Effective and Efficient Visual Stimuli Design for Quantitative Autism Screening: an Exploratory Study

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Introduction

Early detection and intervention for ASD are critical for increasing child success. Previous study show that when interventions for children with ASD begin before age 5, children's success rate is 67%, compared to the 11% success rate seen when interventions begin after age 5 [1]. However, the effect of visual stimulus on early ASD screening has not been considered as a diagnostic consideration in the past. In this paper, we conduct an exploratory study on effective visual stimuli design with two main contributions to improve efficiency of early ASD screening:

- Visual stimuli database design for the ASD screening.
- Evaluation of the impact and efficiency of picture stimuli and exposure time on ASD screening accuracy both independently and dependently.

Methods

ASD SCREENING SYSTEM (Fig. 2): To collect gaze point distribution and perform classification between children with and without ASD.

- ***Visual stimuli design (Fig. 3)***: the main focus of the paper, constructed by 16 pictures for stimuli design database with respect to two assessing aspects:
  - Visual stimuli categories: picture stimulus in different categories to analyze the efficiency of stimuli.
  - Exposure time: gazing duration, to assess the impact of time on ASD screening.
- ***Data acquisition***: setup consists of two main parts (Fig. 1):
  - Tobii EyeX Controller: to accumulate eye positions of movements.
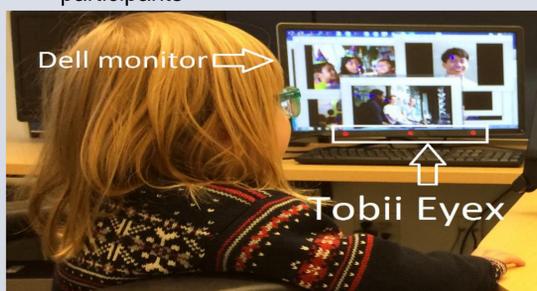 - P2214H monitor: to display visual stimulus for participants

Figure 1. System setup for data acquisition.

- ***Similarity matching:***
  - Wesserstein Distance: to calculate the distance between distributions of gaze point data.
  - Kth Nearest Neighbors: to distinguish children with or without ASD by the given distances.
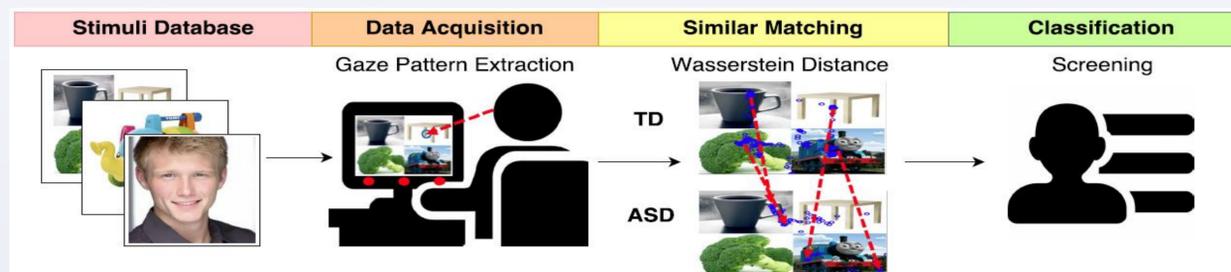
Evaluation Process
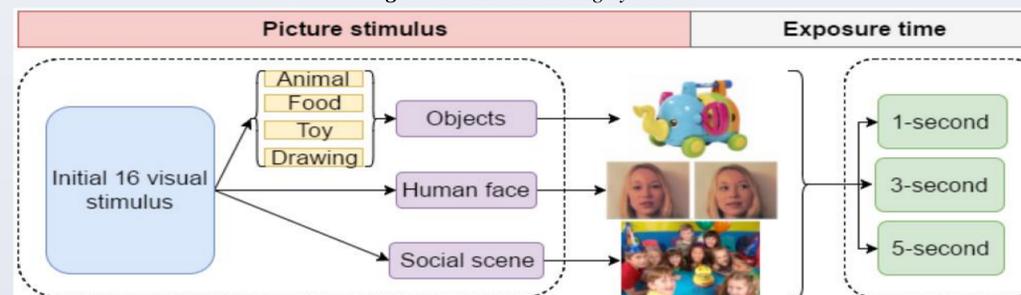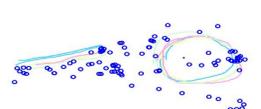

