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Terband, Hayo and Van Brenk, Frits and Henriques, Rafael Neto and van Lieshout, Pascal and Maassen, Ben and Lowit, Anja (2012) Speech rate strategies in younger and older adults. In: Motor Speech Conference, 2012-02-29 - 2012-03-04. ,

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Introduction

Effects of speech rate changes on kinematic movement characteristics and stability of speech movements were assessed in younger and older speakers using electromagnetic midsagittal articulography (EMMA).

Several studies have indicated a general decrease in speed and accuracy of speech output in older compared to younger speakers [1-4]. In a previous study investigating reiterated productions of syllables /pa/, /sa/ and /ta/ at different speech rates, we found that older adults when slowing down, more prominently increased duration and decreased peak velocity in closing movements compared to younger adults [5-6]. As a possible explanation we proposed that older adults may evidence a mechanism that facilitates a closed loop control system to maintain movement stability, possibly due to a reduced quality of somatosensory input.

The aim of the present study is to investigate this phenomenon further using a reiterated speech task with target words /a:pi/ and /ipa:/, which regarding jaw and lips, involve three-step movement schemes consisting respectively of one closing and two opening movements and two closing and one opening movement (Tab. 1; Fig. 1).

Method & materials

TABLE 1: Description of the different phases in movement cycles of bilabial opening/closure for the reiterated production of /a:pi/ and /ipa:/

/a:pi/	/ipa:/
1. full closure to full opening [a] to full bilabial closure [p] -	1. half closure to frontal opening [i] to full bilabial closure [p] -
2. half opening to frontal opening [i] -	2. full opening to full opening [a] -
3. half opening to full opening [a].	3. half closure to frontal opening [i].

