Psychology of Language and Communication 2021, Vol. 25, No. 1

sciendo

DOI: 10.2478/plc-2021-0011

Lisa Andréen[1,2,*], Martyna Galazka[1*], Nouchine Hadjikhani[1,3,*], Steven Jeuris[4,5,6*], Paolo Masulli[4,5,*], and Jakob Åsberg Johnels[1,2,7,*]

[1] Gillberg Neuropsychiatry Centre, Sahlgrenska Academy, Gothenburg University, Sweden

[2] Child and Adolescent Psychiatric services, Queen Silvia Children's Hospital, Göteborg, Sweden

[3] Martinos Center for Biomedical Imaging, Harvard Medical School, Boston, Massachusetts, United States of America

[4] Department of Applied Mathematics and Computer Science DTU Compute, Section for Cognitive Systems, Technical University of Denmark, 2800 Kgs. Lyngby, Denmark

[5] iMotions A/S, 1621 Copenhagen V, Denmark

[6] Department of Health Tech, Digital Health Section, Technical University of Denmark, 2800 Kgs. Lyngby, Denmark

[7] Section of Speech and Language pathology, Sahlgrenska Academy, Gothenburg University, Sweden

Developing tolerance to eye contact in autism: A feasibility study with adults using behavioral, interview, and psychophysiological data

[*] The authors made an equal contribution.

Address for correspondence: Jakob Åsberg Johnels, Institute of Neuroscience and Physiology, University of Gothenburg, Göteborg, Sweden

E-mail: jakob.asberg@gnc.gu.se

This is an open access article licensed under the CC BY NC ND 4.0 License.

Many individuals with autism report that eye contact makes them stressed or uncomfortable. Besides expressing their right to respect for neurodiverse ways of nonverbal communication, some autistic individuals also express the wish to improve their capacity to tolerate eye contact. In the current study, five autistic adults completed a 21- to 28-day computerized program that combines psychoeducation with graduated exposure to eye contact through photos. Interview data, questionnaires, gaze patterns, and psychophysiological measures indexing stress and arousal (pupillary and galvanic skin response levels) were collected to monitor and evaluate outcomes. At intake, discomfort resulting from eye contact in everyday life was described as overwhelming and multifaceted. Post-training data showed that observed increases in eye contact were not happening at the expense of heightened arousal. These results provide information about the (complex) nature of eye gaze discomfort in autism while pointing toward promising techniques to increase discomfort tolerance.

Key words: psychoeducation, autism, arousal, nonverbal communication, eye contact

Introduction

"An eye can threaten like a loaded and levelled gun, or it can insult like hissing or kicking; or, in its altered mood, by beams of kindness, it can make the heart dance for joy."

— Ralph Waldo Emerson (1876)

As illustrated by the above quote, the eyes of others hold a special status during social communication. Among other things, from the eyes we can get clues about a person's intentions and feelings. We also utilize subtle visual cues from the eye region to regulate conversations, including turn-taking. Looking in the eyes of one's interlocutor is often considered a sign of being honest, attentive, and compassionate, at least among lay people in western society (Maratos et al., 2019). Several patient groups within psychiatry and neurology who show alterations in engaging in eye contact with others, which may contribute to the social and communicative difficulties they experience. A group of individuals who have been particularly in focus from this perspective are those with an autism diagnosis[1] (Seltzer et al., 2003).

Reduced eye contact is a common issue among both children and adults diagnosed with autism spectrum disorder (ASD, Lord & Risi, 2003). But what exactly do such alterations of eye contact depend on? Historically, there has been several theories of autism that place eye contact deviations as key aspects of the social-communicative difficulties that define this disability. It has commonly

1 In the recent years, there has been much debate over the use of identity-first (e.g., *autistic people*) versus person-first (*people with autism*) terminology in describing this particular population. Although the official APA recommendations are to use the person-first terminology, many within the disability community oppose it as it tends to perpetuate the stigma associated with the disability (Gernsbacker, 2017). In acknowledging the ongoing debate as well as the wider audience of the current study, we opted to use both person-first and identity-first terminology flexibly and interchangeably, thereby hopefully promoting a value-neutral option to identify a group of people, acknowledging variations in preferences and consensus among the group while promoting sensitivity in academic writing (Dunn & Andrews, 2015).

