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Pupillometric Response to Implicit Social Exclusion

Jared Balbona

Grace Hwang

Lori Markson

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Department of Psychological & Brain Sciences, Washington University in St Louis

Introduction

Pupil dilation is generally thought of as being a simple response to changes in luminescence. However, researchers have found a relationship between pupillometric changes and neural activity in areas associated with processing emotionally relevant stimuli[1]. With regard to processing social interactions, studies report that pupil dilation is greater when participants are explicitly excluded by peers (e.g., rejected by not being chosen as a partner) rather than accepted (e.g., being chosen as a partner)[2]. However, to our knowledge, no studies have directly investigated pupil dilation in response to more subtle and implicit forms of social exclusion. Research also suggests individuals feel less excluded when exclusion was unintentional compared to intentional, but it is unclear if physiological responses are also sensitive to the intention behind social exclusion.

To address this gap, we used an eye-tracker to obtain pupil diameter values from participants as they played *Cyberball,* an online ball game paradigm. Participants were either included or indirectly excluded by human or computer players in a series of ball games to determine how social dynamics and players' intentions affect pupil responses.

Hypotheses

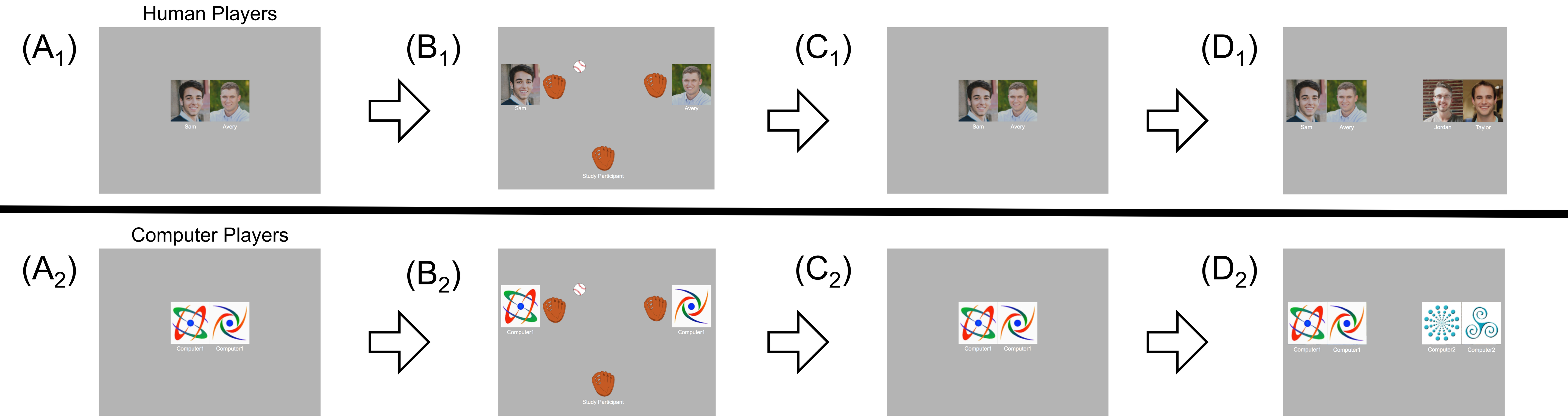
- We predict pupil dilation will be greater when participants view exclusive players compared to inclusive players.
- We predict differences in pupil dilation between inclusion and exclusion will be greater when participants view human players than computer players

Participants & Materials

Eleven graduate and undergraduate students (M=3; F=8) participated. Data were collected using a table-mounted OptiTrack Slim 3U eye-tracker, and were recorded at 100 Hz (every 10 ms).

Design & Procedure

Each participant played three inclusion games and three exclusion games (with two male pairs, two female pairs, and two computer pairs), and answered corresponding questions. The procedure is represented in the figure below. (A) Before each game, participants viewed photos of the two players from the upcoming game while their pupil measurements were taken, providing the *pregame* pupil size. Participants were told before each game that they would be playing with either human players (i.e., other undergraduate participants in the study as shown in A_1), or pre-programmed computer players (i.e., abstract images as shown in A_2). In reality, all players were computerized. (B) Next, participants played a ball-tossing game with these players, during which they were either included (receiving the ball on roughly 1/3 of the tosses) or excluded (receiving the ball only twice across all tosses). (C) After each game, participants were reshown the two photos from (A) while their pupils were measured, giving us the *postgame* pupil size. (D) Finally, participants were shown the pair from the game and a novel pair at the same time, and were asked which pair they would rather play with. Participants then answered a series of questions about their experience during the game. All images used in the task were matched in luminance.