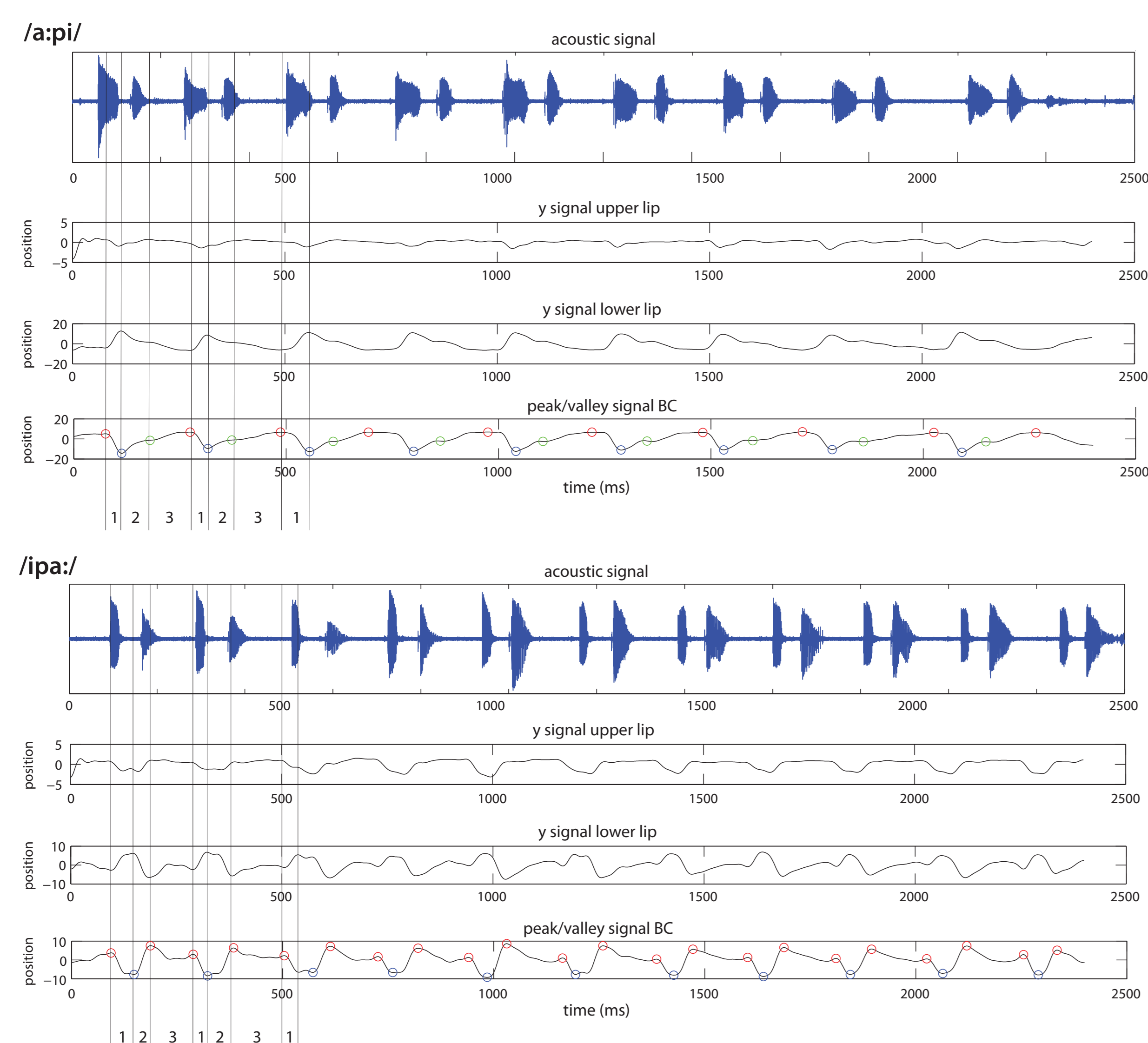


FIGURE 1: Example of the three different phases in the movement cycle for /a:pi/ (top) and /ipa:/ (bottom). The numbers refer to the phases described in Table 1. BC=bilabial opening/closure.

Participants

- Sixteen healthy native speakers of Dutch: 8 young, 8 elderly.
 - Young adults: 2 male, 6 female. Age 21;4 - 27;2 y;m, mean 23;7, sd 2;3.
 - Elderly adults: 4 male, 4 female. Age 66;0 - 84;2 y;m, mean 74;7, sd 6;0.
- Task
- Repetition of /a:pi/ and /ipa:/.
 - Self paced slow, normal & fast rates.

Data collection

- EMMA (Carstens AG100).

Data analysis

- Movement cycle durations bilabial opening/closure (BC).
- cSTI [7-8] BC, tongue body (TB), lower lip & jaw.

Statistics

- Linear Mixed Model analyses.

Results

Speech rate (Fig. 2)

- Both groups successfully changed speech tempo across rate conditions (Rate [F(2,64.859) = 75.038, p < .001]).
- Elderly adults were slower at normal and slow rates compared to young adults, but equally fast at the fast rate (Group [F(1,77.857) = 6.389, p < .05]; Group*Rate [F(2,64.859) = 7.915, p < .001]).

Variability (cSTI; Fig. 3)

- No effects of Rate, Group or Target.

Movement cycle durations (Figs. 4 & 5)

- In the fast rate condition, no 3-step movement cycles were recognizable in the majority of utterances. Therefore, only the normal and slow conditions are analyzed.
- When slowing down speech rate, the elderly adults increased the duration of the full opening from [p] to [a] in /ipa:/ more compared to the young adults (Group [F(1,77.237) = 26.328, p < .001]; Group*Rate [F(2,103.748) = 4.544, p < .05]; Group*Movement cycle [F(10,54.125) = 8.750, p < .001]).

