

Modulation of Visual Search Performance by Acoustic Concurrent Stimulation in Early Childhood

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Introduction

Background:

Early audiovisual exposure seems to play an important role in development and later in life. We address an investigation of this looking at visual search performance, which requires to identify and select relevant targets from a scene and to inhibit irrelevant stimuli.

Previous research has shown that visual search or target detection performance can be modulated by external auditory stimulation in adults (cross modal, van der Burg et al. 2008; Ngo & Spence, 2010; Bolger, Coull, & Schön, 2014; ten Oever et al., 2014).

Here, we used a 4 Hz acoustic beat sequence as the concurrent stimulation in a within-subjects design. We compared visual search performance (speed and accuracy) of young children with / without auditory stimulation. Furthermore, we also investigated if search performance was related to musical environment at home and caregivers' musical engagement.

Hypotheses:

- Visual search performance is enhanced during audiovisual presentation.
- Musical environment at home and musical engagements of caregivers modulate performance.

Methods

Apparatus:

An eye tracker (X2-60, Tobii) was employed to measure binocular eye movements with sampling rate of 60 Hz. Calibration accuracy was within 0.5°. Visual search task was presented on Dell XPS with the operating system Windows 10 Pro.

Participants:

40 children (16 – 48 months old). 11 were excluded due to low data quality, incompleteness of measurements, or extremely low motivation. 29 children (age mean = 36,9 months, SD = 11,2; 17 boys), who completed two measurements, were included in the final data.

Assessments of musical environment:

- Music@Home (Politimou et al., 2018) - to assess home musical environment in early years
- The Music USE (Chin & Rickard, 2012) - to evaluate musical engagements of caregivers

Stimuli and procedure:

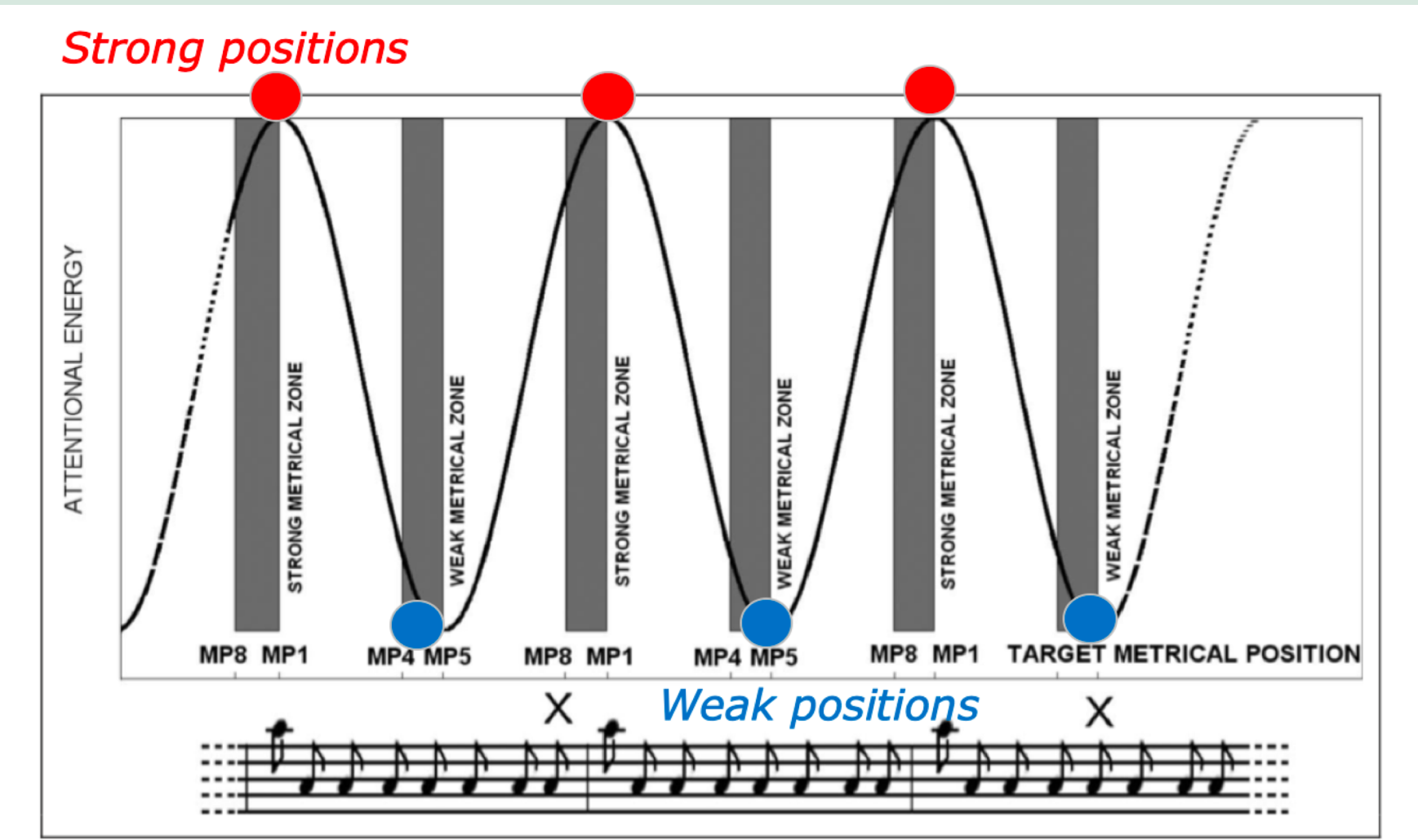
Visual stimuli—set sizes 4,6,8, and 10. Each set size was shown for 1000ms and for 16 times. There were 64 trials in total.

