Introduction

Language production in patients with aphasia and patients with apraxia of speech is affected by several phonological factors, such as word length or syllable structure. Recently, neurolinguistic studies have reported that syllable frequency is also an influencing factor for speech apraxic patients (Aichert & Ziegler, 2004) as well as for aphasic patients with phonological disorders (Laganaro, 2005). In these studies both patient groups demonstrated an advantage of high-frequent as opposed to low-frequent syllables. This syllable frequency effect is controversly discussed with regard to the underlying pathomechanism of aphasic and apraxic patients and to the theoretical question of whether the parameter 'syllable frequency' can be localised at a phonological and / or a phonetic stage of speech production (e.g., Cholin, Levelt & Schiller, in press).

This study was designed to further evaluate the syllable frequency effect in patients with apraxia of speech and, for comparison, also in aphasic patients with a phonological disorder. Furthermore, we also considered the role of frequencies of other sublexical units, i.e., frequencies for single phonemes, biphonemes, syllable onsets and syllable rhymes. For example, a study by Saito, Yoshimura, Itakura & Lambon Ralph (2003) revealed that phoneme and biphoneme frequencies affect the production abilities of a patient with conduction aphasia. Extending earlier studies, we included in our analysis the frequencies of syllables and of subsyllabic units. Particularly, we focused on the aspect of how the frequencies of the target units (syllables, biphonemes etc.) relate to those of the units realised by the patients.

Method

The study was based on a word repetition task. The item list contained 40 two-syllabic, concrete and monomorphemic nouns, which all were of low word frequency. The first syllable of each noun was controlled for syllable frequency, i.e., half of the items were low- or high-frequent, respectively (N = 20 items in each syllable frequency group). These target syllables were additionally varied for syllable structure (CV or CVC).

Three groups of German native speakers with left-hemisphere damage participated in the study: (1) five patients with severe apraxia of speech and concomitant moderate to severe aphasia, (2) five patients with mild apraxia of speech and no or residual aphasia, (3) four aphasic patients with phonological disturbances and no apraxia of speech.

The responses were recorded on audiotape by a Sony TCD-D100 DAT recorder and subsequently analysed using narrow phonetic transcription. In the following, data of the two subgroups of patients with apraxia of speech were collapsed since a homogenous error pattern was observed independent of the severity of apraxic impairment.

We restricted our statistics to the substitution errors produced in the frequency- controlled syllables, since we expected an interaction between syllable structure and syllable frequency. We compared frequencies of *phonemes, biphonemes, onsets, rhymes* and *syllables* of the realised words with those of the target words. All sublexical frequency data were determined on the basis of word frequencies in the German corpus of the CELEX database (Baayen, Piepenbrock & Gulikers, 1995).

Results

In a first analysis of syllable frequency, patients with apraxia of speech substituted low-frequency target syllables more often with high-frequency syllables (Wilcoxon, $Z = -5.0$, $p < .001$). The same result was obtained in patients with aphasia (Wilcoxon, $Z = -2.9$; $p < .01$). Regarding high-frequency syllables, the opposite pattern could be observed: in both patient

groups syllables with lower frequency values were realised compared to the target syllables (Wilcoxon, Z = -2.6; p < .01 in patients with apraxia of speech; Wilcoxon, Z = -3,5; p < .001 in the aphasic population). This pattern was interpreted as a central tendency effect. Therefore, in a next step, extreme target syllable frequency values were excluded, and a total of 20 items for each patient was left for the analysis. On this subset, patients with apraxia of speech showed a strong tendency to produce higher-frequent syllables although this failed to reach significance (Wilcoxon, Z = -1.9; p = .056; see also Fig. 1). The four aphasic patients had no such effect.

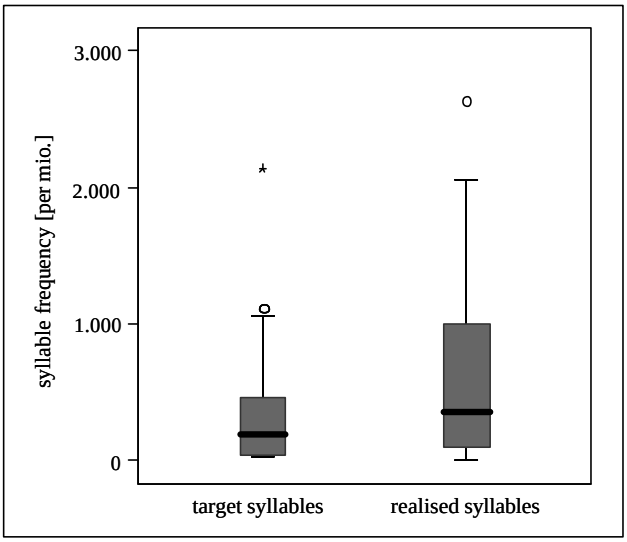

Fig. 1. Syllable frequencies (per million) for the target syllables compared to the realised syllables in 10 patients with apraxia of speech; analysis confined to items within a middle frequency range.

Regarding subsyllabic frequencies, the analysis was based on the whole item set (N = 40 low- and high frequency syllables). For phoneme frequencies, no significant differences between the frequencies of the targets and the realised phonemes was observed. Focusing on consonants, the patients with apraxia of speech tended to realise syllables with higher consonant frequencies (Wilcoxon, Z = -1.6; p = .113), whereas patients with aphasia showed a reverse pattern (Wilcoxon, Z = -1.5; p = .135).
Biphoneme frequencies did not influence speech production of both patient groups.
Further analyses were performed for the subsyllabic constituents *onset* and *rhyme*. For patients with apraxia of speech an effect of onset frequency was observed: the patients produced syllables with higher syllable onsets as compared to the target onsets (Wilcoxon, Z = -2.7; p < .01). No such effects were obtained for the aphasic patients. Regarding rhyme frequency, no significant effect and no tendencies were observed for both patients groups.

Discussion

For patients with apraxia of speech it seems to be easier to produce syllables with higher syllable frequencies. This effect was not influenced by syllable structure since only substitution errors were considered. In contrast, no influence of syllable frequency could be observed for patients with aphasic phonological impairment. These results support the hypothesis that syllable frequency is a parameter which can be ascribed to the phonetic stage of speech production (e.g., Cholin et al., in press), where the pathomechanism of apraxia of

speech is localised to. Regarding the frequencies of the subsyllabic units one might particularly focus on the onset frequency effect in the speech apraxic patients, since these patients are described to exhibit vulnerable onsets. Therefore, in case of an error, it may be easier for them to retrieve the motor program of a higher-frequency onset. On the whole, this study demonstrates that the frequencies of syllabic as well as of subsyllabic units should be considered in the error analysis of phonological and / or phonetic impaired patients, since they may provide differential diagnostic information and may help to give a model-based account of their pathomechanisms.

References

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