Linguistic expirience and the speed-curvature relation in articulation

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It is commonly know that a word's frequency of use and its contextual predictability correlate with its spectral and temporal acoustic characteristics. Aylett and Turk (2004) proposed that the source of this variance is the speech production system's need to maintain a uniform information flow. In high information contexts the speech signal is expanded, in low information contexts it is contracted. Although their “Smooth Signal Redundancy Hypothesis” is widely accepted, little is know about the mechanism that actually controls the variations in the flow of the speech signal.

The current study investigated how a word's frequency of use – i.e. the amount of experience a speaker has with a word and its articulatory gestures (Browman and Goldstein, 1986) – affects the biomechanical behavior of the articulatory apparatus. In order to investigate this, we focussed on the relationship between the articulators' movement speed and the degree of the trajectory curvature it currently discribes. Studies investigating this relationship in hand movements have revealed that the movements become slower with an increasing degrees of the trajectory curvature (Viviani et al., 1991). The association is expressed by a power function, whose exponent is -1/3, which is why the relationship has been termed the “1/3 power law”.

So far there are two studies investigating the power law in articulation (Tasko and Westburry, 2004); Perrier and Fuchs, 2008). By means of a linear regression analysis, both studies have shown that articulatory movements do not strictly obey the power law. Rather, there is large variation depending on speaker, speaking rate and signal size. Inspecting the speed-curvature data we found that linear regression probably does not perfectly capture the relationship. We therefore expanded the analysis by investigating 1. whether the speed-curvature relationship is non-linear and 2. how a word's frequency of use affected the relationship.

We found strong non-linearity in the data, indicating that linear regression analyses do not correctly represent the data and that the 1/3 power does not absolutely apply in articulation (compare green and black curves in Figure 1). In addition, we found that frequency of use interacted with the speed-curvature relationship. In curvatures of high degrees (i.e. narrow curves), articulation velocity was higher in high frequency words than in low frequency words. This means that depending on a speaker's experience with a word and its set of articulatory gestures, he or she will have a different mastery to execute the gestures and perform the articulatory movements.

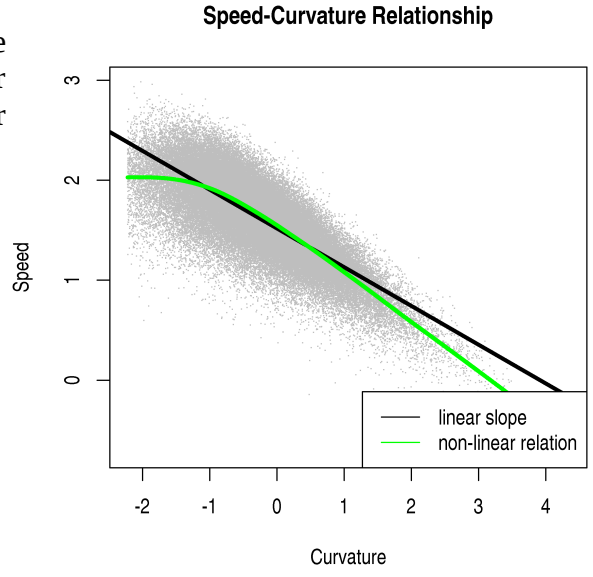

Figure 1: Grey points: single speed-curvature data points. Black curve: result of linear analysis. Green curve: result of non-linear analysis.

References

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