been assumed that these alterations reflect a fundamental social disinterest on the part of the individual — for example, that the lack of eye contact reflects one of the most obvious signs of social detachment (Kanner, 1943). From this perspective, it is not difficult to understand why much of the early research on eye contact, as well as a lot of clinical activity since, has been based on the principles of behaviorism where, with the help of external rewards, attempts are made to increase the amount of eye contact. For example, in an early study by Foxx (1977), three individuals with autism and intellectual disabilities were taught to make eye contact with a therapist according to the following procedure: the therapist held an edible object (e.g., a cookie) next to his own eye region and instructed the individual with autism to "Look at me." If the patient established eye contact, the therapist gave them the cookie along with verbal praise. On the other hand, if the participant did not establish eye contact within five seconds, the therapist physically moved the patient's head upward, then downward, and finally straight ahead, holding each position for 15 seconds, presumably because eye contact requires correct head orientation. This became known as "functional movement training."

However, one problem is that this type of approach is not based on any evidence of what the lack of eye contact in autism reflects or what it depends on. In addition, this method raises concerns from the ethical perspective. Furthermore, long-term follow-up studies are sparse. Generally, few studies have asked autistic individuals directly about their own experiences with eye contact (McGlensey, 2016), which reflects a more general shortcoming in the autism research literature (Jaswal & Akhtar, 2018). One interesting exception is a study by Trevisan et al. (2017), who analyzed how individuals with a self-declared ASD diagnosis describe eye contact. Examining comments on various online forums, the authors found that, in general, eye contact was described as a negative experience accompanied by adverse emotional and physiological reactions, sensory overload, feeling of being invaded, and, for some, as a "physically painful discomfort" (Trevisan et al., 2017). Thus, including the voices of autistic individuals themselves in the development and evaluation of any intervention appears to be mandatory from both the efficiency and ethical perspectives.

Based on such findings, it is likely that eye contact avoidance in autism might be a way of avoiding feelings of overarousal rather than a reflection of disinterest and lack of motivation. To our knowledge, it has never been studied whether autistic children differ from autistic adults in terms of their awareness of eye contact difficulties and their consequences. However, recent research utilizing psychophysiological measures suggests that at least adolescent and adult autistic individuals are most likely emotionally overwhelmed during eye contact and, therefore, often actively avoid it. Also, it has been demonstrated in adolescents and adults that activation in the brain's rapidly processing threat system (including one of the subcortical emotional brain centers, the amygdala) was atypically hyperactive in autistic individuals when they were required to look

at photographs of faces and maintain their gaze at the eye region (Hadjikhani et al., 2017; see also Dalton et al., 2005; Kliemann et al., 2012). Similarly, studies examining psychophysiological components of autonomic system arousal, such as pupillary reaction (Eberhard et al., in preparation) and skin conductance levels (Kliemann et al., 2012) , found elevated responses to photos of faces in general (Joseph et al., 2008) and with direct eye gaze in particular (Kylliäinen & Hietanen, 2006) in autistic children and adults compared with nonautistic controls.

Given this increasing evidence, it has been proposed that it is irresponsible and patronizing to insist that autistic individuals practice maintaining eye contact in order to meet neurotypical social expectations (https://www.learnfromautistics.com/eye-contact-and-autism/). That being said, our clinical experience is that some adults with autism do express the wish to improve their tolerance to eye contact in order to facilitate interactions with others. It is obviously important that these individuals are provided with appropriate intervention. In the current study, we examined whether such an intervention could be accomplished in autistic participants through first acknowledging difficulties associated with eye contact and learning about the nature and sources of the discomfort (psychoeducation), and then gradually exposing the participants to the challenging stimulus on their own terms in order to desensitize them to that stimulus (i.e., eye contact with other people). Several studies have shown that these principles, derived from cognitive behavioral therapy (CBT, Fenn & Byrne, 2013; Perihan et al., 2020; Wright, 2006) are effective in reducing phobias and anxiety in people with autism, provided that treatment protocols are modified with support specifically aimed at difficulties with social communication and reciprocity (Kose et al., 2018; Ung et al., 2015).

