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Research Article

The influence of inhibitory skill on phonological representations in production and perception☆

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ABSTRACT

Inhibition is known to play a role in speech perception and has been hypothesized to likewise influence speech production. In this paper we test whether individual differences in inhibitory skill can lead to individual differences in phonological representations in perception and production. We further examine whether the type of inhibition that influences phonological representation is domain-specific or domain-general. Native French speakers read aloud sentences with words containing a voiced stop that either have a voicing neighbor (target) or not (control). The duration of pre-voicing was measured. Participants similarly performed a lexical decision task on versions of these target and matched control words whose pre-voicing duration was manipulated. Lastly, participants performed linguistic and non-linguistic inhibition tasks. Results indicate that the lower speakers' linguistic or non-linguistic inhibition is, the easier it is for them to recognize words with a voiceless neighbor when these words have a shorter, intermediate, pre-voicing rather than a longer one. Inhibitory skill did not predict recognition time for control words, indicating that the effect was due to the greater activation of the voiceless neighbor. Inhibition did not predict pre-voicing duration in production. These results indicate that individual differences in cognitive skills can influence phonological representations in speech perception.

1. Introduction

Spoken language is characterized by inter- and intra-individual variability. For example, one English speaker's /ɔ/ is another English speaker's /ɑ/ (Peterson & Barney, 1952). Furthermore, the same speaker might produce the same feature differently in different words or occasions depending on linguistic and articulatory constraints, among others. Thus, the voice onset time of English voiceless stops is shorter when the stop is in medial position before an unstressed vowel (Lisker, 1977). Even in the same word, VOT can vary along contextual factors, such as in convergence with the VOT values produced by a recent speaker (Shockley, Sabadini, & Fowler, 2004).

Language comprehension similarly shows both inter- and intra-individual differences. For example, people differ in their ease of lexical retrieval, and their ease of retrieval of a word will depend on contextual factors, among others, leading to greater ease in some contexts than in others. For instance, people rely on the semantic context during language processing, and the more semantically constraining a context is, the easier it is to process the predicted word, yet the ability to rely on this context depends on cognitive resources (Federmeier & Kutas, 2005). People also differ in their sensitivity to gradation and contrasts of different linguistic cues (Kong & Edwards, 2011; Law, Fung, & Kung, 2013) as well as in their ability or tendency to integrate or disregard certain types of cues (Repp, 1981; Stewart & Ota, 2008; Yu, 2010). Few studies have examined the source of such individual differences. One recent emerging pattern, however, suggests that differences in "autistic" traits might influence integration of cues. For example, people with higher yet still typical values of autistic traits are less influenced by lexical factors during phoneme classification (Stewart & Ota, 2008).

Here we examine whether individual differences in a cognitive skill – inhibition – can also lead to inter- and intra-individual variability in the production and perception of phonetic features. We focus on voicing in French stops, and test whether there is a

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relationship between French speakers' inhibitory skill and their production and perception of voiced stops in words that have a voicing neighbor. Specifically, we examine whether lower inhibitory skill leads to the production of intermediate voicing values in such words, but not in control words, because of the simultaneous activation of the competing voicing feature in the voicing neighbor. Similarly, we examine whether lower inhibitory skills facilitates the perception of such words when they are produced with intermediate voicing values because of their greater match with the activated voicing values.

1.1. Inhibition in speech perception

Speech perception is often described as the mapping of an acoustic signal to a lexical item via forward spreading activation from the activated phonemes to lexical items in which they occur, with gradual narrowing of activation as more information is received. Importantly, most speech perception models (e.g., Luce & Pisoni, 1998; McClelland & Elman, 1986; Norris, 1994 but see Gaskell & Marslen-Wilson, 1997; Norris & McQueen, 2008) posit that phonetic neighbors compete during this process and hypothesize inhibitory mechanisms to deal with this competition. Indeed, empirical evidence supports the notion of such competition by showing that speech perception depends on neighborhood density, such that words from denser neighborhoods are recognized more slowly and less accurately (Luce & Pisoni, 1998). Similarly, direct comparison of response times to words that have a neighbor differing in voicing to those that do not, show that those without a neighbor are recognized faster (Andruski, Blumstein, & Burton, 1994).

