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Influence of Early Linguistic Experience on Regional Dialect Categorization by an Adult Cochlear Implant User: A Case Study

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Abstract

Objectives—To investigate the ability of a cochlear implant user to categorize talkers by region of origin and examine the influence of prior linguistic experience on the perception of regional dialect variation.

Design—A post-lingually deafened adult cochlear implant user from the Southern region of the United States completed a six-alternative forced-choice dialect categorization task.

Results—The cochlear implant user was most accurate at categorizing unfamiliar talkers from his region and another familiar dialect region, and least accurate at categorizing talkers from less familiar regions.

Conclusions—Although the dialect-specific information made available by a cochlear implant may be degraded compared to normal-hearing listeners, this experienced cochlear implant user was able to reliably categorize unfamiliar talkers by region of origin. The participant made use of dialect-specific acoustic-phonetic information in the speech signal and previously stored knowledge of regional dialect differences from early exposure prior to implantation despite an early hearing loss.

Introduction

In everyday situations, listeners interact with a variety of people from different geographic regions and diverse language backgrounds. Detailed indexical information about the talker, such as his/her age, gender, and regional dialect is encoded in the speech signal (Abercrombie 1967). For successful robust speech communication, listeners must be able to make use of this information, which plays an important role in speech perception processes (Pisoni 1997). Previous studies have shown that listeners are able to use indexical

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information in speech to make reliable judgements about the vocal source and the talker's language background (Kreiman & Van Lancker Sidtis 2011).

Regional dialect variation is an important source of information in speech. Listeners can use dialect-specific information in the signal and stored knowledge of regional dialect variation to identify an unfamiliar talker's region of origin (e.g., Clopper & Pisoni 2004c). However, the linguistic experience and residential history of the listener has also been found to affect the perception of regional dialects. Previous studies have shown that listeners are better at categorizing talkers from their own region (Williams et al. 1999; Baker et al. 2009) and from other familiar regions with which they have had much experience (e.g., Clopper & Pisoni 2004a; Baker et al. 2009) in forced-choice dialect categorization tasks. Additionally, familiar dialects are perceived as being more distinct, and direct exposure to many dialects can result in greater perceptual distinctiveness among dialects overall (e.g., Clopper & Pisoni 2004a). Taken together, these findings with young normal-hearing listeners suggest that exposure to dialect variation allows a listener to form more robust and highly detailed phonological and lexical representations of regional dialects in long-term memory, which listeners are then able to use to more accurately categorize unfamiliar talkers by region of origin.

Perceiving and using regional dialect and other sources of indexical information in speech may be very challenging to a hearing-impaired listener with a cochlear implant (CI). Discriminating regional dialects of American English requires sensitivity to fine-grained acoustic-phonetic details, including phonemic and subphonemic spectral and durational differences in vowels and consonants (Clopper & Pisoni 2004c). Clopper and Pisoni (2004b) examined the performance of a post-lingually deafened adult from central Indiana (North Midland dialect area), who had experienced a sudden profound bilateral hearing loss and had received a CI in adulthood. They assessed his ability to identify the region of origin of unfamiliar talkers using a forced-choice regional dialect categorization task. Clopper and Pisoni found that while this CI user, “Mr. S.,” performed more poorly overall than a group of young normal-hearing adults, his categorization performance was within one standard deviation of normal-hearing listeners’ scores and significantly above chance. Their results suggest that detailed regional dialect information is encoded and may be available to some CI users, although the amount of information may be degraded and underspecified compared to the robust indexical information that normal-hearing listeners are able to perceive and encode.

Little is currently known about the type of indexical information available to CI users and how this information is encoded and stored in long-term memory. The current study examined the perceptual categorization of regional dialects by another experienced post-lingually deafened CI user in order to explore how previous exposure and a different developmental history influences the perception of regional dialects. Unlike “Mr. S.,” the participant in the current study had experienced a progressive hearing loss leading to a profound hearing loss at an early age and had grown up exclusively in the Southern dialect region of the United States (U.S.). Dialect-specific information, especially cues conveyed by fine spectral detail, may be poorly encoded and regional dialect categories may be less robustly represented in long-term memory due to early hearing loss. However, we expected

that if this CI listener could benefit from previous experience and early exposure, he should be able to reliably use dialect-specific differences to categorize talkers by region of origin and should be more accurate at categorizing talkers from his own Southern dialect region than other unfamiliar dialect regions. He should also be more sensitive to subtle differences between the Southern dialect and other similar dialects (e.g., South Midland) that are difficult for listeners from other regions, and he should be less able to distinguish between dialects with which he had little early exposure.

Materials and Methods

Listener: "Mr. R."

One adult experienced CI user participated in this case study. The participant was a post-lingually deafened 33-year-old male. He reported a moderate-to-severe sensorineural hearing loss that was identified at 3 years of age. Hearing loss progressed to a severe-to-profound by age 8. The participant wore bilateral hearing aids from age 3 to 21, with intermittent use between ages 16 and 21. He was implanted with an Advanced Bionics CI in the right ear at age 21. Hearing aid use in the opposite ear was discontinued. The participant received a revision surgery in the right ear to correct for device failure around the age of 22, and received a CI in the left ear at the age of 31. At the time of testing, he was only using a unilateral CI in the left ear (after another right ear device failure). He obtained 89% accuracy on HINT sentences (Nilsson et al. 1994) and 74% accuracy on PRESTO (Gilbert et al. 2013) presented in quiet, and was considered to be an exceptionally good CI user in quiet listening conditions. The CI device was an Advanced Bionics HiRes with a Harmony speech processor, using Fidelity processing.