The current study aims to evaluate the usefulness and feasibility of a new exercise program called Ögonblick. In this program, autistic individuals who wish to improve their tolerance to eye contact may do so through an at-home computer-based gradual-exposure program with psychoeducational content. We assumed that a computer-based setup might be particularly feasible and effective since the participants can perform the exercises in the comfort of their homes, circumventing communication challenges they may encounter during in-person training and/or in a laboratory setting. The program contains seven different modules in which the participants gaze at the eye region of photos with faces. There is a gradual increase in difficulty level, with an increased prominence of eye contact in the latter modules. The program starts with (psychoeducation about eye contact discomfort and CBT-based exposure therapy. Then within each module, an automatic built-in feedback function allows the participants to move from one module to the next once a minimum threshold of amount of eye gaze is achieved. We uniquely collected different data types to monitor and preliminarily evaluate the training effects. The data consisted of interviews and questionnaires, infrared eye tracking, and psychophysiological indices (pupillary reactions and galvanic skin response, GSR). We want to highlight that the provision of such individual support is not in conflict with respecting neurodiverse ways of

functioning. This kind of technique does not aim at a forceful "normalization" of autistic people. Rather, the idea is to see whether the approach can provide help to those who wish to improve their tolerance to eye contact. Guided by the mixed-methods single case research methodology, the following three research questions (RQs) were formulated:

RQ1: How do the participants experience and cope with their eye contact difficulties? This question was raised in order to better understand the participants' current concerns. As argued above, this is not only important in and of itself, but also because it lays an important foundation for the training.

RQ2: Is there evidence of change in discomfort levels during the training period, as assessed through GSR and self-reports of positive and negative affect?

This question was raised to verify whether the possible effects of the training happen at the expense of psychological wellbeing of the participants, which we wanted to avoid. In addition, it provided a unique possibility to monitor the quality of data registration and adherence to practice in this home-based, psychophysiological training study.

RQ3: Are there changes between pre- and post-training in (a) spontaneous eye gaze, (b) emotional arousal and stress levels, or (c) self-reported perceived effect at follow-up?

This question targeted several issues regarding the measured and reported changes to eye gaze and arousal before and after the training, as well as the perceived meaningfulness of taking part in the training.

Method

Participants

Participants were recruited through advertisement and through ongoing contacts at the Gillberg Neuropsychiatry Centre (GNC) in Gothenburg, Sweden. Six participants with self-identified difficulties in maintaining eye contact, and who themselves wished to see whether they could improve this capacity, contacted us. One participant (P4) dropped out and discontinued training. This participant was the only one who did not have a formal ASD diagnosis, and we had discussed with her during the pretest session whether this training program would be appropriate for her, considering that she did not experience difficulties engaging in eye contact with the pictures. Data from this participant was excluded from the analyses.

The other five participants (three women, two men, aged 32-53 years) were all previously diagnosed with ASD. Four of them had received their diagnosis in adulthood. As is common for adults with autism, comorbidities were also present, including ADHD and anxiety disorders. Three of the five participants

held a job at the time of the study, including one that required higher education. All five lived independently, and three out of five were married and had children. We refer to them as P1, P2, P3, P5 and P6 in the results.

Design, Procedure, and Data Collection

Our research methodology was inspired by the mixed-methods literature (Creswell, 2014) and, in particular, the single case mixed methodology as described by Onghena et al. (2019). In this approach, different data sources are collected and, to the extent that it is possible, integrated with the aim of providing a rich description of the treatment process. This approach is considered especially relevant "if the research question is not merely 'Does it work?' but also involves issues of process, feasibility, appropriateness, and meaningfulness" (Onghena et al., 2019, pp. 436). In the current study, we uniquely collected, analyzed, and integrated interview data, behavioral data, and clinical ratings, as well as psychophysiological recordings.

Pre-and Post-Training Visits: "In the Lab"

Figure 1 illustrates the overall design of the study, organized around the research questions. The figure also shows the study procedure. It indicates that pre- and post-training assessments took place in the lab (at the GNC lab), while the training program was self-administered at home by the participants.