Auditory concurrent beat—a simple-duple metrical beat sequence with sinusoidal tone. It was presented with the frequency of 4 Hz (Fig1, (d)). In audiovisual condition, visual stimuli appeared simultaneously with the beat.

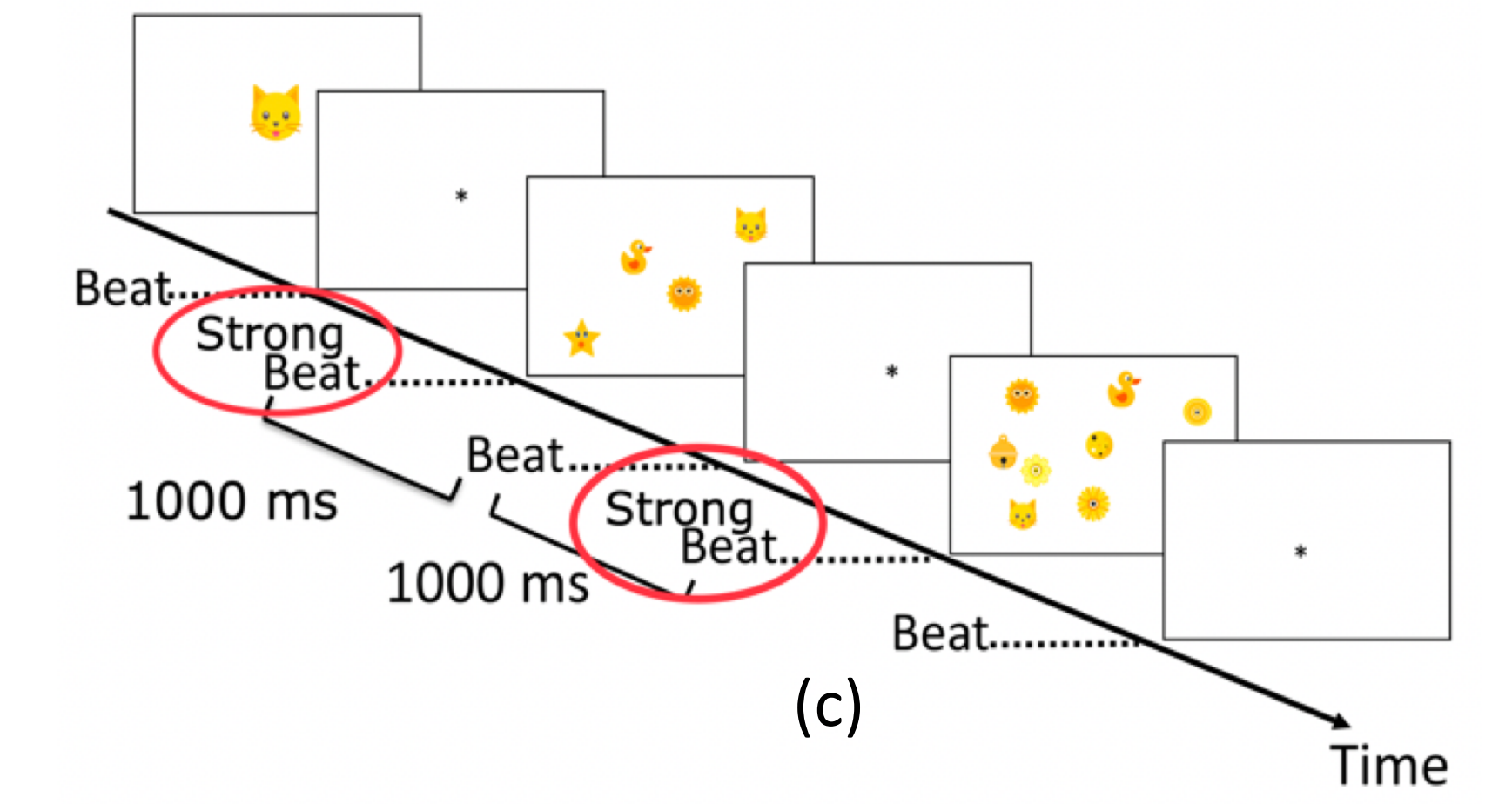
Procedure—Participants sat in a dark room with an experimenter and a caregiver. After calibration of the eye tracker, they were encouraged to watch a 3 min video and look at where the target was. Each participant had 2 measurements in successive weeks. Orders of conditions were counterbalanced.



