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ARE MOBILE DEVICES SUFFICIENTLY PRECISE TO CAPTURE INDIVIDUAL DIFFERENCES IN AUDITORY-MOTOR SYNCHRONIZATION TASKS?

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WHY SHOULD WE ASSESS AUDITORY MOTOR SYNCHRONIZATION?

- Moving along to a beat is an automatic (spontaneous) and widespread behavior [1]
- Synchronization ability shows significant variability in the general population [2]
- The variability in rhythmic abilities is exacerbated by diseases [3]

[1] Sowiński and Dalla Bella, 2013; Leman et al., 2013

[2] Palmer et al., 2014; Sowiński and Dalla Bella, 2013; Repp, 2010

[3] Lundetræ and Thomson, 2018; Ladanyi et al., 2020; Puyjarinet et al., 2017; Yahalom et al., 2004; Puyjarinet et al., 2019

Humans are generally well equipped to move along with auditory rhythms via finger or foot tapping, body swaying or walking. A growing body of studies shows that this ability is quite variable in the general population, however. Moreover, this variability is exacerbated by diseases, such as language/speech disorders, attention deficit hyperactivity disorder, and neurodegenerative diseases (e.g., Parkinson). Testing tools which show sensitivity to this variability have been developed, such as dedicated batteries of tests using finger tapping. One of the limitations of these tools is that they are used in the lab, require dedicated equipment, and they have limited portability. These limitations can be circumvented by using more common and widespread mobile devices such as tablets or smartphones for testing auditory-motor synchronization abilities.

RESEARCH PROBLEM

Do off-the-shelf mobile devices have sufficient precision and accuracy to capture individual variability in auditory motor synchronization?