While at the GNC, each participant met with two members of the research team who have extensive practical experience in working with individuals with autism as a PhD-level educator and clinical psychologist, respectively. During the pre-training visit, the participants were given a laptop computer, a Shimmer skin conductance unit and an eye tracker, and received training on how to properly use the equipment at home. Each participant was instructed on how to attach the eye tracker to the screen monitor, how to put on the Shimmer sensor for skin conductance measure, and how to start the training program. Along with the set-up training, the pretraining session at GNC included a semi-structured interview, which was carried out to assess the participants' experienced difficulties and current strategies used to manage eye contact and social interactions in everyday situations. A similar semi-structured interview was also conducted after the training in order to assess the perceived effects and meaningfulness of having conducted the training program.

A number of additional measures were taken in order to support the participants in conducting the training independently in their home, based on previous studies that showed the need for modifying treatment protocols, with support specifically aimed at autism-related difficulties in order to increase participation and fidelity (National Institute for Health and Clinical Excellence (NICE), 2012; Kose et al., 2018; Ung et al., 2015). Along with guided practice in how to set up and apply

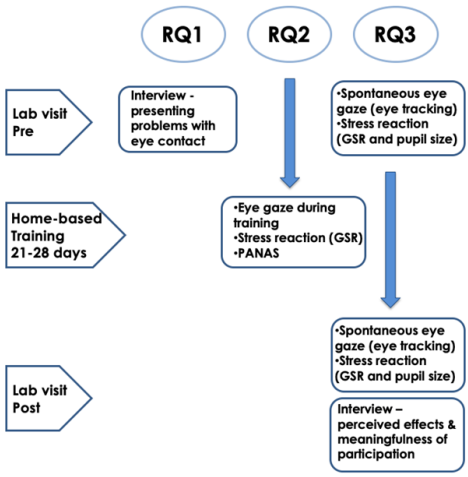


Figure 1. Project flowchart depicting the order of the visits and data collection. GSR = galvanic skin response; PANAS = Positive and Negative Affect Schedule; RQ = research question.

the training, adjustments included providing written and picture-based support in the form of checklists to help with conducting the training independently, and scheduling structured follow-ups for assistance as needed.

Finally, as part of the pre- and post-training visit, the participants' eye gaze, pupillary reactions, and galvanic skin response (GSR) were collected while they observed still images of emotionally expressive and neutral human faces.

Apparatus and Software "In the Lab"

During the pre- and post-training session in the lab, gaze and pupil response measures were collected using a Tobii T120 (Tobii Technology Inc., Danderyd, Sweden) eye tracker, integrated in a 17 in. (33.7 × 27 cm) monitor which used infrared light projections to record reflections from both eyes at 120 Hz. After being seated in a chair at around 60 cm distance from the monitor, the participants were instructed to simply look at the images presented on the screen. A standard nine-point calibration procedure preceded stimulus presentation, during which a small ball was shown at nine locations on the screen. The calibration was used not only to allow the eye tracker to detect and follow eye gaze but also to make sure the participants were seated at an appropriate distance from the screen. Calibration was considered incorrect when the eye tracker was unable to detect the eyes or when the participant was sitting too close or too far from the screen. In case of incorrect calibration, calibration was repeated until successful.

Galvanic skin response was measured from the proximal phalanges of the index and the middle fingers of the nondominant hand at sampling rate of 128 Hz

via the Shimmer3 GSR+ Unit (Shimmer, MA, USA). Ag/AgCl electrodes with constant voltage (0.5 V) (Lafayette Instrument, IN, USA) were used.

Both eye tracking and GSR signals were recorded via the iMotions Biometric platform (iMotions A/S, Copenhagen, Denmark) so that data could be synchronized using common system timestamps between these two signals.

Stimuli "In the Lab." Following the standard nine-point calibration, participants were instructed to look freely at the displayed images. Participants were shown 24 black-and-white photographs of human faces (12 male and 12 female) created from the NimStim set of facial expressions (Tottenham et al., 2009). Sixteen of these images included emotionally expressive faces (either angry or happy) and eight included neutral expressions. Images were shown in random order with each facial identity and emotional expression shown once for a duration of 6 s, preceded by a fixation cross which was presented for 15 s. The fixation cross served as a baseline measure with which GSR during image presentation was compared. The photographs were shown in a 1024 × 768-pixel array of which the faces (from the top of the head to the chin) were approximately 400 × 580 pixels (6.72 horizontal × 13.78 vertical visual degrees) presented against a light gray circular background, which was embedded in a dark gray square against black background (see Figure 2).