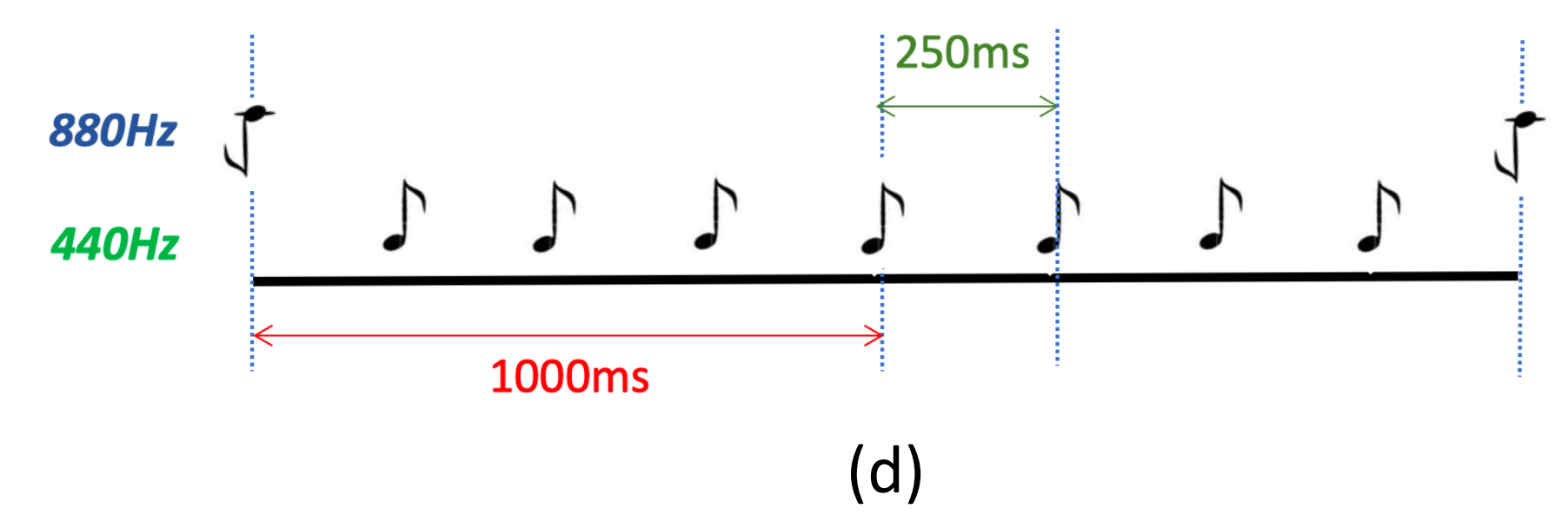
(a)