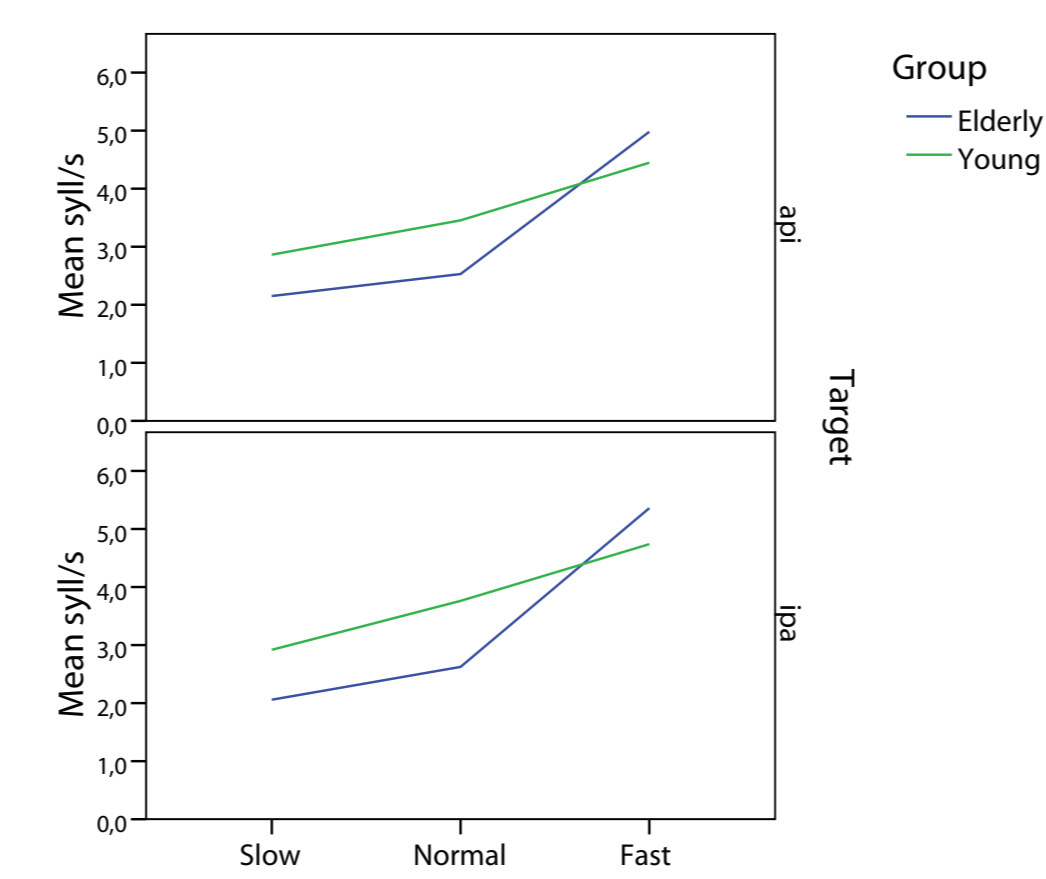


FIGURE 2: Realized speech rates in self paced slow, normal & fast rates.