Training Program "In the Home." The training program, used at home by each participant, is called Ögonblick©. It was designed by authors NH and JÅJ based on their research (e.g., Hadjikhani et al., 2017) and practical experience. Ögonblick training includes looking at the eye region of a series of photos of faces for approximately 5 minutes per day. There is a total of seven modules in the program (see Table 1), with each module being presented three times, thus totaling 21 sessions, with one session per day. The face stimuli comprising the modules gradually evolve from inducing little or no stress to potentially generating more anxiety, according to our clinical experience and hundreds of hours of interviews with people with ASD.

The program starts with an audiotaped introduction describing eye contact and eye contact difficulties, as well as the principles of graduated exposure based on psychoeducation. The participants are then instructed to look at the photographs, especially the eye region. It is communicated to the participants that they should try to challenge themselves, but that if they feel too overwhelmed, they can look away briefly from the eyes and return once they feel ready again.



Figure 2. Examples of the face stimuli used 'in the lab' data collection.

Table 1. Module number and types of stimuli.	
Module	Stimuli
Module 1	Photos of animals
Module 2	Photos of babies
Module 3	Photos of people with diverted gaze
Module 4	Photos of children with direct gaze
Module 5	Photos of adults with neutral facial expressions
Module 6	Photos of adults with happy facial expressions
Module 7	Photos of adults with distressed (sad/angry) facial expressions

Apparatus and Software "In the Home." During the training period at home, gaze measures were collected using the Tobii X2-30 (Tobii Technology Inc., Danderyd, Sweden). Much like the eye tracker used in the lab, this eye tracker uses infrared light projections to record reflections from both eyes, but at 30 Hz, and is attached and detached to an ordinary laptop computer using a magnetic strip placed on the bottom of the monitor. The laptop used was an HP Envy with a 15 in. monitor. The same nine-point calibration procedure was used in the home as in the lab. Galvanic skin response was measured using the same unit as in the lab. Pupillary size was not considered for data collected at the participants' homes since the light conditions during which the training took place could not be controlled for, which would be a critical factor in this type of measure.

Much like in the lab, the eye tracking and GSR signals were recorded via the iMotions Biometric platform, so that data could be synchronized between these two signals. In addition, a new iMotions user interface was developed specifically for the training program to help the participants navigate the platform. This included a welcome screen that reminded the participant to connect the sensors and provided feedback on whether data was correctly being recorded. Once this was verified, the participant could press the START button, which led to the current module of the training program. Besides being user-friendly, an important feature of this application was that each session was repeated if the participant did not gaze at the eye region sufficiently, according to a built-in threshold of 25% of the total time that the face stimuli were presented.

Finally, after the first and third trial of each module, the participants answered questions based on the Positive and Negative Affect Schedule (PANAS) regarding their current emotional state (Watson et al., 1988).

Data Analysis

RQ1: How do the participating adults experience and cope with their eye contact difficulties?

An interview (approximately 30 minutes to one hour in length) regarding eye contact was carried out at the GNC before the training in the home. We used semi-structured interviews with open-ended questions about the experience of

eye contact that were supplemented with recommended support for people with autism, such as visual analog scales and response alternatives (Ortiz & Sjölund 2015). The response alternatives were based on how other autistic people have described eye contact (Trevisan et al., 2017) and were used when needed during the interviews.

*Thematic analysis***.** The interviews were transcribed and thematic analysis was used to identify the key themes within the answers to the open-ended questions. The thematic analysis followed six steps (Braun & Clarke 2006). The transcripts were read several times (Step 1) before producing initial codes from the data (Step 2). In sorting the codes into potential themes (Step 3), we iteratively used thematic maps to illustrate how they belonged to overarching topics, which were reviewed according to how the themes fit together and how they mirrored the data (Step 4). Next, we defined, named, and renamed the themes several times (Step 5). In the final analysis, they were captured by four main themes, each presented with illustrative quotes (Step 6). The analysis had a theoretical approach, in the sense that the coding was guided by a specific research question, and a semantic approach, such that the themes were identified in the participants' explicit statements.

