Technological Intervention Combined with Metacognitive Guidance for Promoting Eye Contact among Children with HFASD

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Abstract

The current study explored the effect of metacognitive guidance, combined with an innovative technological intervention program, for promoting eye contact among children with high functioning autism spectrum disorder (HFASD). In this study 18 boys ($M = 91.67$, $SD = 14.26$ age in month) participated, and were divided randomly into two equal intervention groups (with vs. without metacognitive guidance). The intervention was based on a computer game (C-Me), that contains four cartoon characters. Each character has three problems to solve with the help of the child, who was requested to make an eye contact with the character in order to proceed in the game. C-Me monitored the participants' eyes and head movements while playing, using a laptop built-in camera. The participants played with C-Me for six 30-minute sessions, and their ability to make eye contact was measured pre- and post-intervention. The results indicate a significant improvement in eye contact in favor of the metacognitive intervention group, as compared to the non-metacognitive intervention group. The results will be discussed during the conference.

Keywords: Eye contact, Metacognition, Technology, Autism Spectrum Disorder, Intervention.

Theoretical background

The aim of the current study was to examine the effect of an innovative technological intervention program combining meta-cognitive guidance, on making eye contact among children with Autism Spectrum Disorder (ASD), a neuro-developmental disability. Children with ASD present difficulties in communication and social interactions, and in behavioral patterns (APA, 2013). Difficulty in making eye contact is one of the most recognized symptoms of ASD (Altay, 2019), a difficulty that might lead to repeatedly missing opportunities for social and emotional learning (Trevisan et al., 2017). Eye contact, like gestures and facial expressions, is a means for non-verbal communication, which occurs during face-to-face interactions (Nakano & Ishii, 2010). Children with high functioning ASD (HFASD) have normal IQ (IQ>75) (Filipe et al., 2018), usually do not understand the social meaning of eye contact, and they are less inclined to derive information from a gaze (Wang et al., 2020).

Previous interventions for improving eye contact among children with ASD, using various prompts and reinforcements, were documented; nevertheless, the current study is the first to use metacognition, as far as we know. Metacognition refers to a person's ability to think about his/her own thoughts (Flavell, 1976), which includes components of knowledge regarding an individual's thinking (metacognitive knowledge), and the ability to regulate his/her cognitive processes (metacognition regulation). Self-regulation includes three skills: 1) *planning* – choosing suitable thinking strategies before task performance and allocating resources for optimal performance. 2) *Monitoring and control* – conscious activity while monitoring the task performance. 3) *Evaluation* – reflective assessment of the processes and products of the thinking (and the task) upon task completion (Woolfok, 2019).

Most people with ASD are naturally inclined to use technology and learn with computers (Alves et al., 2013; Valencia et al., 2019). By using a variety of assistive technologies, different researchers were able to develop social and communication skills among HFASD children (e.g., Eden & Oren., 2021). A few recent studies tested the efficiency of using computer games (e.g. Miller et al., 2018), robots (e.g. Feng et al., 2013; Yun et al., 2017), computerized animation (e.g. Charlton et al., 2020), and augmented reality (e.g. Escobedo et al., 2012) for promoting eye contact among children and adolescents with ASD. Some of those studies used direct interventions, in which promoting eye contact is the main objective. Others might be indirect interventions, where eye contact is only one component of a more complex social-emotional skill (Ninci et al., 2013). Only a small number of studies have tested the effect of a metacognition-based intervention in a technological environment on various functions, among people with special needs. Studies indicated that using an educational digital book with metacognitive guidance showed improvement in preschoolers at risk of learning disabilities rhyming abilities (Shamir & Lifshitz, 2013), improvement in children's vocabulary and story- comprehension abilities after using specific metacognitive guidance (Shamir & Dushnitzky, 2019), and improvement in reading comprehension among 18 deaf and hard-of-hearing pre-academic college students (Alsalem, 2018).The metacognitive guidance in the current study followed the "Triple-A Model" (Shamir & Dushnitzky, 2019), whereas each A refers to one of three metacognitive skills (mentioned above): the first A stands for *"Aim"* – What do I want to do? (aimed at understanding the task); the second A stands for: *"Action"* – What am I doing? (monitoring and control of my actions while addressing the task); the third A stands for *"Assessment"* – What did I learn from addressing the task? (evaluation and reflection). Among participants with ASD, it was found that metacognitive intervention improves shopping efficiency indices with a virtual reality supermarket environment (Lamash & Josman, 2021). An additional study, conducted among children with ASD, tested the impact of integrating a computer game with metacognitive guidance provided by an adult, on attention and executive functions. Interviews held with the parents and teachers indicated an improvement in the children's social abilities following the integrated intervention (Macoun et al., 2020). Studies also found a significant contribution of metacognition to the prediction of children with ASD social skills (Bednarz et al., 2020; Leung et al., 2016; Torske et al., 2018). According to these findings, as well as the fact that the current study focused on children with a normative level IQ (> 75) (Filipe et al., 2018), we used a direct metacognitive technology intervention for promoting eye contact.

