Research paper

Influence of working memory on stimulus generalization in anomia treatment: A pilot study

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ABSTRACT

Neuropsychological testing of distinct cognitive domains holds promise as a prognostic indicator of aphasia therapy success; however, it is unclear the degree to which cognitive assessments may also predict generalization abilities. The present study aimed to assess the relationship between working memory skills and stimulus generalization from a visual picture-naming treatment to an auditory definition-naming task. Seven individuals with aphasia completed verbal and nonverbal assessments of working memory prior to participating in a cued picture-naming treatment for anomia. After treatment ended, stimulus generalization percentages were calculated for definition naming for the same items that were trained using picture naming. Scores on two nonverbal working memory measures, the backward spatial span and the 1-back, and one verbal working memory assessment, the picture span, were positively correlated with generalization percentage. These results provide preliminary evidence of the relationship between working memory and stimulus generalization. When comparing performance across working memory measures, the spatial span and the picture span were highly correlated in this sample. We propose that despite the verbal and nonverbal distinction, these tasks may have tapped into working memory similarly by relying on a shared central processing mechanism.

1. Introduction

Generalization of treatment gains can be classified into two broad categories: response generalization and stimulus generalization. Response generalization refers to generalization of therapy gains from trained items to untrained items, whereas stimulus generalization refers to the ability to generate a learned response in a different stimulus environment (i.e. from trained tasks to untrained tasks). Treatments for post-stroke word-retrieval deficits have generally resulted in poor response generalization (Coppens & Patterson, 2018; Snell, Sage, & Lambon Ralph, 2010; Wambaugh, Mauszycki, & Wright, 2014). However, there is a body of work showing that individuals perform better on naming untrained items when they share semantic properties with trained items (Kiran & Thompson, 2003) and when the trained items are less prototypical exemplars of a semantic category than are the untrained items (Kiran, Sandberg, & Sebastian, 2011). Although response generalization tends to be poor with anomia treatments, best chances occur when a strategy for word retrieval is internalized during training so that it can be used with novel exemplars (Coppens & Patterson, 2018).

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Stimulus generalization also tends to be minimal, at best, for word-retrieval therapies (Boyle & Coelho, 1995; Boyle, 2004), many of which rely on picture naming paradigms. Demonstrating generalization of picture naming treatment gains to an untrained context is methodologically challenging (Conroy, Sage, & Lambon Ralph, 2009) due to the difficulty in providing opportunities to use words trained during picture naming for another task. For example, an untrained story retell task must provide the appropriate context so that an individual has the opportunity to produce each of the words trained during picture naming treatment during the story retell task. This challenge is compounded by the need to choose individually-tailored stimulus sets that target specific deficits in word retrieval, as well as the considerable variability in exemplars produced for a target word from even neurologically-intact individuals in response to retelling of a narrative (Armstrong, 2000). These factors make choosing specific stimulus items and modes of elicitation (e.g., narrative to retell, picture description) for measurement of stimulus generalization a challenging endeavor.

