Complexity of Rhythmic Tapping Task and Stuttering

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Etiology stuttering: neuro-motor disorder

- disfluent speech production[1]
- upperlimb and non-speech orofacial movements are also affected[2,3].

Hypothesis: Stuttering is caused by a temporal processing deficit.

Evidence: When synchronizing with an auditory stimulus, PWS show larger asynchrony with a beat than PNS[4] and perform less accurate and consistently[2,3].

Shortcoming: Simple rhythmic tasks, such as the ability to synchronize with an external, predictable beat, or continuing a discontinued external beat.

Speech: characterized by a quasi-rhythmic structure that requires more complex temporal skills to estimate the less predictable timing of the consecutive events such as strong and weak syllables.

Question:

- Compared to PNS, do PWS differ in their ability to perform a more complex rhythmic task, such as filling an empty time interval with a sequence of regular taps?

Validation:

- Do PWS differ in their tapping behavior when synchronizing with a metronome beat?
- Do PWS differ in their ability to continue tapping a periodic rhythm without an external metronome when the external driving metronome stops?

Methods

Participants: 16 French PWS (13 M, aged 19 to 65) and 16 French PNS (13 M, aged 19 to 70).

Tasks:

1) Synchronized tapping with their dominant index finger with an auditory beat played binaurally through earplugs (120 BPM).
2) Filling up a gap with 3 extra taps (30 BPM)
3) Continuing the rhythm of an auditory beat (120 BPM).

For each rhythmic task, the participant listened to 2 cycles of the pattern before starting tapping, and then produced at least 3 tapping cycles of that pattern until the participant was instructed to stop.

2 repetitions for each rhythmic task so that at least 6 cycles (of 8 taps) of each rhythmic pattern were considered for analysis.

Analysis

Tapping events: annotated semi-automatically with MATLAB scripts.

1. Ta:
   a. Estimation actual tapping period: the theoretical period (Tt) should be 500 ms.
   b. Ta of each 8-taps cycles, we considered the time differences (Δt) between a tap and the following one within a tapping cycle and removed Δt values which were larger than 1.5*Tt (750 ms.; considered as a missed tap) or smaller than 0.5*Tt (250 ms.; considered as a "double" tap).
   c. Ta: We then calculated Ta in seconds as the average value of the remaining Δt values, for each tapping cycle.
2. TV:
   For each tapping cycle, the tapping variability (TV) around this actual periodicity Ta (in percentages).
3. Missed and double taps were counted.

Statistics

General Mixed Models in R

- Random effects:
  - participants
- Fixed effects:
  - rhythmic task (T1, T2, T3),
  - musical experience (no experience 0, medium 1, advanced 2)
  - group (PWS, PNS)

The level of significance was α = 0.05.

Discussion

- PWS were able to synchronize with an external auditory stimulus and keep a regular beat once the auditory reference stopped. For both groups, musical experience improved the tapping accuracy of both groups.

However:

- PWS: more tapping variability than PNS on all the tasks, confirming earlier studies[3,4].
- PWS missed more taps than PNS, suggesting that this task is more difficult than the synchronization and continuation tasks.

These results suggest a possible deficit in temporal processing by people who stutter that we are currently investigating by:

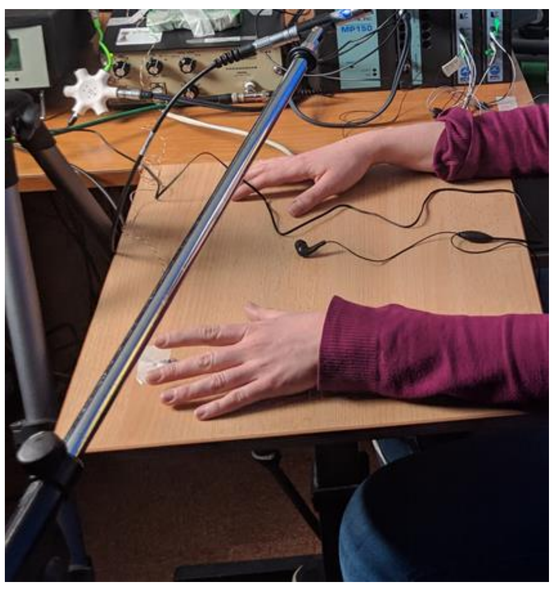
1. comparing finger tapping tasks and speech productions.
2. comparing simple regular rhythmic patterns with more complex patterns.

Hypothesis

Stuttering is a temporal processing deficiency

↓

Are PWS having more difficulties in estimating periodicity or temporal dimensions?



