Aphasic patients with phonetic impairment show phonetic flexibility

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Introduction and aims

Phonetic flexibility is the ability of the speaker to adapt his/her speech behavior to the internal or external constraints of the communication situation by adjusting his/her motor programs in real time. This ability has been demonstrated in neurotypical individuals in both experimental and ecological situations (Delvaux et al., 2015). In contrast, the study of these abilities in patients with neurological disorders affecting speech motor control is less frequent.

Non-fluent aphasias, such as Broca's aphasia, frequently co-occur with speech motor control deficits in the context of apraxia of speech (AOS) or dysarthria (Laganaro, 2012). The aim of the present study is to examine whether these patients remain able to modify their articulatory patterns "on demand" within a focused experimental paradigm.

Such a protocol allows us to explore the patients' abilities to adapt their articulatory patterns to compensate for their speech difficulties or to relearn new speech patterns in speech therapy. Moreover, in addition to the clinical perspectives, this research aims at better understanding the cognitive mechanisms that support the production of speech, conceived as a strategic behavior. In this study, we focused on two supra-segmental aspects of speech: pitch register and speech rate.

Methods

Three French-speaking aphasic female patients, BD (aged 72), SV (aged 76) and CC (aged 81) participated in the study. The patients were diagnosed by speech-therapists as presenting a non-fluent aphasia and AOS or dysarthria. A first language evaluation (picture description, picture naming, word and non-word repetitions) revealed that the 3 patients presented a phonetic deficit: phoneme distortions, substitutions, cluster reductions and effortful speech were observed. Patients' performances were compared to those of 7 healthy speakers matched for age (Mean age=71.23, *SD*=4.53) and sex.

The experimental corpus was designed in order to induce variations in speech rate and pitch in the participants' speech productions. It consisted of 25 sentences, i.e. 5 versions of 5 initial sentences. Each initial sentence (produced by a "model" female French speaker) underwent 4 types of modifications affecting either its total duration (75% or 125% of the initial duration), or its average pitch (75% or 125% of the initial pitch). The sentences in the corpus (e.g. "Lalie vend du Lila"/Lalie sells Lilacs) varied in length (6-11 syllables), syllabic complexity, phonological content (e.g., some sentences are fully voiced) and prosodic pattern. The paradigm consisted of four tasks, completed in a single session: (i) reading (in order to measure the baseline pitch and speech rate); (ii) and (iii) first and second repetitions of the sentences pronounced by the model speaker; (iv) repetition with explicit instruction to imitate the oral model. In each task, the participant produced the 25 sentences. The participants' productions were recorded and acoustic measures were performed with Praat (Boersma & Weenink, 2018). The measures were: the total duration of the sentence, converted into speech rate (number of syllables/second), as well as the fundamental frequency (Hz) calculated every 5 ms, from which we extracted the median value.

Results

Figure 1 displays the variations of pitch and speech rate in participants as a function of the task. We performed two series of Mann-Whitney *U*-tests on speech rates and z-score transformed pitch values

(one in the control group and one in the aphasic participants), in order to compare the differences between the pitch/speech rate values measured in the reading task (baseline levels for each participant), and the values measured in the other tasks as a function of the presented stimulus (75%, 100%, 125% of the initial value).

In the control group, speakers tend to "follow" the model in all experimental conditions, producing sentences with a higher/lower pitch or speech rate values in response to a higher/lower pitch or speech rate (significant differences: Pitch: reading and repetition 1, 75% : U=801.00, p<.001; 100%: U=4856.00, p<.001; and repetition 2: 75% : U=1097.00, p<.001; 100%: U=5182.00, p<.001; and imitation, 75% : U=1005.00, p<.001; 125%: U=1714.00, p=.003; Speech rate : reading and repetition 1, 75% : U=1550.50, p=.001; 100%: U=5811.00, p=.001; and repetition 2: 75% : U=1414.50, p<.001; 100%: U=5591.00, p<.001; and imitation: 75% : U=1182.00, p<.001).

In aphasic patients, we also note tendencies to follow the presented model, but the differences are less marked than in controls, and are often restricted to the “imitation” condition. With regards to pitch variations, we mainly note significant differences between the reading and the imitation tasks. In this task, patients show an increase of their pitch values as the pitch of the stimuli increased. These differences from baseline as a function of stimulus characteristics are exacerbated in BD (Pitch: significant differences between reading and imitation, BD: 75%: U=00.00, p<.001; 100%: U=9996.00, p<.001; SV*:* 75%: U=15.50, p=.05; 100%: U=88.00, p=.005; 125%: U=00.00, p<.001; CC: 125%: U=15.00, p=.05).

Regarding speech rates variations, SV shows less ability to modulate her speech rate according to the stimulus than the other patients. BD and CC show mainly gradual increases/decreases of speech rate as a function of stimulus in the imitation task. However, the differences are only significant between

the reading task and the 75% and 100% stimuli in CC (U=12.00, p=.005 and U=78.50, p=.002, respectively, no significant difference for BD). It should be noted that the patients made a large number of errors and self-corrections in the requested repetitions, which may have interfered with the speech rate values in some cases. These latter results should therefore be taken with caution.

Discussion

The outcomes of this study indicate that, despite their speech motor control difficulties, our patients remain able to modify their articulatory patterns as a function of stimuli and/or requisites of the task. They therefore exhibit phonetic flexibility, at least for supra-segmental aspects of speech such as pitch and speech rate. Indeed, when asked to produce sentences in response to an oral model, aphasic patients tend to imitate the pitch register (and to a lesser extent, the speech rate, notwithstanding aphasia-typical errors) of the target voice, the more so when they are explicitly prompted to imitation.

Differences between patients with regards to their different profiles will be discussed as well as language rehabilitation possibilities.

References

Boersma, P., & Weenink, D. (2018). *Praat: doing phonetics by computer [Computer program]*. Amsterdam : The Nederlands.

Laganaro, M. (2012). Patterns of impairments in AOS and mechanisms of interaction between phonological and phonetic encoding. *Journal of Speech, Language, and Hearing Research*, *55*(5), S1535–S1544. https://doi.org/10.1044/1092-4388(2012/11-0316).

Delvaux, V., Cano-Chervel, J., Huet, K., Leclef, C., Verhaegen, C. & Harmegnies, B. (2015). Capacités d'apprentissage phonétique et vieillissement, in A.-M. Etienne (ed). Evolutions sociales, Innovations et Politiques : nouvelles questions pour la psychologie de la santé, Liège, Belgium, Mardaga.