Figure 2. ASD screening system

Figure 3. Visual stimuli design frame work

PROTOCOL

- Approved with IRB: 595026.
- 32 participants between 2 – 10 years old (16 children with ASD and 16 children without any developmental impairments).
- Participants were instructed to sit in front of a computer monitor.
- 16 pictures were shown in 5-second duration.
- Gaze patterns for each picture were collected.
- After Wesserstein Distance was applied, kNN was then utilized 30 times sequentially for each gaze data of that picture to record *precision (P)* and *recall (R)*.
- F-score accuracy (F_1) was employed to accumulate classification results: $F_1 = 2 \cdot \frac{P \cdot R}{P+R}$

Visual Stimuli Design: A Closer Look

VISUAL STIMULI CATEGORIES

Total of 12 pictures are divided into three stimuli categories:

- ***Social scene (SS):*** widely known for its association with ASD. Consist of two reverse versions of the same picture, birthday party scene and workplace scene.

- ***Human face (HF):*** children with ASD typically struggle to process characteristics of a human face. Consist of a pair of blurred/normal faces, a pair of direct gaze/averted gaze faces and two pairs of happy/sad faces.

- ***Object (OJ):*** children with ASD appear to show no impairment in processing global information. Contain four pictures of food, toys, animals and an abstract drawing.

	With ASD	Without ASD
SS		
HM		
OJ		

Figure 4. A comparison between gaze patterns of children with and without ASD in regard to visual stimuli categories

Evaluation Results

Stimuli comparison
- "Social scene" stimulus gives consistently high accuracy, at about 98%.
- Followed are "human face" (97.22%) and "object" (90.26%).

Impact of exposure time
- 5-second duration has the highest result, at 98.24%.
- Followed are 3-second (90.01%) and 1-second (85.56%) duration respectively.

Stimuli and duration combination
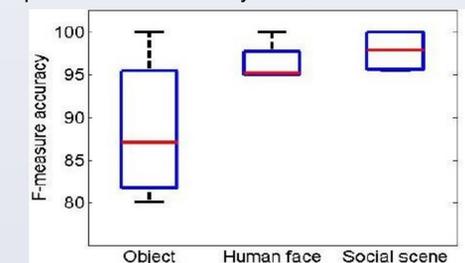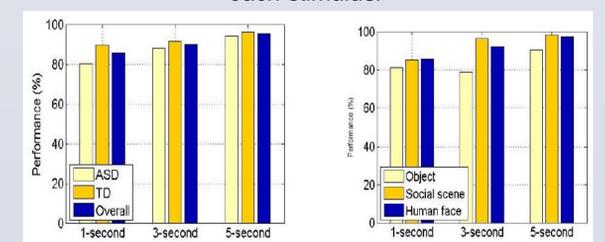- Social scene with full duration yields the optimal result at nearly 100%.

Figure 5. Boxplot on F-score accuracy (%) of three picture stimuli.

Stimuli	Object (%)	Social scene (%)	Human face (%)
ASD	88.59 ± 8.84	97.82 ± 1.52	96.36 ± 2.34
TD	91.55 ± 6.74	98.61 ± 1.20	96.87 ± 1.41
Overall	90.26 ± 2.08	98.24 ± 0.56	97.22 ± 1.07

Figure 6. . Average accuracy performed by each stimulus.

a) Over exposure times among ASD, TD (typical development) and overall.

b) With respect to visual stimuli and exposure time simultaneously.

Figure 7. Accuracy percentage

Conclusion

"Social scene" stimulus in fusion with full exposure duration (5-second) show the most promising visual stimuli correlation for effect ASD screening and early ASD detection.

References

[1] E. C. Fenske et al., "Age at intervention and treatment outcome for autistic children in a comprehensive intervention program," *Analysis and Intervention in Developmental Disabilities*, vol. 5, no. 1-2, pp. 49–58, 1985.