Method

Participants

Eighteen boys with HFASD, ages 5-9 (M = 91.67, SD = 14.26, in months), participated in this study. All attend special education preschool or first-grade classes, which are integrated in mainstream educational settings at central Israel. All children were diagnosed with ASD by an autism-specialist psychiatrist, and all have a normal IQ (> 75) according to the WISC-R test (Wechsler, 1974). The children were randomly assigned into two equal intervention groups, with or without metacognitive guidance. Demographic data on the children are presented in Table 1.

Table 1. Demographic data in division to intervention groups

Characteristic		Intervention without metacognition N (%)	Intervention with metacognition N (%)	Total N (%)
Age (months)	62-86	4 (44.4%)	1 (11.1%)	5 (27.8%)
	87-110	5 (55.6%)	8 (88.9%)	13 (72.2%)
Educational setting	Special preschool	3 (33.3%)	1 (11.1%)	4 (22.2%)
	Special class	6 (66.7%)	8 (88.9%)	14 (77.8%)
		9 (50%)	9 (50%)	18 (100%)

Observing the sample by groups shows that the research group is independent of the age $\chi^2_{(1)} = 2.49$, $p = .114$, and of the educational institution $\chi^2_{(1)} = 1.29$, $p = .257$.

Research tools

1. **Demographic questionnaire** – filled out by the teachers regarding personal details of the participants' such as age, gender, educational setting, intelligence level, etc.

2. **The software**– C-Me, a computer game adjusted for children with special needs aged > 5 years old, includes three stages: 1) *Practice* – children learn to control the mouse cursor by moving only their head and eyes, while trying to focus on an airplane on the screen. Only a direct gaze at the airplane will make it fly. 2) *Diagnosing eye contact* – examines the children's ability to make eye contact with a set character (basketball player). Only direct eye contact will make it dribble the ball, spin it on his finger and shoot it into the hoop. 3) *Game* – three characters are presented (a fireman, Superman, and a farmer), and the purpose of the game is to make direct eye contact with each character. During the game, the character asks the children to look it in the eyes so it can complete a task or solve a problem. For example, the children are asked to look into Superman's eyes in order to fix a bridge that has fallen. Each screen in the game while playing is divided into 8 areas: face, eyes, and 6 additional areas on the screen. For each area, the software provides the following data: *eye-contact duration* for each area (in percentage) and *total gaze time* (the cumulated time in seconds in which the child focused this gaze in all areas on the screen from start to finish of the game). These measures were analyzed.
3. **C-Me with metacognitive guidance** is identical to the one described above, apart from the specific metacognitive guidance, which was given via a childlike voice alongside the voices of the game characters. The childlike voice used specific guiding sentences and rhymed slogans as well as supportive visual markers which appeared on the screen. The metacognitive guidance referred only to the Aim and Assessment parts of the "Triple-A Model" (Appendix A).
4. **Intervention**: The intervention program was held twice a week for six 30 minutes sessions. The first and the sixth meetings were dedicated to measuring the children's eye contact performances pre- and post-intervention. Meetings two to five had the children play with their choice of either of the three other characters.

Procedure

The research included 4 stages: (1) *Pilot study* – following the software development, there was a pilot study that focused on 6 children (3 with typical development, 3 with HFASD), to test the operation and comprehensibility of C-Me. (2) *Pre-intervention* –the children participated in C-Me's practice stage and eye contact measurement by the software. (3) *Intervention program* – 4 meetings in which the children practiced making eye contact with C-Me (4) *Post-intervention* – measurements of eye contact by the software.