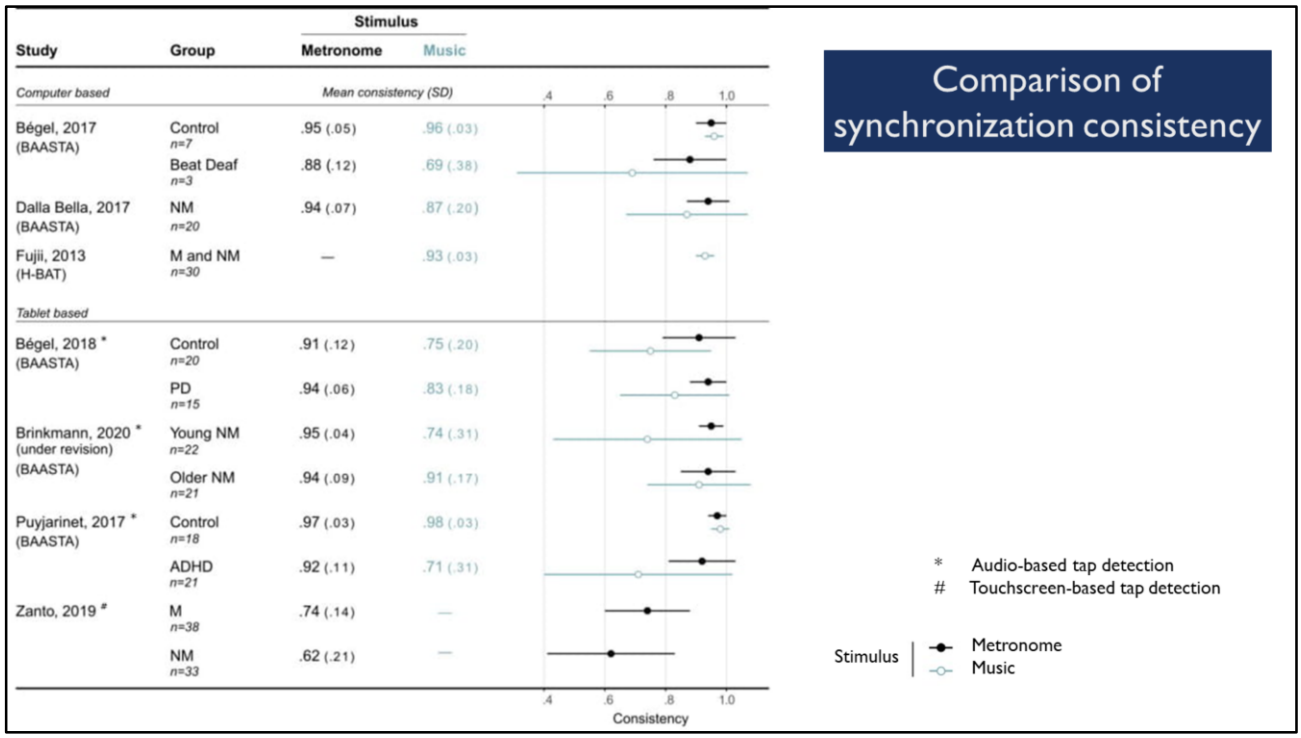
SOURCES OF INACCURACY

When the touchscreen sensor is used to measure auditory-motor synchronization on a tablet, there are several important sources of timing measurement inaccuracy:

- **Audio output delay**: Affects when the participant hears the stimulus
- **Temporal uncertainty**: Arises from the sampling rate of touch detection
- **Processing delay**: Occurs between the touch detection and the recording of a tap

There are different sources of timing inaccuracy when recording auditory-motor synchronization (AMS) in a tapping task on tablet: 1) the audio output delay that affects when the participant hears the stimulus, 2) a temporal uncertainty arising from the sampling rate of touch detection, and 3) processing delay between the touch detection and the recording of a tap.

Because of this inaccuracy, the participant's taps would appear more variable (i.e., corresponding to lower AMS consistency) than their actual performance when measured in the lab. This hinders the capacity of the task to capture individual differences in rhythm abilities and distinguish between good and poor synchronizers.



We compared auditory-motor synchronization (AMS) consistency from studies done using laboratory equipment or using tablet devices. In particular, one study by Zanto et al. used the touchscreen of tablet devices to record tap responses, and that study reports lower tapping consistency than the other studies that used either computer-based equipment in the laboratory, or a non-touchscreen approach (audio recording) on tablet devices. It is notable that in the touchscreen-based study, tapping consistency measured in healthy participants was lower than values reported by non-touchscreen studies for patient populations with rhythm disorders or for beat deaf adults. Thus, the precision afforded by touch detection allows teasing apart, for example, musicians from non musicians, but may lack sensitivity to subtle individual differences, and in detecting individual with rhythm disorders.

USING SOUND INSTEAD OF TOUCHSCREEN

- Mobile devices provide an audio sampling rate considerably higher than the touchscreen rate, allowing a better temporal precision
- Recording the sound of the tap to assess rhythmic abilities has been successfully implemented in a tablet version of BAASTA [1]
- [1] Dalla Bella, S., and Andary, S. (2020). International Patent No WO 2020/128088 A1.

The problem of low temporal precision of touchscreen responses can be circumvented by using a different approach: making an audio recording of sound produced by the finger on the touchscreen while tapping, together with the sound of the stimulus, thus benefitting from the considerably higher temporal resolution of the audio sampling rate. This solution, already implemented in the tablet version of BAASTA (Dalla Bella, S., and Andary, S., 2020. International Patent No WO 2020/128088 A1), could explain why the results on AMS tasks using the computer-based BAASTA could be successfully replicated on the tablet version of BAASTA.

CONCLUSION

- The use of mobile devices to assess rhythmic abilities is a very promising method…
- … but it requires greater temporal precision than provided by the current generation of mobile touchscreen sensors
- A sound recording approach allows mobile devices to achieve sufficient temporal precision of tap measurements to be sensitive to individual differences

Using mobile devices such as tablets or smartphones to assess auditory-motor synchronization (AMS) is a very promising method. However, data acquisition must be more precise than what the current generation of mobile touchscreens allow, to avoid large measurement uncertainty and ensure sufficient sensitivity to individual variability and potential rhythm disorders.

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THANK YOU FOR YOUR ATTENTION!

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