1.2. Inhibition in speech production

Models of speech production similarly propose that phonetic neighbors are activated during speech planning, and some of these models hypothesize that inhibition is exercised to overcome the competition from these neighbors (Meyer & Gordon, 1985; Stemberger, 1985). In accordance with this hypothesis, Wheeldon (2003) showed that picture naming is delayed if participants just produced a phonetically related word rather than a phonetically unrelated word in response to a definition.

At the same time, other models of speech production (Dell, 1986; Roelofs, 1997) do not assume any inhibitory connections between competing items. Indeed, many studies not only fail to find effects of inhibition between phonetically related words, but, in contrast, find that such competition facilitates production. For example, Meyer & Schriefers (1991) showed that picture naming is facilitated if the speaker has just heard a phonetically related compared with an unrelated word.

Studies examining the role of neighborhood density have similarly exhibited conflicting results. Some studies found neighborhood density to inhibit production (e.g., Sadat, Martin, Costa, & Alario, 2014; Vitevich & Stamer, 2006), while others found that words from denser neighborhoods are produced more quickly than words from sparser neighborhoods (e.g., Vitevitch, 2002). Some factors, such as frequency, and the position of the competing segment (onset vs. rhyme) have been proposed to account for some of these conflicting results (e.g., Colombo, 1986; Wheeldon, 2003). Others have argued that differences are due to a lack of control of other factors in the stimuli, or to the simultaneous facilitatory priming links and inhibitory selection links between lexical and phonological units (Chen & Mirman, 2012; Sadat et al., 2014). For now, the issue of whether and when neighbors inhibit production has yet to be fully resolved.

1.3. Individual differences in inhibitory skill and phonological representation

Considering the role that inhibition might play in speech production and perception, one might wonder how individual differences in inhibitory skill might influence production and perception abilities, and more importantly, whether individual differences in inhibitory skill can even lead to individual differences in linguistic representations.

Some preliminary evidence attests to the influence of inhibitory skill on perception ability. In particular, when embedded in noise, words of denser neighborhoods are recognized less accurately, and, crucially, this effect of neighborhood density is larger for those who have lower inhibitory score, as measured by a lexical Stroop task (Taler, Aaron, Steinmetz, & Pisoni, 2010). Similar evidence has been found at other linguistic levels with bilinguals. In general, bilinguals must inhibit the language not in use during language processing and production (Green, 1998), but this inhibition is rarely fully successful (Spivey & Marian, 1999). Importantly, it has been shown that success at inhibition depends, among other things, on individuals' level of inhibitory skill (Gollan, Sandoval, & Salmon, 2011; Linck, Schwieter, & Sunderman, 2012).

Further evidence shows that individual differences in inhibitory skill during language processing can lead to individual differences in representation. Looking at bilinguals, Lev-Ari and Peperkamp (2013) showed that individual differences in inhibition of competing languages lead late bilinguals with lower inhibitory skill to produce voiceless stops in their native and dominant language with Voice Onset Times (VOT) that are closer to the canonical values of their second language. Additionally, lower inhibitory skill leads bilinguals to discriminate between native languagephonetic neighbors differing in their VOT in a manner more similar to the way monolingual speakers of their second language discriminate them.

The goal of the current study is to examine whether individual differences in inhibitory skill can similarly influence phonological representations among monolinguals. Specifically, this study tests whether, in cases where words have a neighbor differing in voicing, the co-activation of this neighbor leads individuals to form representations with intermediate VOTs and, consequently, be faster at recognizing the words when they have intermediate rather than canonical voicing values. The logic is that if individuals with lower inhibitory skill habitually experience greater activation of the competing neighbor, and therefore the competing voicing feature, then their representation of the word would have an intermediate voicing value, as in the case of the intermediate VOTs of English–French bilinguals with relatively low inhibitory skill. We assume here, in line with the common phonological tradition, that negative and