RQ2: Is there evidence of change in stress level during the training period as assessed through GSR signals and self-reports of positive and negative affect?

The eye gaze and GSR data collected at home were analyzed in order to address this question

Eye gaze. For the eye gaze data, a rectangular area of interest (AOI) was defined around the eye region on each face stimulus in the training material. Given the diverse nature of the stimuli in each module (animals, humans of different ages, direct and diverted gaze) and the fact that naturalistic photos were used, the AOIs were manually drawn on each stimulus around the eyes. An eye gaze metric was defined for each stimulus as the ratio between the time the participant gazed in the AOI and the total presentation time separately for each day of the training.

*Galvanic Skin Response***.** Galvanic skin response was measured using a Shimmer3 GSR+ Unit sensor. The sensor has a 12 bit analog to digital converter (ADC) that converts voltage change resulting from increased moisture content of the skin to values between 0 and 4095 which are proportional to skin conductance. The raw ADC output value was transformed with a linear function in order to calculate the galvanic skin response (calGSR):

$$y = p1 * x + p2$$

For each module of the training program, the mean signal value during the initial introduction video (with a duration of 38 s) was used as baseline. The baseline value was subtracted from the signal during stimulus presentation (0-6

s). In order to account for individual differences in skin conductance levels, the difference was then divided by the baseline skin conductance levels resulting in calibrated GSR (Zhou et al., 2015).

Positive and Negative Affect Scale. A Swedish translation of the PANAS (Watson et al., 1988) was administered at the end of the first and final training day of each module (14 times) in order to determine how the participants were feeling at that moment. The PANAS is an instrument with high validity and reliability in both clinical and nonclinical settings (Merz et al., 2013) as a means of delineating immediate outcomes of therapeutic interventions. The participants are presented with a list of 20 affect terms (both positive and negative) to judge on a Likert scale from "Not at all/Very slightly" to "Extremely" as it applies to them at the moment. Positive affect includes feeling "excited," "interested," "strong," "enthusiastic," "proud," "alert," and "determined," while negative affect is identified in emotion words such as "distressed," "upset," "guilty," and "irritable." Both the negative ($\alpha = .87$) and the positive ($\alpha = .91$) PANAS scores have shown excellent reliability in previous research (Díaz-García et al., 2020).

RQ3: Are there changes between pre- and post-training in (a) spontaneous eye gaze, (b) emotional arousal and stress levels, or (c) self-reported perceived effect at follow-up?

The eye gaze, pupil size, and GSR data collected in the lab, as well as the data from the semi-structured interviews were analyzed in order to address this question.

To examine the amount of eye gaze, an AOI was created for each image around the eye region. The AOI was 247 × 92 pixels and corresponded to 4.15 horizontal × 2.19 vertical visual degrees. For each participant and stimulus presentation, the eye gaze data was analyzed with the same method used for RQ2, namely, by calculating the ratio of the time spent gazing within the defined AOI and the total time spent gazing at the screen. Stimuli where the participant did not have any valid eye tracking samples were removed (three stimuli in total).

Data files for the pupil response and GSR were exported from iMotions and were processed within the TimeStudio program (Version 3.19; timestudioproject.com; Nyström et al., 2016), a MATLAB based open-source analysis tool specifically designed for analyzing timeseries data.

The processing of pupil responses within TimeStudio included a linear interpolation of the gaps up to five samples, followed by smoothing of the entire dataset using a moving average over 10 samples. Trials that were missing more than 40% of sampled data due to technical problems or inattention were rejected from the analysis. These constituted 10.8% of all collected data. Pupil size values of the remaining trials were adjusted using the first second of the image presentation as the baseline. This was done by subtracting the pupil size at the baseline (0-1 s) from the average pupil size during the analysis interval (1-6 s). Note that the end of the baseline interval at 1 s post stimulus onset also corresponds to the halfway point of the pupillary light reflex response, or the

initial dilation and contraction of the pupil due to the presence of a new stimulus.