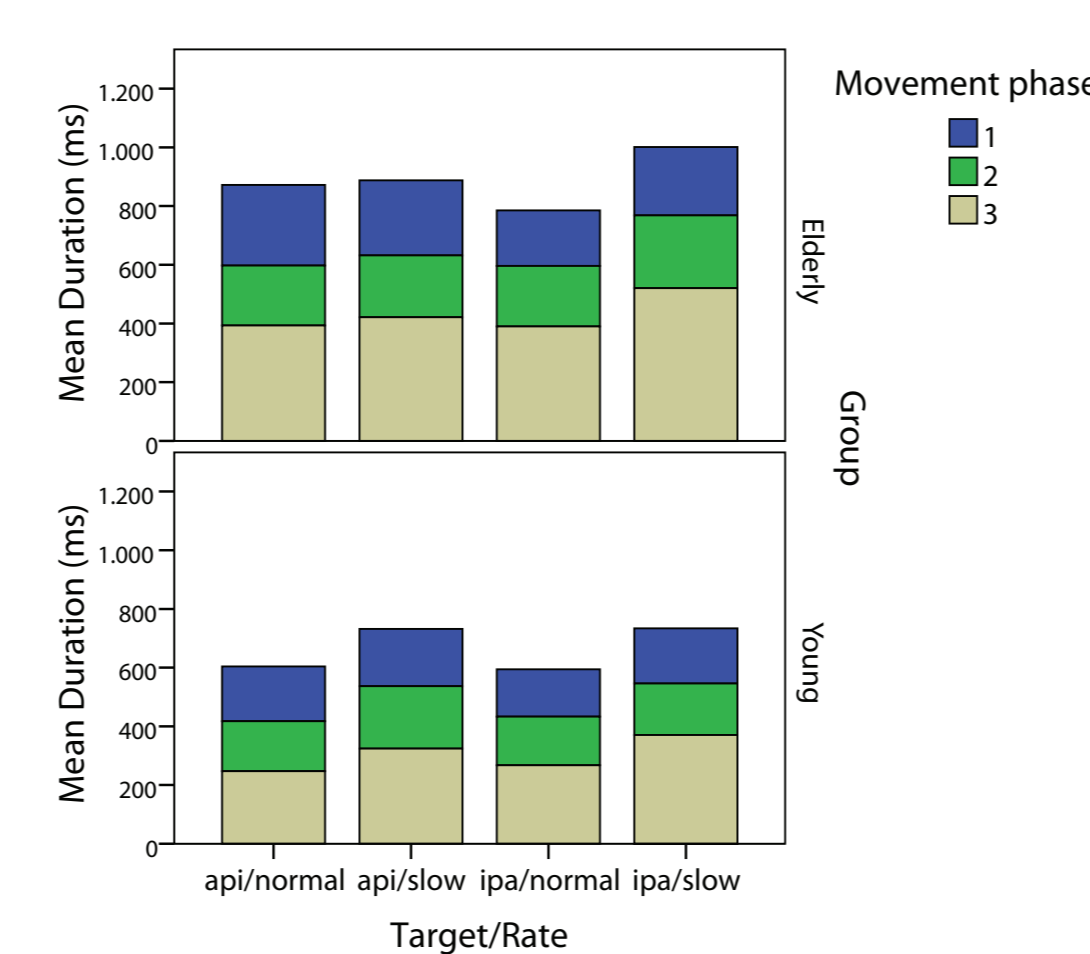


FIGURE 4: Durations of different phases in bilabial opening/closing movements.

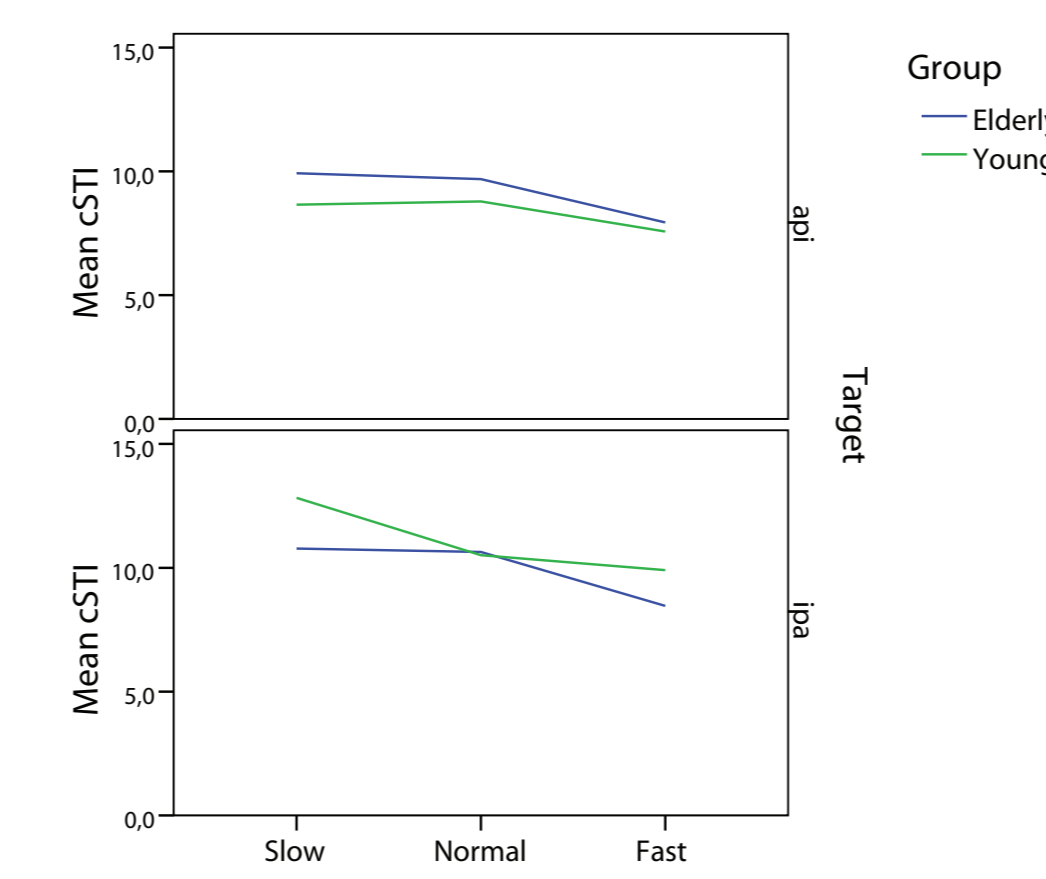


FIGURE 3: Variability (cSTI) of speech movement trajectories in self paced slow, normal & fast rates.

