Do phonological neighbourhood density and phonotactic probability influence speech output accuracy in acquired speech impairment?

Nicole Lallini and Nick Miller

Introduction

We investigated the effects of phonological neighbourhood density (ND) and phonotactic probability (PROB) on speech output accuracy in English speakers with acquired speech impairment. Both ND and PROB are reported to exercise a significant, inhibitory effect on speech perception and a facilitatory effect on production in healthy speakers (e.g. Vitevitch & Luce, 1998, 1999; Luce & Pisoni, 1998).

However, many issues remain in understanding the role in and effects of ND/PROB on speech/language processes, especially in disordered speakers. Further insights are needed, not just into ND and PROB for their own sake, but also for the insights these can deliver into understanding speech output and its disorders.

The study addressed the following questions:
1.Do ND and /or PROB have a significant effect on production accuracy in native English speakers with output impairment after stroke?
2.If there is a significant effect is it facilitatory or inhibitory?
3.Can ND/PROB help in differentially diagnosing phonemic paraphasia (PhPa) and apraxia of speech (AOS)?

Terminology

Acquired Output Impairment	PROB	ND
▪ Acquired after stroke ▪ Perceived production errors ▪ Not due to neuromuscular impairment ▪ Includes AOS and PhPa	▪ Frequency of occurrence of phonemes/sequences of phonemes ▪ High PROB: sp- →'spin' ▪ Low PROB: -sp →'wasp' ▪ High in English: sp- ▪ Low in English sf-	▪ Total number of neighbours of a target ▪ Neighbours differ from target by 1 phoneme through substitution, deletion, or addition ▪ Sparse vs. dense neighbourhoods (e.g. elf vs. cat)

Method

Participants: 20 English speakers

Inclusion Criteria	Exclusion Criteria
✓ At least 4-month post CVA ✓ Output impairment displayed by perceived production errors ✓ Viable attention, memory, visual and auditory-perceptive skills ✓ Native English speaker ✓ Hearing within normal range	✓ Output impairment too severe ✓ Output impairment too mild ✓ Non-CVA aetiology ✓ Concurrent language impairment significantly affecting understanding or performance of investigatory task

Stimuli and Task

Stimuli	Repetition Task
▪ 847 real English and 59 nonsense words ▪ Words were of 1- to 5-syllable length ▪ Words varied in complexity from simple V- to complex CCVC/VCC-syllable structure	▪ Participants repeated what they heard via headphones ▪ No time restriction on response production ▪ Responses scored as either 'correct' or 'incorrect' ▪ Scoring based on perceptual analysis

Data Analysis

• Logistic regression analyses for each participant separately
• Dependent variable: repetition accuracy for all stimuli
•Predictor variables: number of syllables, number of clusters, number of phonemes, word frequency, lexicality, ND, PROB, syllable frequency

Results

• 12 speakers showed a positive effect of PROB on repetition accuracy for all stimuli
• 1 speaker showed a negative effect of PROB on repetition accuracy
• 2 speakers showed a positive effect of ND on repetition accuracy for all stimuli
• 1 speaker showed a negative effect of ND on repetition accuracy
• No double dissociations between the ND and PROB effect

Discussion

• Items with higher PROB are produced with more accuracy than items with less probable sequences.
• Demonstrating a facilitatory effect of PROB on response accuracy is in the expected direction when comparing the results with those of studies involving healthy speakers
• ND had only a minimal effect on accuracy: items with higher ND were produced with more accuracy than those with lower ND
• Others have found strong effect of ND in people with aphasia (e.g. Gordon , 2002)
  ➢BUT did not consider full range of possible confounding variables
• Usefulness of the ND and PROB effect regarding differential diagnosis of AOS and PhPa is restricted
  ➢no double dissociations regarding the effect of ND and PROB were found

Recommendations

• Future studies involving tasks such as lexical decision, confrontation naming
  ➢repetition task does not tap into earlier occurring stages of speech production (e.g. semantic and lexicon level)
  ➢ND and/or PROB effect might operate at these earlier occurring stages of production
• Future studies involving contrasting elicitation tasks
  ➢to further determine the roles of PROB/ND in assessment/treatment of AOS and PhPa
  ➢ND/PROB have effect at different stages in speech output
  ➢Stages are differentially affected in AOS/PhPa
  ➢contrasting elicitation tasks should show different performance profiles in AOS/PhPa groups

References

Gordon, J.K. (2002). Phonological neighborhood effects in aphasic speech errors: spontaneous and structured contexts. *Brain and Language*, *82*, 113-145
Luce, A.L., & Pisoni, D.B. (1998). Recognizing Spoken Words: The Neighbourhood Activation Model. *Ear and Hearing*, *19*, 1-36.
Vitevitch, M.S., & Luce, P.A. (1998). When Words Compete: Levels of Processing in Perception of Spoken Words. *Psychological Science*, *9*, 325-329.
Vitevitch, M.S., & Luce, P.A. (1999). Probabilistic Phonotactics and Neighborhood Activation in Spoken Word Recognition. *Journal of Memory and Language*, *40*, 374-408.

Email address for correspondence:
Nicole.Lallini@ncl.ac.uk