Methods: tapping task

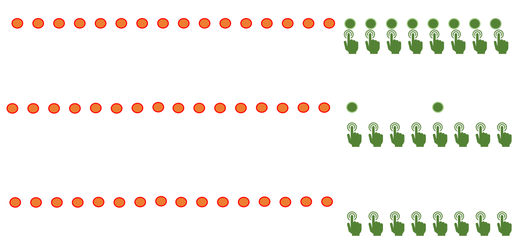
People who do not stutter (PNS)

People who Stutter (PWS)

T1) synchronization task (120 BPM)

T2) 4 taps on one metronome beat (30 BPM)

T3) continuation task (120 BPM)



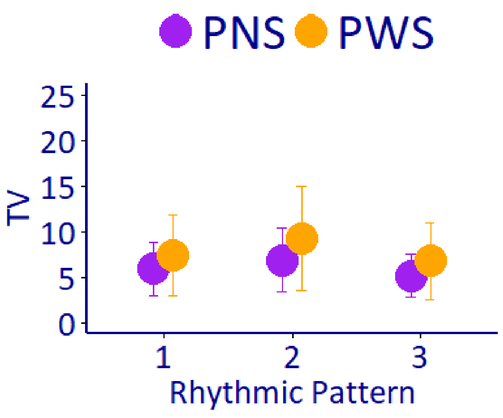
Analysis

- Ta = averaged actual tapping period
- TV = mean($\frac{\Delta t - Ta}{Ta} \times 100$)
- # Missed taps

General Mixed Models

- Random effects: participants
- Fixed effects:
- group (PWS, PNS)
- rhythmic task (T1, T2, T3)
- musical experience (no experience 0, medium 1, advanced 2)

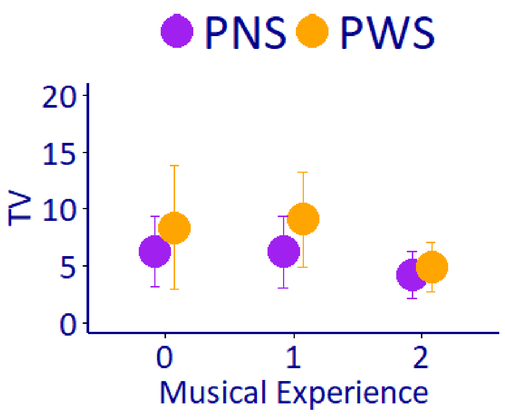
Results



GROUP: PWS > PNS $\chi 2(1)= 7.2168$, $p<0.01$

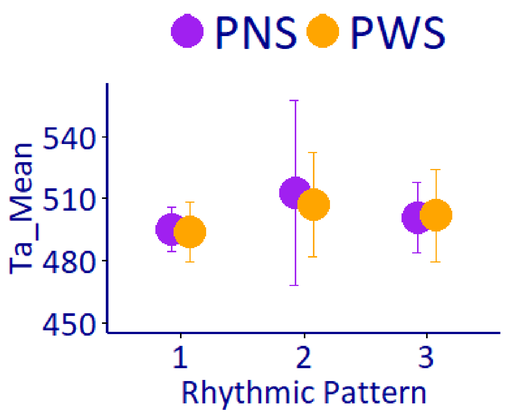
Rhythmic Pattern: $\chi 2(2)= 27.045$, $p<0.0001$

- T2 > T1 $p<0.01$
- T2 > T3 $p < 0.001$
- T1 < T3: $p = 0.04$



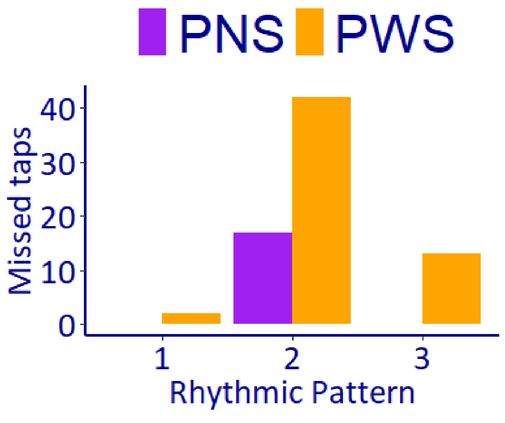
Musical Experience: $\chi 2\ (2)=7.95$, $p=0.02$

- 2 < 0 & 1



Rhythmic Pattern: $\chi 2(2)= 11.47$, $p<0.01$

- T1 < T2: $p < 0.001$



Missed taps ($\Delta t > 750$ ms): PWS > PNS

- T1<T3<T2

Conclusion

- People who stutter do show different tapping behaviour than people who do not stutter.
- So: Internal clock deficiency?

1. Bloomstein, O., & Bernstein Ratner. N. (2008). A Handbook on Stuttering. Thomson Delmar Learning
2. Falk, S., Müller, T., & Dalla Bella, S. (2015). Non-verbal sensorimotor timing deficits in children and adolescents who stutter. *Frontiers in Psychology,* 6.
3. Hulstijn, W., Summers, J.J., van Lieshout, P., & Peters, H.F.M. (1992). Timing in Finger Tapping and Speech: A Comparison between Stutterers and Fluent Speakers. Human Movement Science 11(1), 113–24.
4. Sares, A.G., Deroche, M.L.D., Shiller, D.M., & Gracco, V.L. (2019). Adults who stutter and metronome synchronization: evidence for a nonspeech timing deficit. *Annals of the New York Academy of Sciences,* 1-14.