The participant was a monolingual native speaker of American English, and had lived exclusively in the U.S. Southern dialect region until age 27, and again between ages 29 and 32. Before testing, he had lived approximately two years in the Western dialect region and approximately one year in the North Midland region. Both of his parents were also native speakers of English from the Southern dialect region. Given that his exposure to different dialects was late, it was determined that the participant was representative of a Southern dialect listener (e.g., Clopper and Pisoni 2004a). Before testing, he signed an IRB-approved consent form. He received $40 for two hours of testing, which involved completing other speech perception and neurocognitive tasks.

Stimuli

Forty-eight talkers (24F/24M) were selected from the TIMIT acoustic-phonetic speech corpus (Garofolo et al. 1993). Eight talkers (4F/4M) represented each of six U.S. dialect regions: New England, North Midland, South Midland, North, South, and West. Some acoustic-phonetic characteristics of these dialects are provided in Table 1.

Two sentences were selected for each of the forty-eight talkers. All talkers read the sentence "She had your dark suit in greasy wash water all year," which was one of the baseline calibration sentences collected from all talkers in the TIMIT database and was designed to obtain characteristic dialectal features. The second sentence was unique to each talker and

contained phonological/phonetic variation representative of each dialect region. All sentences were semantically meaningful with unique linguistic content. Content words in each sentence contained characteristic features of the talker's dialect region (see Table 1). Stimulus materials were comparable to those used in the previous studies.

Procedure

The listener was seated in a sound-attenuated booth in front of a computer monitor and a high-quality external speaker. The experiment consisted of a six-alternative forced-choice regional dialect classification task. This design was based on the methodology originally developed and used by Clopper and Pisoni (2004c). In the first half of the experiment, the participant heard each talker in random order reading the same sentence; in the second half, the participant heard each talker in random order reading a unique sentence. Each talker was presented once per block, for a total of 96 trials.

On each trial, the participant was presented with a sentence produced by a single talker at a comfortable listening level and was asked to select the (U.S.) geographic region of origin of the talker from six response alternatives (New England, North Midland, South Midland, North, South, and West) represented on a map displayed on the computer monitor. The participant responded by clicking on a labeled box within the geographic regions.

Results and Discussion

“Mr. R.”'s responses were analyzed for accuracy. Table 2 shows a summary of the average accuracy for each regional dialect and the overall score for “Mr. R.,” 10 normal-hearing listeners selected from Tamati et al. (2013), and “Mr. S.” from Clopper and Pisoni (2004b); Table 3 displays the perceptual confusions calculated from each listener group's responses by talker dialect. Across all conditions, “Mr. R.” responded correctly on 27.1% of trials, which is comparable to the performance obtained by “Mr. S.” and the normal-hearing young adults (Tamati et al. 2013) with the same stimulus materials.

Examining categorization accuracy by geographic region, “Mr. R.” was more accurate at categorizing talkers from more familiar dialect regions than less familiar dialect regions. He was highly accurate at categorizing talkers from the Southern dialect region at 56.3% correct. Although normal-hearing young adults from the North Midland region are also quite good at the marked Southern dialect, they also performed well on their own dialect region, as demonstrated in Table 2 and in previous studies (e.g., Clopper & Pisoni 2004c). Compared to North Midland listeners (normal-hearing comparisons and “Mr. S.”), “Mr. R.” was much poorer at categorizing North Midland talkers at 18.8% correct, as well as talkers from other unfamiliar dialect regions. Overall, “Mr. R.” was clearly more accurate on the Southern and South Midland regions, and less accurate on the less familiar North, North Midland, and West regions.

The types of errors made by “Mr. R.” are also consistent with his experience with his own region. “Mr. R.” was quite good at distinguishing the acoustically similar South Midland from his own Southern dialect. Table 3 shows that North Midland listeners often categorized Southern talkers as South Midland, and vice-versa. “Mr. R.” was less likely to show this

pattern, suggesting that those dialects were less perceptually confusable to him. Taken together, the accuracy and perceptual confusions demonstrate that “Mr. R.” performed most accurately on his own (Southern) dialect region, was better at distinguishing other acoustically and perceptually similar (South Midland) dialect regions, and was worse at categorizing and discriminating other unfamiliar regional dialects.

The results from this case study show that although the indexical information in speech available to CI users may be degraded and poorly specified compared to normal-hearing listeners, “Mr. R.” was able to perceive and encode dialect-specific information from personal experience with regional dialect variation in his own early language-learning environment. Through his early experience, he was able to form robust representations and memory codes of familiar dialects in long-term memory, which he was able to use to reliably categorize unfamiliar talkers by region of origin on a forced-choice dialect categorization task.

Additional research is needed to further investigate the contribution of linguistic experience and residential history in speech perception and spoken word recognition by hearing-impaired listeners. In particular, cross-dialect spoken word recognition and comprehension should also be explored, because familiar regional dialects are often more intelligible (e.g., Clopper & Bradlow 2008), and individual listeners who are better at encoding and processing indexical information in speech are also better on measures of spoken word and sentence recognition (e.g., Cleary & Pisoni 2002; Tamati et al. 2013). Research on regional dialect categorization may help identify sources of strengths and weaknesses in individual CI users and motivate the development of novel training and intervention programs to improve speech perception and speech recognition abilities under high variability listening conditions.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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