Results

A nonparametric analysis suitable for a small sample size was performed in order to test the effect of the interventions. First, in order to find differences in eye contact between the intervention groups before the intervention and after the intervention, we conducted Mann-Whitney tests for independent samples. We tested the average gaze duration on eyes, face, and areas 1-6 across the screen (in percentages) and overall gaze time (in seconds). The results are presented in Table 2.

Table 2. Eye contact duration (%) pre- & post-intervention divided to intervention groups

	Pre intervention						Post intervention					
Variable	**Intervention without metacognition (N=9)**		**Intervention with metacognition (N=9)**		**U**	***p***	**Intervention without metacognition (N=9)**		**Intervention with metacognition (N=9)**		**U**	***p***
	M	**SD**	**M**	**SD**			**M**	**SD**	**M**	**SD**		
Face	48.93	15.44	3.94	3.09	0	.000***	52.87	24.15	6.15	6.28	5.00	.002**
Eyes	28.55	8.38	30.48	14.31	38.50	.860	30.24	13.12	53.87	13.38	8.50	.005**
Area 1	7.20	4.75	14.97	13.64	21.50	.093	5.66	4.18	8.94	11.32	39.00	.893
Area 2	8.11	10.44	33.15	9.34	4.00	.001**	7.61	20.90	19.72	9.61	9.00	.004**
Area 3	1.30	3.16	5.85	6.31	18.00	.034*	0	0	5.50	5.04	13.50	.004**
Area 4	0.99	1.60	2.32	3.43	32.00	.393	2.27	4.07	1.25	2.52	36.00	.615
Area 5	3.37	6.16	3.87	4.77	36.00	.671	0.76	1.26	4.57	5.34	25.00	.133
Area 6	0.53	1.60	3.90	6.17	27.00	.131	0.58	1.75	0	0	36.00	.317
Total gaze time (seconds)	68.00	19.49	75.33	47.14	38.50	.860	73.78	44.91	36.44	14.27	8.50	.005**

$^*p < .05$, $^{**}p < .01$, $^{***}p < .001$

As seen in Table 2, no significant differences were found between the groups in percentage of eye contact duration and in the total gaze time in seconds, before the intervention. However, there were significant differences between the groups in percentage of face-gaze duration in favor of the intervention group without metacognition, and in percentage of areas 2 and 3 gaze duration in favor of the metacognitive intervention group. After the intervention, significant improvement was found in percentage of eye-contact duration in favor of the metacognitive group. The efficiency of the gaze focus is also observed in the overall gaze time in seconds, which was shorter in the metacognitive group. Significant differences still exist between the groups in percentage of face-gaze duration (in favor of the intervention group without metacognition) and in areas 2 and 3 (in favor of the metacognitive intervention group).

In order to find differences in the intervention efficiency (the value received as a result of decreasing the score at the beginning of the intervention from the score at the end of the intervention) between the groups, we conducted Mann-Whitney tests for independent samples. We tested the intervention efficiency measures, which were calculated for the average gaze duration on eyes, face, and areas 1-6 across the screen in percentages and overall gaze time in seconds. The results indicated that the efficiency measure was significant only for the percentage of eye-contact duration, $U = 2.00$, $p = .001$, and for the overall gaze time in seconds, $U = 8.50$, $p = .005$, in favor of the metacognitive group (eye contact duration: $M = 23.40$, $SD = 8.52$; total gaze time: $M = -38.89$, $SD = 33.48$) in comparison to the group without metacognition (eye contact duration: $M = 1.68$, $SD = 7.99$; total gaze time: $M = 5.77$, $SD = 34.70$).

In order to find differences in eye contact post-intervention in each intervention group, we conducted Wilcoxon tests for independent samples for each group separately. We tested the average gaze duration on eyes, face, and areas 1-6 across the screen in percentages and overall gaze time in seconds. There were no significant differences within the intervention group without metacognition between pre- and post-intervention in all tested measures. The results for the metacognitive intervention group are presented in Table 3.

