# An analysis of speech rate strategies in aging

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## Introduction

**Aging and speech production**

- Older adults decrease their average rate of speech, compared to younger adults
- A frequently used strategy is increasing syllable- and segment duration.
- Goozee et al. [1] found lip- and tongue movement cycle durations for younger adults to be shorter for the closure and opening phase at self-chosen moderate and fast rates than for older adults.
- Possible explanations:
  - Aging affects the ability to speak faster; or
  - Older adults employ a different speed/accuracy trade-off strategy

**Current study**

Aim: to evaluate the influence of age on movement cycle durations during the production of reiterated non-word utterances with a controlled speech rate using an auditory metronome.

Research questions:

1. Can the rate of articulation modeled by an external metronome be matched equally well by younger and older adults.
2. How is movement cycle duration used as part of a strategy to increase and decrease syllable repetition rates in both young and older adults.

## Methodology

### 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;8, sd 2;3.
- Older adults: 4 male, 4 female. Age 66;0 - 84;2 y;m, mean 74;8, sd 6;0.

### Task

- Repetition of /pa/, /sa/ and /ta/ in 12-sec recording trial.
- Pacing conditions: self paced and metronome paced.
  - Self-paced: slow, habitual and fast.
  - Metronome: modeled at 2, 2.5, 3, 3.5 and 4 bps prior to recording; stopped at beginning of recording.

### Instrumentation and analysis

- Data were collected by Electromagnetic Midsaggital Articulography (Carstens AG100).
- Calculation of speech rate from acoustic data.
- Analyis of articulatory data with custom Matlab software [2].
  - /pa/: lower lip articulator.
  - /sa/ and /ta/: tongue tip articulator.
- Calculation of mean movement cycle duration of reiterated syllables, derived from positional data.
- Movement cycles were used to derive cycle duration by measuring the time between two points at maximum oral closure

## Results

**Syllable repetition rates** were analyzed for Group, Rate and Task effects (Huynh-Feldt epsilon corrected where the sphericity assumption was violated). See figure 1.

- Self-paced condition:
  - Both groups succesfully changed speech tempo across rate conditions (Rate [F(1.51,21.13) = 233,91, p < .001]).
  - Across speech tasks, older adults were faster at fast rate, but slower at habitual and slow rates compared to young adults (Rate*Group [F(1.51,21.13) = 15,83, p < .001]).
  - Across speech rates, older adults were faster at /pa/, but slower at /sa/ and /ta/ compared to young adults (Task*Group [F(1.65,23.15) = 5,272, p < .05]).
- Metronome condition:
  - Both groups succesfully changed speech tempo across rate conditions (Rate [F(1.67,23.33) = 413.37, p < .001]).
  - No effects of Task, Group*Rate and Group*Task: both groups manipulated speech tempo in a similar manner, irregardless of task.

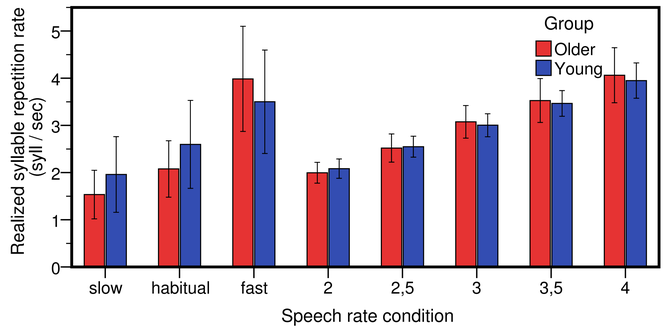


Figure 1: Means and standard deviations of syllable repetition rates across speech tasks, broken down by group and speech rate.

**Mean movement cycle durations** were calculated for the metronome condition only; because speech rate was comparable across groups (unlike non-metronome condition). See figure 2 for results.