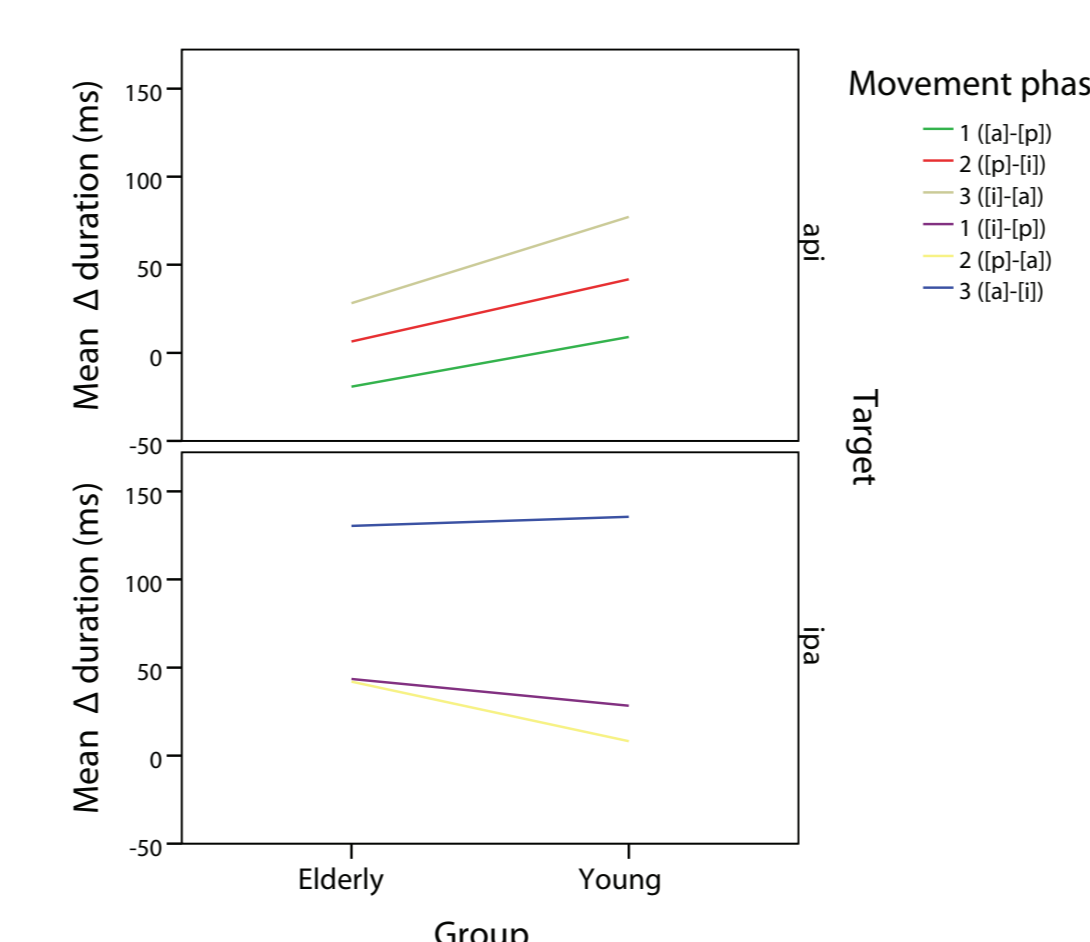


FIGURE 5: Differences in duration of bilabial opening/closing movements between the normal and slow rates.