Table 3. Differences in eye contact duration (%) pre- and post-intervention within the metacognitive intervention group

Variable	**Pre**		**Post**		**W**	***P***
	M	**SD**	**M**	**SD**		
Face	3.94	3.09	6.15	6.28	-0.84	.398
Eyes	30.48	14.31	53.87	13.38	-2.66	.008**
Area 1	14.97	13.64	8.94	11.32	-1.36	.73
Area 2	33.15	9.34	19.72	9.61	-2.07	.038*
Area 3	5.85	6.31	5.50	5.04	-0.14	.889
Area 4	2.32	3.43	1.25	2.52	-0.73	.465
Area 5	3.87	4.77	4.57	5.34	-0.28	.779
Area 6	3.90	6.17	0	0	-1.83	.068
Total gaze time (seconds)	75.33	47.14	36.44	14.27	-2.67	.008**

*$p < .05$, **$p < .01$

Table 3 indicates that after the intervention there was significant improvement in the percentage of eye-contact duration. In addition, the gaze-time duration in area 2 (the area where the eyes were placed) in percentage was significantly narrowed down. The efficiency of the gaze focus was also observed in the overall gaze time measure (in seconds), which was significantly narrowed down in favor of the intervention.

Discussion

The current study explored the impact of metacognitive guidance embedded in technological intervention for promoting eye contact among children with HFASD. According to the results, we can conclude with caution that integrating metacognitive guidance in a technological intervention is efficient for improving eye contact among children with HFASD. This contribution joins previous findings, which focused on populations of children with special needs (Alsalem, 2018; Lamash & Josman, 2021; Shamir & Dushintzky, 2019). In contrast to these cited studies, which tested the influence of metacognitive technology interventions on cognitive and functional processes (e.g., reading comprehension, literacy and shopping skills), the outcomes of using C-Me has not yet been tested on communicative, social, and cognitive processes. In more pervasive further attempts to study C-Me, we intend to examine the effects on similar processes.

As stated, previous research found the meaningful contribution of metacognition in predicting the social abilities of ASD children and adolescents (Bednarz et al., 2020; Leung et al., 2016; Torske et al., 2018). The current research findings expand those findings, since it examined the impact of metacognitive guidance as a direct change instigator, on promoting one of the key social and communication skills in children with HFASD – eye contact. The specific metacognitive guidance that was integrated in the software used metacognitive regulation skills according to the Triple-A model. The main differences between the two C-Me versions existed only in two components: goal definition (Aim), and evaluation and reflection (Assessment). McMahon et al. (2016) found impairments in the metacognitive monitoring ability of ASD children. Since this ability is impaired, focusing the metacognitive guidance in a way that strengthens goal and evaluation skills seems to be effective.

Another explanation refers to the verbalization of the metacognitive regulation processes by using an additional (childlike) voice. According to Ellis et al. (2014), one of the ways to establish a learning environment that nurtures metacognition is by verbalizing out loud or through inner dialogue, while demonstrating or by practicing metacognitive strategies. In the current research verbalization of the Aim/Assessment guiding sentences and rhymed slogans was present. Literature shows that children with ASD have difficulties with inner dialogue (Mulvihill et al., 2020), and that inner dialogue is related to emotional self-regulation (a re-evaluation strategy) (Albein-Urios et al., 2020). In this context, the current research used a childlike voice, allowing the children to internalize it, and thus using it to improve their ability to make eye contact.

To conclude, integrating metacognitive guidance within technological intervention for promoting eye contact is especially efficient for children with ASD. Further studies are needed to compare the results with children with ASD who engaged with computer games that do not have direct guidance for eye contact. Follow-up studies are recommended in order to examine the ability to replicate simulated eye-contact ability into real human eye contact (generalization effect), and to examine the efficiency of the intervention by measuring how long the effect remains after the intervention (consolidation effect). It is recommended to repeat the tests with software that use human figures, and to examine how the eye contact improvement with C-Me is expressed in the ASD children's communicative, social and cognitive abilities.

