, such as “farm animals”) or “low-dimensional” (i.e., the objects shared one or a few features, such as “things that are green”). Participants with aphasia were selectively impaired on low-dimensional categorization. This selective impairment was correlated with the severity of their naming impairment and not with the overall severity of their aphasia, semantic impairment, lesion size, or lesion location. These results indicate that linguistic impairment impacts categorization specifically when that categorization requires focusing attention and isolating individual features – a task that requires a larger degree of cognitive control than high-dimensional categorization. The results offer some support for the hypothesis that language supports cognitive functioning, particularly the ability to select task-relevant stimulus features.

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1. Introduction

To what degree does human cognition depend on language? Contrary to the view that language simply makes use of already existing concepts and cognitive faculties (Fodor, 1975; Li and Gleitman, 2002), there is mounting evidence that language is “potentially catalytic and transformative of cognition” (Bowerman and Choi, 2001). Indeed, not only does language appear to be instrumental in the learning of concepts during development (e.g., Balaban and Waxman, 1997; Casasola, 2005; Yoshida and Smith, 2005), but as initially hypothesized by

William James (1890) categorization may continue to depend on language in adulthood (Lupyan et al., 2007; Lupyan, 2009).

If language affects cognition, then language deficits may produce cognitive deficits. This idea was discussed at length by the German neurologist Kurt Goldstein in the context of possible cognitive impairments concomitant with aphasia (1924, 1948). Rejecting the view prevalent at the time that aphasia was a disorder of general intelligence (Jackson, 1878), Goldstein argued that a loss of words did not bring with it a loss of thoughts, but an impairment of naming was also not circumscribed to language:

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Thinking is not only expressed in language, but language influences in turn thought formation... Language is not only a means to communicate thinking; it is also a means to support it, to fixate it. Defect in language may thus damage thinking (Goldstein, 1948).

Indeed, following Goldstein's initial observations (see Noppeney and Wallesch, 2000 for review), a number of researchers found that linguistic impairments were often correlated with difficulties in nonverbal sorting and categorization tasks. For example, individuals with aphasia were found to have trouble sorting objects by color—a task requiring selectively focusing on a specific dimension while overlooking differences in other dimensions such as shape (De Renzi and Spinnler, 1967). Cohen et al. likewise noted a specific impairment in encoding object features stressed by the experimenter (Cohen et al., 1981; see also Wayland and Taplin's, 1982 discussion of patients with aphasia failing to organize feature set information, and Vignolo, 1999 for review).

In an effort to systematize the observed patterns of results, the so-called Konstanz group concluded that "... aphasics have a defect in the analytical isolation of single features of concepts" (Cohen et al., 1980, 1981), yet are equal to controls "when judgment can be based on global comparison" (Cohen et al., 1980). In their examination of the anomic patient LEW, Davidoff and Roberson reached a similar conclusion, arguing that when a grouping task requires attention to one category while abstracting over others, LEW is "without names to assist the categorical solution. Where patients such as LEW can name, they can categorize." (Davidoff and Roberson, 2004).

In a study especially relevant to the present work, Semenza et al. (1992) measured the ability of a varied group of patients with aphasia to select the stronger of two associates given a target item. The patients were asked to choose the better of two alternatives related to the target (e.g., ring) in a taxonomic relationship (necklace vs belt) and in a thematic relationship (finger vs wedding). Although the patient group performed worse than the control group on both trial types, greater impairments in confrontation naming predicted poorer performance specifically for the taxonomic trials.

Although these studies suggest an association between linguistic and categorization impairments, no consensus could be reached, owing to wide variety of methods of diagnosing and testing the patients (cf. Caramazza et al., 1982; De Renzi and Spinnler, 1967; Hjelmquist, 1989; Semenza et al., 1992; Wayland and Taplin, 1982; see Vignolo, 1999 for discussion). For example, it is unclear to what degree the deficits observed by Semenza et al. (1992) were due to failures of the categorization process versus disrupted semantic knowledge (cf. Caramazza et al., 1982) and it is unclear whether the studies of the patient LEW (Roberson et al., 1999; Davidoff and Roberson, 2004) generalize to a broader population.

Here, we report a systematic investigation of categorization deficits in aphasia by comparing performance of participants with aphasia to age- and education-matched control participants on a task that required selecting pictures of common objects that matched a particular criterion. For example, one criterion asked participants to click on all the

farm animals; another asked to choose all "things that are green" (see Appendix for a full listing).

One reason why naming impairments may lead to categorization impairments is that language is inherently categorical (i.e., words denote categories) and as such helps to dynamically cohere entities that are otherwise too distinct (Lupyan, 2012a). A label like "red" for example may facilitate forming a category of red things independently of their semantic categories. Indeed, in a series of studies investigating the impact of aphasia on detecting commonalities between objects, Koemeda-Lutz et al. found that patients with aphasia were impaired in detecting common properties of sequentially shown objects. The authors observed that "red cherries and red bricks may be judged to be alike mainly via what is concentrated and coined in the verbal label 'red'" (Koemeda-Lutz et al., 1987).

Our main prediction was that individuals with aphasia would be selectively impaired on trials that required categorizing according to a specific dimension, e.g., choosing all the green items while abstracting over shape, semantic class, etc. We call such trials *low-dimensional*. We reasoned that because such categories cohere on the basis of one or a small number of dimensions, they may require more on-line support from language. Language impairments, particularly naming impairments, may therefore lead to a failure in forming the task-relevant category representation resulting in a lower rate of correct target selection. In contrast, grouping together items that cohere on numerous dimensions such as a pillow and a blanket (*high-dimensional* trials) does not require the same level of selective representation/cognitive control and can be accomplished by relying on broader inter-item associations. Performance on these trials was predicted to be less affected by linguistic impairments such as naming.¹ So, although grouping together a cow, a pig, and a chicken as instances of farm animals depends on semantic knowledge of what animals are typically found on farms, forming this type of classification on our account does not require a high level of active selection or cognitive control and can be accomplished by activating a broad semantic representation of things-associated-with-farms (see Lupyan et al., 2012 for discussion). Note that our predictions concern the possible contributions of language in constructing task-relevant category representations on-line. So, although it is true that semantic impairments observed particularly in Wernicke-type aphasias manifest in disordered conceptual organization (Whitehouse et al., 1978; Caramazza et al., 1982), our present goal is to test the hypothesis that language may be implicated in constructing certain types of categories (low-dimensional) controlling for any concomitant semantic deficits.

¹ Our notion of category dimensionality is similar to Sloutsky's distinction between sparse categories—those cohering on only a small number of dimensions, and dense categories—those in which many of the dimensions covary (Sloutsky, 2010). It is also related to the distinction of rule-based versus information-integration categories (e.g., Ashby et al., 1999; Waldron and Ashby, 2001). These authors have argued that learning low-dimensional/sparse/rule-based categories appears to depend more on language than learning high-dimensional/dense/similarity-based categories.

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