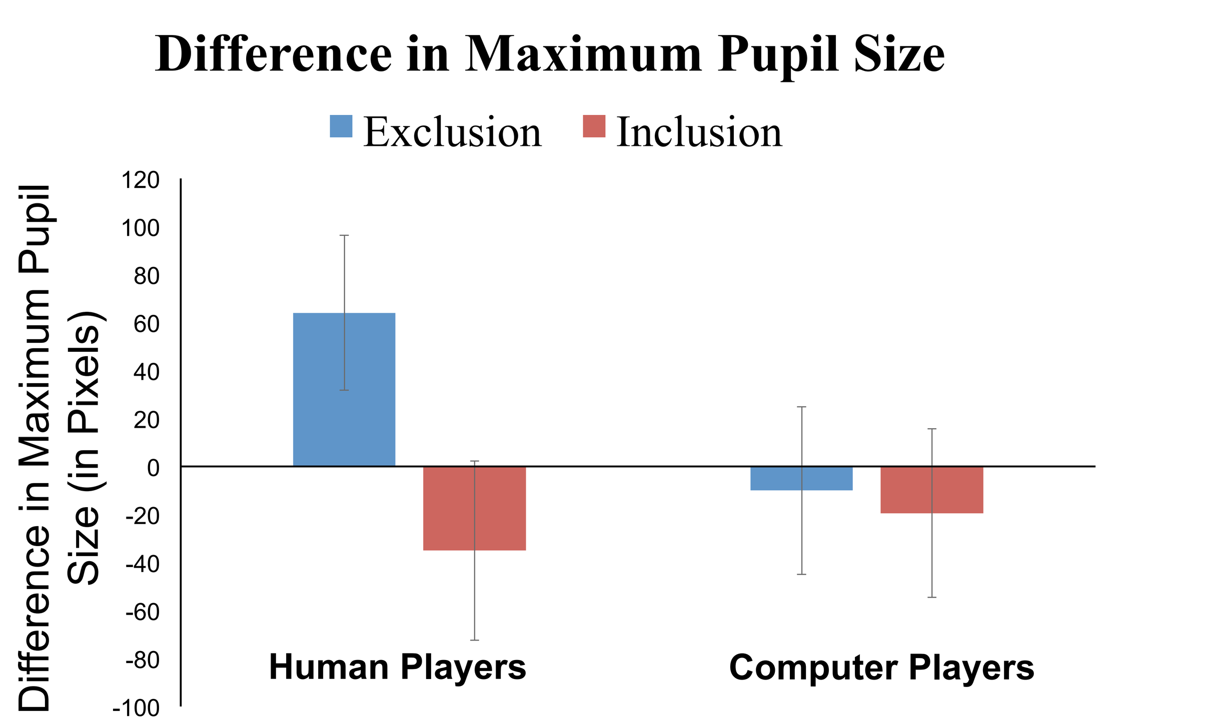
Results

Mean Ratings of Participants' Responses

	Throws Received (%)	OP Liking Rating	NP Liking Rating	Mood Rating
Inclusion	42.12	5.09	4.33	5.88
Exclusion	21.82	3.18	4.36	4.27

	Self-Esteem Rating	Control Rating	Belonging Rating	Existence Rating
Inclusion	5.79	4.94	4.12	5.15
Exclusion	4.64	3.18	2.30	3.06

Participants were asked after each game what percentage of throws they felt they received, how much they like the original (OP) and novel (NP) pairs, as well as questions on a 7-point scale that assessed their mood, self-esteem, sense of control, sense of belonging, and sense of meaningful existence. Consistent with the extant literature[4], we found participants reported significantly lower ratings of mood, t (64) = 4.763, p < .001, self-esteem, t (64) = 3.293, p = .002, control, t (64) = 5.154, p < .001, belonging, t (64) = 4.092, p < .001, existence, t (64) = 5.370, p<.001, and OP liking t (65) = -11.994, p < .001, following exclusive games compared to inclusive games. Participants also correctly reported that they received the ball significantly less during the exclusion condition of the game than in the inclusion condition, t(64) = 7.36, p < .001, showing that they were consciously aware of whether they were being included or excluded.



Pupil data was interpolated and averaged in 10 ms bins. Difference in maximum pupil dilation on each trial was calculated by subtracting the maximum pupil size collected during the pregame measurement from the maximum pupil size collected during the postgame measurement. We conducted a 2 x 2 (Exclusion vs. Inclusion) x Player type (Human vs. Computer) repeated-measures ANOVA, which revealed a significant interaction, F (1, 9) = 10.003, p = .011. There was no main effect of dynamic, F (1, 9) = .044, p = .838 or player type, F (1, 9) = 1.701, p = .225. Participants showed greater increase in pupil diameter when viewing exclusive human players than inclusive human players, t(10) = 2.947, p = .015, but did not show a difference in pupil diameter between exclusive and inclusive computer players, t(9) = -.087, p = .933.

Discussion

Our findings provide the first evidence that pupillometry is a sensitive measure and can detect nuanced changes in physiological arousal from implicit social exclusion. Furthermore, pupil dilation is less reactive to computer players than human players, suggesting that how people cognitively process exclusion can affect their physiological arousal. It is important to note the small sample size used in this study; we are currently conducting a study with a larger sample size to ascertain the relationship between pupil dilation and implicit social exclusion in a *Cyberball* paradigm. It is also possible that the difference in pupillary responses between human and computer players were due to the nature of the images themselves (i.e., participants viewed faces for human players, but viewed abstract images for computer players), rather than the intentional aspect of the players. Therefore, in the future, we plan to use face images to represent both human and computer players to rule out such alternative explanations. This research contributes to our understanding of the neurophysiological mechanisms behind social exclusion and has implications for understanding human social interaction.

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Author Contact

Jared Balbona: Jbalbona@wustl.edu
Grace Hwang: hwang.h@wustl.edu
Lori Markson: markson@wustl.edu