References

Albein-Urios, N., Youssef, G., Klas, A., & Enticott, P. G. (2020). Inner Speech Moderates the Relationship Between Autism Spectrum Traits and Emotion Regulation. *Journal of Autism and Developmental Disorders*. https://doi.org/10.1007/s10803-020-04750-7

Alsalem, M. A. (2018). Exploring metacognitive strategies utilizing digital books: Enhancing reading comprehension among deaf and hard of hearing students in Saudi Arabian higher education settings. *Journal of Educational Computing Research, 56*(5), 645-674. https://doi.org/10.1177/0735633117718226

Altay, M. A. (2019). Family physicians' awareness of autism spectrum disorder: Results from a survey study. *Open Access Macedonian Journal of Medical Sciences*, *7*(6), 967-972. https://doi.org/10.3889/oamjms.2019.199

Alves, S., Marques, A., Queirós, C., & Orvalho, V. (2013). LIFEisGAME prototype: A serious game about emotions for children with autism spectrum disorders. *PsychNology Journal*, *11*(3), 191-211.

American Psychiatric Association [APA]. (2013). *Diagnostic and statistical manual of mental disorders: DSM-5* (5th ed.). Arlington, VA: Author.

Bednarz, H. M., Trapani, J. A., & Kana, R. K. (2020). Metacognition and behavioral regulation predict distinct aspects of social functioning in autism spectrum disorder. *Child Neuropsychology, 26*(7), 953-981. https://doi.org/10.1080/09297049.2020.1745166

Charlton, C. T., Kellems, R. O., Black, B., Bussey, H. C., Ferguson, R., Goncalves, B., Jensen, M., & Vallejo, S. (2020). Effectiveness of avatar-delivered instruction on social initiations by children with Autism Spectrum Disorder. *Research in Autism Spectrum Disorders*, *71*. https://doi.org/10.1016/j.rasd.2019.101494

Eden, S., & Oren, A. (2021). Computer-mediated intervention to foster prosocial ability among children with autism. *Journal of Computer Assisted Learning, 37*(1), 275-286. https://doi.org/10.1111/jcal.12490

Ellis, A. K., Denton, D. W., & Bond, J. B. (2014). An analysis of research on metacognitive teaching strategies. *Procedia-Social and Behavioral Sciences, 116*, 4015-4024. https://doi.org/10.1016/j.sbspro.2014.01.883

Escobedo, L., Nguyen, D. H., Boyd, L., Hirano, S., Rangel, A., Garcia-Rosas, D., ... Hayes, G. (2012). MOSOCO: A mobile assistive tool to support children with autism practicing social skills in real-life situations. In *CHI '12: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 2589-2598). https://doi.org/10.1145/2207676.2208649

Feng, H., Gutierrez, A., Zhang, J., & Mahoor, M. H. (2013, September). Can NAO robot improve eye-gaze attention of children with high functioning autism?. In *2013 IEEE International Conference on Healthcare Informatics* (pp. 484-484). https://doi.org/10.1109/ICHI.2013.72

Filipe, M. G., Frota, S., & Vicente, S. G. (2018). Executive functions and prosodic abilities in children with high-functioning autism. *Frontiers in Psychology*, *9*. https://doi.org/10.3389/fpsyg.2018.00359

Flavell, J. H. (1976). Metacognitive aspects of problem solving. In L. B. Resnick (Ed.). *The Nature of Intelligence.* (pp. 231-235). NJ: Hillsdale, Erlbaum.

Lamash, L., & Josman, N. (2021). A metacognitive intervention model to promote independence among individuals with autism spectrum disorder: Implementation on a shopping task in the community. *Neuropsychological rehabilitation, 31*(2), 189-210. https://doi.org/10.1080/09602011.2019.1682621

Leung, R. C., Vogan, V. M., Powell, T. L., Anagnostou, E., & Taylor, M. J. (2016). The role of executive functions in social impairment in Autism Spectrum Disorder. *Child Neuropsychology, 22*(3), 336-344. https://doi.org/10.1080/09297049.2015.1005066

Macoun, S. J., Schneider, I., Bedir, B., Sheehan, J., & Sung, A. (2020). Pilot Study of an Attention and Executive Function Cognitive Intervention in Children with Autism Spectrum Disorders. *Journal of Autism and Developmental Disorders*. https://doi.org/10.1007/s10803-020-04723-w

McMahon, C. M., Henderson, H. A., Newell, L., Jaime, M., & Mundy, P. (2016). Metacognitive awareness of facial affect in higher-functioning children and adolescents with autism spectrum disorder. *Journal of Autism and Developmental Disorders*, *46*(3), 882-898. https://doi.org/10.1007/s10803-015-2630-3