1.1. Therapy studies investigating stimulus generalization

Studies investigating stimulus generalization have used different elicitation methods to assess the transfer of treatment gains from trained items to untrained tasks. Elicitation tasks have included story retell (Conroy et al., 2009; Faroqi-Shah & Virion, 2009; Hickin, Mehta, & Dipper, 2015; Maher et al., 2006; Rider, Wright, Marshall, & Page, 2008; Rose, Mok, Carragher, Katthagen, & Attard, 2016), picture description (Conroy et al., 2009; Rose et al., 2016), and conversation (Best et al., 2011, 2013; Boo & Rose, 2011; Conroy et al., 2009; del Toro et al., 2008; Grande et al., 2008; Greenwood, Grassly, Hickin, & Best, 2010; Rose, Douglas, & Matyas, 2002; Rose et al., 2016). These studies have produced mixed results, in part due to the methodological difficulties in demonstrating this effect, especially to more natural conversational tasks. Gross measurements focused on quantifying improvement in discourse (e.g., number of utterances, words, novel utterances, or correct information units) often provide insufficient evidence of item-specific generalization of trained items, as they do not elicit production of specific words trained in therapy. Although valuable as a measure of functional language abilities, they also leave us wondering whether the lack of demonstrated generalization may be related to additional task demands, such as syntactic planning for longer utterances. In addition, some investigations may be blurring the line between stimulus and response generalization. That is, measuring verb retrieval in conversation after a picture-naming therapy may be measuring both stimulus generalization (e.g. a different task for retrieval) and response generalization (e.g. retrieval of any verbs and not specifically the verbs trained in therapy). Similarly, when examining whether a treatment has generalized to overall language abilities using standardized measures, both the context and the specific items will vary from the trained context and items. Although these outcomes tend to demonstrate better ecological validity than does picture naming, they may not be constrained enough to demonstrate pure stimulus generalization without other confounding variables.

Some studies investigating stimulus generalization of trained items to untrained contexts have attempted to isolate target lexical items as opposed to measuring improved production of all lexical items. That is, the generalization task is designed to elicit specific words that have been trained in therapy. For example, in a case study, Hashimoto and Frome (2011) found stimulus generalization after a modified semantic feature analysis treatment from naming black and white line drawings to naming the same items in colored photographs in their natural setting (e.g. all animals in a zoo setting). Rider et al. (2008) investigated generalization of confrontation naming gains after semantic feature analysis on discourse production in closed-set contexts. Target words came from story retellings and procedural explanations. They found an increase in the number of target words produced in discourse after therapy. Similarly, Conroy et al. (2009) investigated generalization of improved confrontation naming after picture naming therapy to picture supported narratives, using the Cookie Theft picture and the Cinderella story, and to unsupported narratives, using the Cinderella story without the book. Unsurprisingly, they found a stepwise decrement in naming from picture naming to supported narrative to unsupported narrative. However, picture naming accuracy in the confrontational naming task significantly predicted accuracy in the connected language tasks. In these studies, some of the previously mentioned confounding variables posed by discourse/conversational tasks were more tightly controlled because items trained in therapy were also targeted during stimulus generalization tasks.

One criticism of picture-naming therapies is that the task is not functionally relevant. Picture-naming therapy may change a subset of the neural circuitry involved in lexical retrieval (Kleim & Jones, 2008), resulting in improved picture naming but without much generalization to word retrieval in other contexts. If we measure success in anomia therapy with task specific acquisition of a lexical item, then we fail to meet the critical need for translation of that skill to functional communication tasks that may actually impact communicative abilities and quality of life. Intensive restorative therapy aims to rehabilitate the impaired language processes (as opposed to therapy that seeks to compensate for a language loss using specific strategies), and can be a powerful tool for rehabilitation of language (Cherney, Patterson, & Raymer, 2011; Dignam, Rodriguez, & Copland, 2016; Harnish et al., 2014). However, if we achieve improved lexical retrieval in the context of a picture stimulus, we cannot assume that improved retrieval will occur in the absence of the picture. Thus, to facilitate real change in communicative competence, we must either assess and treat generalization of those lexical items across contexts or equip patients with portable picture stimuli to facilitate retrieval in the context in which they were trained. Without these steps, we are falling short of our goal to rehabilitate communication abilities by discharging patients with improved picture naming skills, for example, but without any translation to functional skills.

1.2. Definition-naming as a measure of stimulus generalization for picture-naming therapies

Definition naming offers a well-controlled opportunity to demonstrate stimulus generalization by providing the opportunity to name each item trained with picture naming in a different, arguably more functionally-relevant, modality. There are shared and distinct task demands for picture naming and definition naming. The shared demands are retrieval of lexical-semantic and phonological features of the items to be named and production of the motor response. Task differences are related to the stimulus input