(b)



(c)



(d)

Figure 1: In (a), a participant was seated in front of a test monitor with distance of 60 cm. (b) illustrates the acoustic beat sequence with strong and weak beat positions (Original picture from Bolger et al., 2014). (c) presents the visual search paradigm with inter onset interval of 1000ms. Participants were instructed to find a cat across 64 trials. (d) shows the frequencies and time intervals of the acoustic auditory stimulation.

Results

1 Modulation of search efficiency and effectiveness by a concurrent acoustic beat sequence

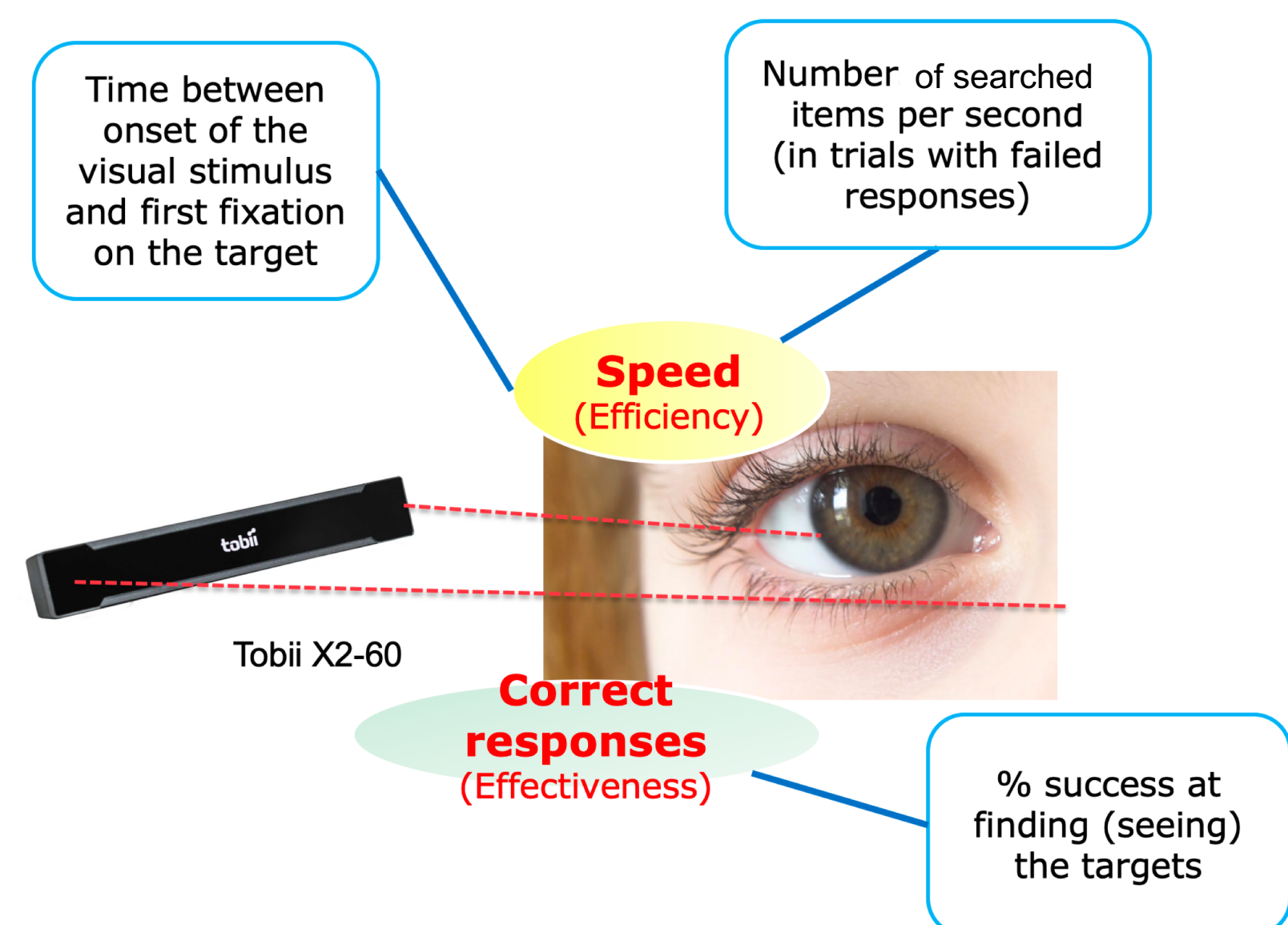


Figure 2: Search speed and accuracy were measured by a binocular eye tracker with a sampling rate of 60 Hz. Two different ways were applied to determine search speed, one was classic reaction times, the other was to measure scanned number in a second.