Miller, N., Wyatt, J., Casey, L. B., & Smith, J. B. (2018). Using computer-assisted instruction to increase the eye gaze of children with autism. *Behavioral Interventions*, *33*(1), 3-12. https://doi.org/10.1002/bin.1507

Mulvihill, A., Carroll, A., Dux, P. E., & Matthews, N. (2020). Self-directed speech and self-regulation in childhood neurodevelopmental disorders: current findings and future directions. *Development and psychopathology, 32*(1), 205-217. https://doi.org/10.1017/S0954579418001670

Nakano, Y. I., & Ishii, R. (2010). Estimating user's engagement from eye-gaze behaviors in human-agent conversations. In *IUI '10: Proceedings of the 15th International Conference on Intelligent User Interfaces* (pp. 139-148). https://doi.org/10.1145/1719970.1719990

Ninci, J., Lang, R., Davenport, K., Lee, A., Garner, J., Moore, M., Boutot, A., Rispoli, M., & Lancioni, G. (2013). An analysis of the generalization and maintenance of eye contact taught during play. *Developmental Neurorehabilitation*, *16*(5), 301-307. https://doi.org/10.3109/17518423.2012.730557

Shamir, A., & Dushnitzky, G. (2019). Metacognitive intervention with e-books to promote vocabulary and story comprehension among children at risk for learning disabilities. In J. E. Kim & B. Hassinger-Das (Eds.), *Reading in the digital age: Young children's experiences with e-books* (pp. 237-257). Cham: Springer.

Shamir, A., & Lifshitz, I. (2013). E-Books for supporting the emergent literacy and emergent math of children at risk for learning disabilities: can metacognitive guidance make a difference?. *European Journal of Special Needs Education*, *28*(1), 33-48. https://doi.org/10.1080/08856257.2012.742746

Torske, T., Nærland, T., Øie, M. G., Stenberg, N., & Andreassen, O. A. (2018). Metacognitive aspects of executive function are highly associated with social functioning on parent-rated measures in children with autism spectrum disorder. *Frontiers in Behavioral Neuroscience, 11*. https://doi.org/10.3389/fnbeh.2017.00258

Trevisan, D. A., Roberts, N., Lin, C., & Birmingham, E. (2017). How do adults and teens with self-declared autism spectrum disorder experience eye contact? A qualitative analysis of first-hand accounts. *PLoS One*, *12*(11). https://doi.org/10.1371/journal.pone.0188446

Valencia, K., Rusu, C., Quiñones, D., & Jamet, E. (2019). The impact of technology on people with autism spectrum disorder: A systematic literature review. *Sensors*, *19*(20). https://doi.org/10.3390/s19204485

Wang, Q., Hoi, S. P., Wang, Y., Lam, C. M., Fang, F., & Yi, L. (2020). Gaze response to others' gaze following in children with and without autism. *Journal of Abnormal Psychology, 129*(3), 320-329. https://doi.org/10.1037/abn0000498

Wechsler, D. (1974). Manual for the Wechsler intelligence scale for children. Psychological Corporation.

Woolfok, A. (2019). *Educational Psychology* (14th edition). Pearson Publishing.

Yun, S. S., Choi, J., Park, S.-K., Bong, G.-Y., & Yoo, H. (2017). Social skills training for children with autism spectrum disorder using a robotic behavioral intervention system. *Autism Research*, *10*(7), 1306-1323. https://doi.org/10.1002/aur.1778

Appendix A

C-Me script:

Adult's recorded voice saying (white boxes): Thanks for your willing to play with me. Are you ready? Look, the house on fire! We need to put out the fire. In order to do this, you must look in my eyes. Where are my eyes? Can you please point at them? Great! Only if you look in my eyes, we will be able to put it out.
Child's recorded voice saying / metacognitive guidance (gray boxes): [eyes image sign appears] Our goal is to look in the fireman's eyes.
Only if you look in my eyes, we will be able to put it out.
A simple gaze for some praise [eye image sign disappears]

Following the first eye contact:

Very good!

Following the second eye contact:

Excellent!

Following the third eye contact:

Well done! The house is not burning anymore. Thank you for helping me. Looking in the eyes is important!
[stop sign appears] Stop and think! What were you looking at before, the fireman’s eyes or something else?
Don’t look away and win today. Looking in the eye is important [stop sign disappears]