- Results were collapsed over speech task in the absence of task and rate effects, with Direction of movement as factor: opening vs. closing durations.
- Increasing speech rate leads to a decrease in movement cycle duration (Rate [F(1.89,87.01) = 878.14, p < .001]).
- Cycle duration is marginally longer for younger adults, compared to older adults (Group [F(1,46) = 7.11, p < .05]).
- Cycle duration is longer for closing movements, compared to opening movements (Direction [F(1,46) = 70.01, p < .001])
  - This effect is more apparent for older adults, compared to young adults (Direction*Group [F(1,46) = 4,2, p < .05]).
  - Increases with decreasing speech rate (Direction*Rate [F(1.60,73.41) = 84.87, p < .001]).
- The increase in duration difference between closing and opening movements during decreasing speech rate (esp. metronome conditions 2, 2.5, 3) is significantly larger for older than for young adults (Direction*Rate*Group [F(1.60,73.41) = 5.53, p < .05].

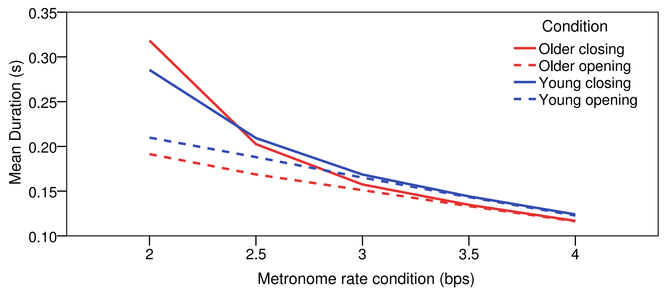


Figure 2: Mean movement cycle duration per metronome pacing rate, broken down by age group and direction of movement.

### Repetition rate and movement cycle duration

Further results of the relation between syllable repetition rate and corresponding movement cycle duration are presented in figure 3.

- Data are merged for both pacing conditions (self-paced and metronome).
- With increasing realized repetition rate, movement duration is decreasing.
- This effect is asymmetric with respect to direction of movement, and approaches a power scaling function dur = 1/rate, except for opening movements < 2 syll/sec.

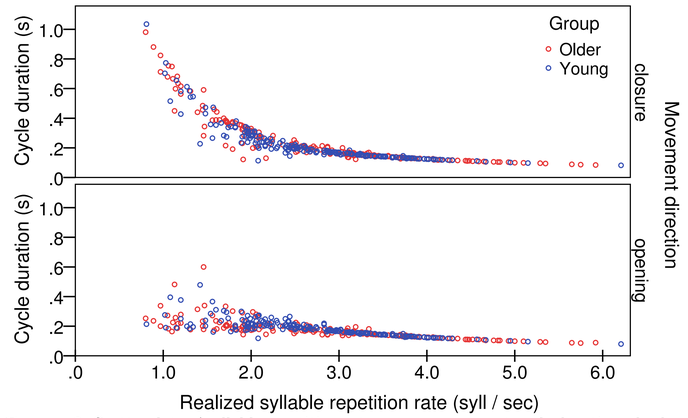


Figure 3: Scatterplots of syllable repetition rates versus movement cycle durations, broken down by direction of movement; metronome and self-paced conditions combined.

## Discussion

**Syllable repetition rates**

- In the **self-paced condition**, older adults were capable of reaching syllable repetition rates equal to younger adults in the fast rate condition, but were slower at habitual and slow rates.
  - Fits notion of a different trade-off in speed vs accuracy.
  - Rate pattern is in line with Bennet et al. [3], but contradicts Goozee et al [1].
  - Age differences do not reflect rate limitations, but other aspects of motor control (e.g. feedback influence).
- In the **metronome condition**, syllable rates were comparable between groups.
  - A metronome as pacer is succesfull in controlling the rate of articulation by younger and older adults (research question 1).

**Movement cycle duration**

- The asymmetry in movement direction indicates that manipulating closing movements is more important in speech rate reduction than opening movements (research question 2).
  - In line with gestural theory where the closing movement is towards the constriction target, while the opening movement (release) is presumably more passive [4].
- The particular relation between syllable repetition rate and cycle duration (figure 3) is similar for stiffness (peak velocity/amplitude) and duration [5].
- Trade-off effects were eliminated by the metronome: increasing the asymmetry in movement direction is age-related, and more common at slower speech rates.
- However, motor control processes are different for the more natural self-paced and metronome conditions, and therefore difficult to compare.

## Future research

In order to gain more insight in speech rate strategies and performance, we are now working on analyzing additional kinematic and dynamic parameters, phase relations and functional synergies between different articulators, (non)linear analysis of variability of articulatory and acoustic data: (cyclic) spatio-temporal index and functional data analysis.

## References

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