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The relationship between vowel, consonant and word perception in cochlear-implant patients

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Nonsense-syllable tests have low face validity. Thus, they are often de-emphasized and not included in test batteries for cochlear-implant patients. In this report we describe the advantages of studying nonsense-syllable perception and consider how test results can be used for comparing implant devices, for feature analysis, and for quantifying audiovisual perception. Furthermore we examine the relationship between nonsense-syllable perception and word recognition.

Nonsense-syllable tests have many advantages. They are less susceptible to cognition and language effects than are sentence materials. Learning effects associated with repeated presentation are minimized. A major advantage is that feature analysis of confusions can be performed to determine the types of cues being used.

Nonsense syllables do have some disadvantages as well. They do not capture some of the real-time speech effects. Particularly, testing with isolated nonsense syllables or words does not require the listener to segment the continuous stream of information into words or phrases, and suprasegmental cues are not available in nonsense-syllable tests. Furthermore, tests with nonsense syllables do not require rapid, sequential processing of information that must occur in normal conversation.

Method

We studied vowel and consonant perception with patients using the 3M/House, 3M/Vienna, Symbion, and Nucleus (only one patient reported here has the newer F1-F2 processor) implants. Each patient had at least nine months experience with their implant.

Nine vowels "heard, had, hid, hawed, who'd, head, hud, heed, and hood" were presented via a computer. The consonants were "/ibi, isi, ifi, igi, iki, imi, ini, ipi, ishi, iti, ivi/, and /izi/". The options were written on a computer screen and the patients were required to touch the syllable they heard using a touch-sensitive screen. The consonants were also presented in an audiovisual mode (see Tyler et al., 1986[1] for details). The stimuli were spoken by a male speaker presented at a level of about 73 dB SPL.

Results

Figure 1 (left) shows the results from the vowel-recognition test. Performance ranged from 17 to 90% correct. Patients with multichannel implants scored higher than the patients with the single-channel implants. Consonant performance is shown on the right. Again a wide range of performance is observed (from 7 to 60% correct). There is more overlap among devices on the consonant-recognition task than on the vowel-recognition task.

We performed an information-transfer analysis, sequential information-transfer analysis and multidimensional scaling on the consonant and vowel responses.[2,3] The multichannel patients appeared to use duration, nasality and sometimes envelope cues for identifying the consonants. Place information was also used, but less well. For the vowels, the results suggested that the Nucleus patients perceived duration and F2 information while the Symbion patients perceived fundamental frequency, F1 and duration cues. The single-channel patients appeared to use F1 cues for vowel recognition, with the 3M/House patients also using F0 and the Vienna patients using duration cues. Nasality and duration cues were important for consonant recognition, with the 3M/House patients also utilizing voicing cues.

Figure 2 (right) shows a high correlation (r=0.80) between vowel and consonant perception, indicating that similar cues (envelope, duration, F0) may be utilized. This is consistent with our feature analysis of vowel and consonant perception. In contrast to the findings of Dowell, Mecklenberg, and Clark (1986)[4] we found a larger range of performance on the vowel than on the consonant test. Dowell et al. (1986)[4] noted a lack of correspondence between performance on the two tests.

To evaluate how well an implant enhances a patient's speechreading ability, tests are administered in both a vision-alone and audion-plus-vision condition. Figure 2 (left) shows the relationship between consonant recognition in the vision condition and in the audition-plus-vision condition. All patients show an improvement in their speechreading ability with the implant. It is difficult to compare the amount of improvement across patients when the patients have different vision scores. However, it is possible to compare patients in Figure 2 (right) with the same vision scores. In general, the single-channel cochlear implant patients show less improvement in speechreading (regardless of their baseline speechreading scores) than do multichannel patients. These speechreading augmentation results are therefore consistent with the audition-alone results shown in Figure 1.