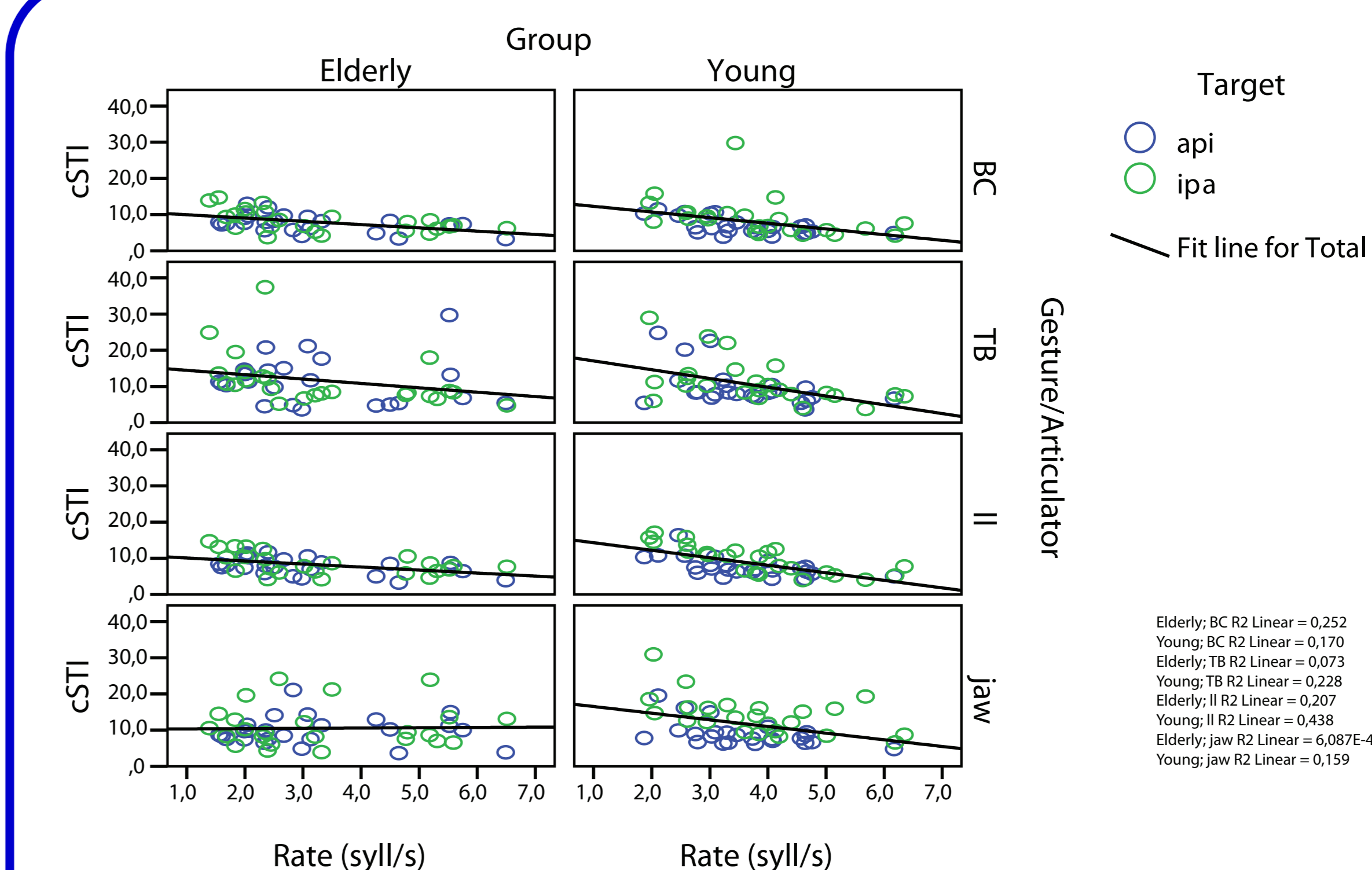


FIGURE 6: Variability (cSTI) vs. Rate in bilabial opening/closure (BC), tongue body (TB), lower lip (ll), and jaw movements.