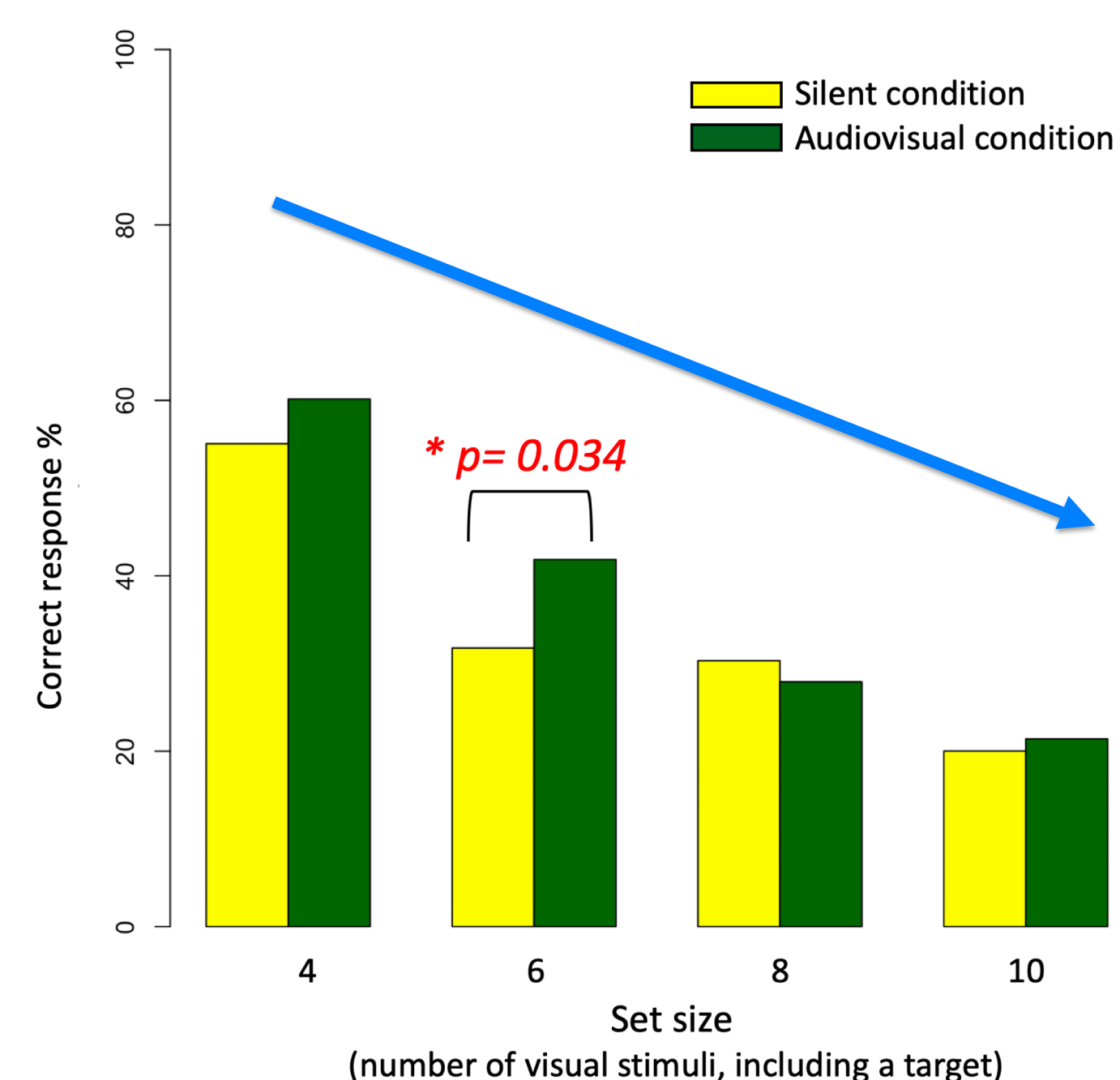


Figure 3: Correct responses of all set sizes in two conditions. Young children showed adult-like (a slope) results regarding decrease in accuracy that is corresponding to increase in task difficulty.

2 Correlation coefficient between musical environment at home, music engagement of caregivers and search speed, overall accuracy

Table 2. Correlation coefficient between search speed, and age

	Searched items/second	Age
Searched items/second	1	0.71
Age	0.71	1

Table 3. Correlation coefficient between "musical environment at home", "music engagement of caregivers" and search speed, overall accuracy

	Reaction Times	Search Speed (items/second)	Overall Accuracy
Music@Home	0.16	0.12	-0.38
Music USE (of caregivers)			
- Music listening	0.32	-0.10	-0.15
- Instrument playing	0.11	-0.57	-0.37
- Music training	0.15	-0.33	-0.09
- Cognitive and emotional regulation	0.26	0.26	0.36
- Engaged production	0.50	-0.44	-0.11
- Social connection	0.50	-0.19	0.01
- Physical exercise	-0.09	0.18	0.15
- Dance	0.13	0.08	-0.09

- Search speed is highly correlated with age.
- Reaction times show positive correlation with music engaged production (e.g. demonstration of music skills and knowledge) and social connection of caregiver (e.g. feeling more related to people sharing similar music type).
- Number of searched items/second is negatively correlated with instrument play and engaged production of caregivers.
- Accuracy of search performance shows positive correlation with cognitive and emotional regulation of caregivers.

3 Summary

- Number of searched items per second is significantly different between two conditions. This indicates search efficiency might be enhanced by acoustic concurrent auditory stimulations.
- In set sizes 4 and 6, accuracy is higher with the presence of acoustic concurrent auditory stimulations. Difference in set size 6 reaches significance.
- Musical environment at home doesn't correlate with search performance.
- Music engagement of caregivers doesn't positively correlate with visual search performance of young children. Interestingly, number of search items is negatively related to duration of instrument playing of caregivers.

Discussion

Here we have investigated (audio-) visual search performance with a search paradigm that is suitable for pre-verbal and very young children. The main results seem to be consistent with adult studies. Limitations are pointed out as following and will be improved in future studies.

- Efficiency of visual search is enhanced by concurrent auditory stimulation. From current observations, enhancement might result from visual stimuli that appeared concurrently with strong beat.
- Questionnaires of musical home environment and engagement of caregivers did not show strong correlations with visual search performance. It is seen that musical engagement in production of caregivers is moderately correlated with search efficiency. Interestingly, accuracy of search performance of children is correlated with the use of music for cognitive and emotional regulation of caregivers.
- Limitations and future studies
 - Age range → will be limited to 16 months old
 - Homogeneity of participants (only 5% from non-musical based kindergarten)
 - Task difficulty → will be modified to lower set sizes
 - Gaze data do not always represent allocation of attention → combine EEG measurement

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