Word and sentence level tests have high face validity. They depend both on vowel and consonant perception, and patient abilities to integrate this information utilizing context, grammatical and cognitive skills. Figure 3 shows moderately high correlations between vowel recognition and the number of phonemes correct in a word (left; r=0.70), and the number of words correct in sentences (right; r=0.76). The former, however, is strongly influenced by two outliers. Figure 4 shows the relationship between consonant recognition and word perception (left; r=0.55) and sentence perception (right; r=0.71). Again the former relationship is weaker and is influenced by an outlier. These moderately-high correlations are consistent with the notion that word recognition does depend, in part, upon processing individual vowels and consonants. However, sentence perception also is influenced by language/cognitive skills and processing rapid information.

Conclusion

Nonsense-syllable tests have many advantages. They are less susceptible to cognition/language effects than are sentence tests. It is possible to perform detailed analysis to determine the features used based on an analysis of error patterns. Finally, nonsense-syllable tests are less susceptible to learning effects.

There are two main disadvantages to nonsense-syllable tests. They have poor face validity and they do not capture some important real-time effects of speech, namely segmentation and the continuous rapid processing required in real-speech perception.

References

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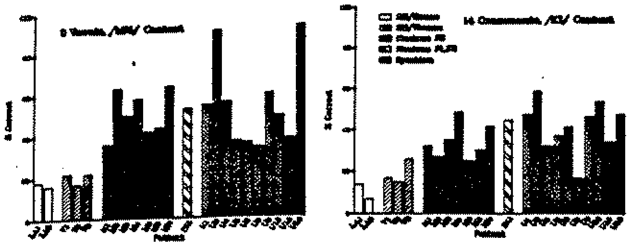

Figure 1. Vowel (left) and consonant (right) recognition.

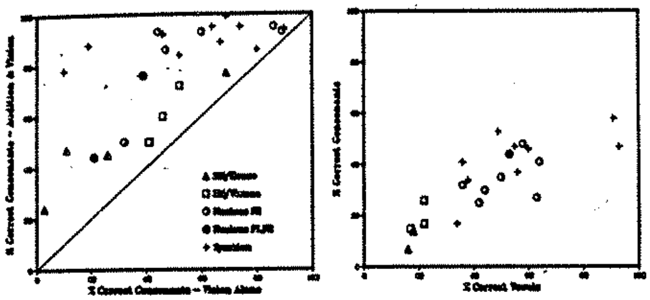

Figure 2. Left) The relationship between vision-alone and audition-plus-vision consonant recognition. Right) The relationship between vowel and consonant recognition.

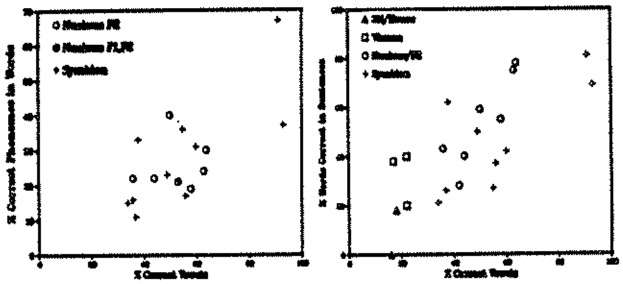

Figure 3. The relationship between vowel recognition and the perception of phonemes in word (left) and words in contextual sentences (right).

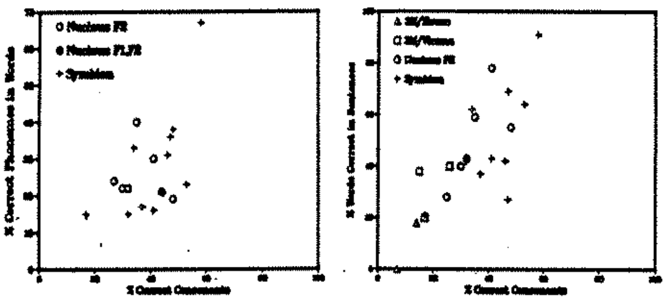

Figure 4. The relationship between consonant recognition and the perception of phonemes in word (left) and words in contextual sentences (right).