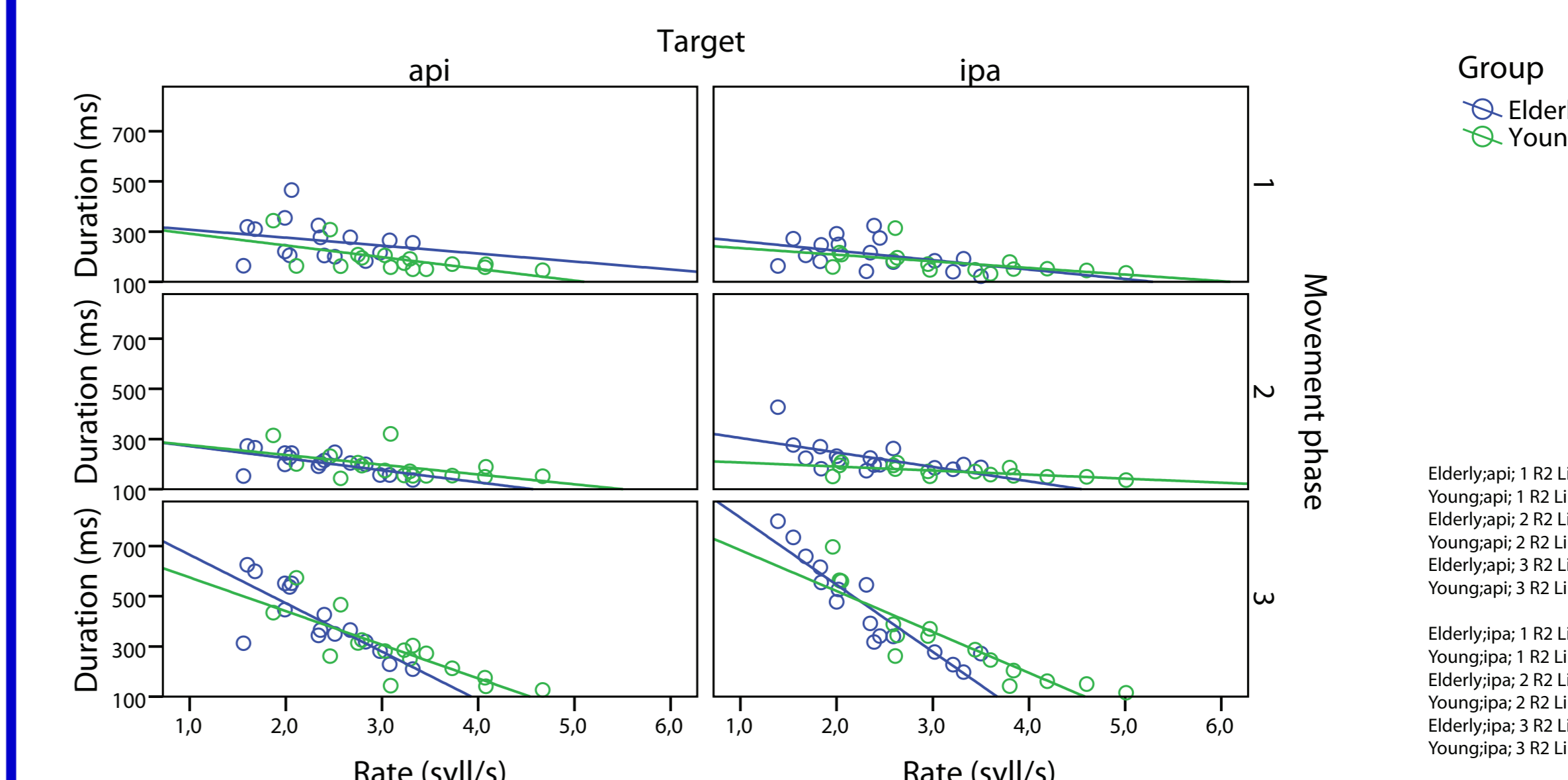


FIGURE 7: Duration vs. Rate in different phases in bilabial opening/closing movements.

Discussion & Conclusions

- Elderly adult speakers appear to be capable of slower repetition rates while maintaining the same stability compared to young adults (Fig. 6).
- In contrast to our expectations, the results on 3-step movement cycles showed the most prominent increase for elderly adults compared to younger adults for the duration of the full opening from [p] to [a] in /ipa:/ (Fig. 7).
- However, for both /a:pi/ and /ipa:/, the results also indicate that elderly adults when slowing down, more prominently increased the duration of the vowel-to-vowel transitions compared to younger adults (Fig. 7).
- Together, these results can be interpreted as elderly speakers exploiting a strategy that favours closed loop control.

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