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Research report

Cross-situational word learning in aphasia

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ABSTRACT

Human learners can resolve referential ambiguity and discover the relationships between words and meanings through a cross-situational learning (CSL) strategy. Some people with aphasia (PWA) can learn word-referent pairings under referential uncertainty supported by online feedback. However, it remains unknown whether PWA can learn new words cross-situationally and if such learning ability is supported by statistical learning (SL) mechanisms. The present study examined whether PWA can learn novel word-referent mappings in a CSL task without feedback. We also studied whether CSL is related to SL in PWA and neurologically healthy individuals. We further examined whether aphasia severity, phonological processing and verbal short-term memory (STM) predict CSL in aphasia, and also whether individual differences in verbal STM modulate CSL in healthy older adults. Sixteen people with chronic aphasia underwent a CSL task that involved exposure to a series of individually ambiguous learning trials and a SL task that taps speech segmentation. Their learning ability was compared to 18 older controls and 39 young adults recruited for task validation. CSL in the aphasia group was below the older controls and young adults and took place at a slower rate. Importantly, we found a strong association between SL and CSL performance in all three groups. CSL was modulated by aphasia severity in the aphasia group, and by verbal STM capacity in the older controls. Our findings indicate that some PWA can preserve the ability to learn new word-referent associations cross-situationally. We suggest that both PWA and neurologically intact individuals may rely on SL

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mechanisms to achieve CSL and that verbal STM also influences CSL. These findings contribute to the ongoing debate on the cognitive mechanisms underlying this learning ability.

1. Introduction

Determining the relationships between unknown words and their meanings is an essential aspect of vocabulary acquisition. In natural language learning contexts, learning new word-referent mappings can be challenging due to the multiple possible referents available for a given word in a single learning scenario and the limited cues as to which word-referent associations are conclusive. Nevertheless, while conceptual referents may remain indeterminate in a single learning encounter, this referential ambiguity can be resolved cross-situationally, across various learning instances (Trueswell, Medina, Hafri, & Gleitman, 2013; Yu & Smith, 2007). Previous research has demonstrated that cross-situational learning (CSL) might be a fast avenue into effective word learning for infants (Smith & Yu, 2008), children (Suanda, Mugwanya, & Namy, 2014) and adults (Roembke & McMurray, 2016; Yu & Smith, 2007), suggesting that this learning ability might be available throughout the lifespan. However, little is known about the extent to which this learning capacity can be affected in aphasia following focal brain damage, and the cognitive mechanisms that support this ability.

Theories of language learning and its underlying dynamics are highly relevant to aphasia research as they can inform approaches to aphasia diagnostics and intervention. Moreover, an increased understanding of the methods and cognitive abilities that support learning in neurologically healthy individuals may benefit anomia therapy (Basso et al., 2001). There is strong evidence that associative learning methods can aid some PWA to learn single unambiguous word-referent pairings (Kelly & Armstrong, 2009; Tuomiranta, Càmara, et al., 2014; Tuomiranta, Rautakoski, Rinne, Martin, & Laine, 2012). Furthermore, this new word learning ability predicts anomia treatment outcomes (Dignam et al., 2016; Tuomiranta, Càmara, et al., 2014), which supports the idea that anomia therapy may involve new word learning processes (Kelly & Armstrong, 2009).

Only recently, the study of residual new word learning ability in aphasia has been extended into more challenging learning settings involving referential ambiguity. Peñaloza et al. (2016) examined whether fourteen PWA could learn six novel words presented together with a limited set of different possible visual referents. In each trial, a word co-occurred with the target referent and a foil referent of the learning set. The task for participants was to identify the correct word-object associations on the basis of trial-to-trial online feedback. This study found that some PWA demonstrated a preserved ability to learn new word-referent associations from individually ambiguous scenes across several instances, and retain the acquired mappings for up to one week without further training. Although the learning setting employed in that study differed from traditional paradigms measuring CSL without performance-based feedback, these preliminary findings suggest that this learning ability could remain spared in some PWA.

The main aim of the present study was to examine the ability of PWA to learn a small set of word-referent associations through CSL as compared to neurologically healthy individuals. Based on the abovementioned findings, we predicted that CSL would remain functional in at least some PWA. In order to examine CSL in aphasia we employed a modified version of the experimental task reported by Yu and Smith (2007). Briefly, the task includes a series of learning trials, each one presenting 2 spoken words together with 2 pictures of the learning set (i.e., lowest level of within-trial ambiguity with 4 possible word-referent associations per trial) followed by a test. This experimental setting sought to determine whether PWA can simultaneously learn word-referent mappings from trials that are individually ambiguous without relying on performance-based feedback. To this aim, the learning performance of the PWA on the first learning block and test was compared to that of a group of neurologically intact older controls and a young adult group recruited for task validation purposes. In addition, although it has been demonstrated that CSL in this 2×2 condition can be achieved rapidly in healthy adults (Yu & Smith, 2007), previous research has shown that aphasia can impact the speed of learning under referential ambiguity in PWA (Peñaloza et al., 2016). Therefore, our experimental task included three additional learning blocks and tests to fully examine how learning unfolded over time.

A second purpose of the present study was to examine further the hypothesis that CSL is related to statistical learning (SL) mechanisms in healthy individuals and in PWA. This hypothesis is based on current statistical-associative learning accounts of CSL which propose that CSL can be achieved via SL mechanisms through the statistical computation of the co-occurrence of words and referents across several learning instances (Smith & Yu, 2008; Yu & Smith, 2007). According to this view, learners could resolve the referential uncertainty problem gradually across learning trials by storing several possible word-referent pairings, accruing and evaluating the statistical evidence of the learning context across multiple undetermined word-referent combinations, and finally mapping individual words to their true meanings (Smith & Yu, 2008; Yu & Smith, 2007). However, other theories of CSL advocate hypothesis-testing accounts such as the "propose but verify" learning strategy (Trueswell et al., 2013). According to this view, learners formulate a single hypothesis as to which is the true referent for a given word