The GSR data were analyzed with the same methodology used for RQ2, except that the baseline consisted of the average response during the 15 s fixation cross presented right before the stimulus presentation. The response was calculated as the difference between the response during the fixation cross (0-15 s) and stimulus presentation (0-6 s).

The statistical analysis for all three measures was performed with custom R scripts. Average GSR and pupil size for each image as well as the ratio of eye gaze were used in a nonparametric Wilcoxon signed ranks test examining the difference during pre- and post-training.

Finally, all participants took part in a semi-structured interview regarding the perceived meaningfulness and effect of the training, including generalizations to real world contexts. The interviews were supplemented with visual analog scales but had no response alternatives. Regarding the perceived meaningfulness and generalizations, we opted for a conservative approach by marking answers that did not easily translate into a "yes" or "no" response with a question mark. Qualitative and quantitative results were integrated and compared in a final analytical stage, as seen in Figure 3, by the use of joint displays (Creswell & Báez, 2020; Guetterman et al., 2015) comparing and analyzing whether the qualitative and quantitative results complemented or contrasted one another.

Results

RQ1: How do the participating adults with autism experience and cope with their eye contact difficulties?

Guided by procedures from the thematic analysis, the content of the interviews was summarized in four main themes: "Sensory-emotional over-arousal," "Wish to be perceived as normal and trustworthy," "Coping and strategies," and "Social contextual modulators." The key contents of these themes together with illustrative quotes are presented in Table 2. The four themes collectively present a picture of an everyday experience of negotiating social expectations in the face of the strong sensory reactions provoked by eye contact.

All participants reported that eye contact itself provoked a strong reaction. They described feeling uncomfortable or anxious and found it difficult to interpret what was communicated through eye contact. Many of the participants described it as an experience of unwanted intimacy, in that eye contact evoked a feeling that the other person came too close or that they revealed too much of themselves in a way that created physical discomfort. They described it as most difficult when meeting someone in person, but eye contact with a person in a photo, or with the news anchor on television, also caused considerable discomfort.

In addition to being uncertain about their ability to interpret eye contact, participants reported experiencing insecurity regarding what was expected of

Table 2. Overview of results from the interviews with the participants regarding the experience of eye contact.

Main theme	Subthemes	Illustrative quotes
Sensory-emotional overarousal	Hard to interpret	"[Eye contact] takes a lot of energy, but does not give me anything. It is just an unnecessary component or something."
	Unnatural/ uncomfortable	"I can't do it in passing. It will be more like, 'now I will look into the eyes'. But then it will be only looking in the eyes and then I have to remind myself that 'oh, I have to talk as well'. It is like that, there's no flow in it. It doesn't feel natural."
	Intimate: giving too much of oneself	"It's uncomfortable. It feels… unnatural. I don't know how else to explain it ... in some way I associate eye contact with ... love or something."
	Worried; being on guard	"Also, it is very uncomfortable with eye contact. Because it is… you´re feeling exposed in a way."
	Overloaded: too much information	"I can understand what it looks like from the perspective of others. Someone who doesn't even look at them when talking to them, who looks at a table or something. It seems like you're not listening. When in fact it's harder for me to listen if I look at them."
Wish to be normal and trustworthy	Experienced as normal	"Really, I don't think there should be anything called normal, but I still think it's important because [lack of eye contact] is perceived as a bit different. And I always strive not to be different."
	Get in touch / do not reject	"If someone sits down and tells you about something, then you have to have eye contact to show that you are listening and that you are interested. Even if you are not interested."
	Stand out as credible	"It is the same if you're going to the doctor or something. Then you also know that you have to look the person, or the doctor, in the eyes in order for him to believe what you say... and this is a dilemma. This can really stress me out."
Coping and strategies	Look elsewhere	"Although I usually look at the nose because then I don't have to look in the eyes, I'm cheating. It looks like you're looking in the eyes."
	Blurred focus	"It is as if you are shutting down in a way. Somehow you put on inner blinders and look them in the eyes anyway."
	Limit time	"Yes, that's also difficult. You don't want to end up staring. I have figured out that a few seconds at a time is enough for me."
	Choose other means of communication	"So, as far as possible, I communicate in writing. I very often misunderstand what people say. Especially at work when people try to be a bit smart and joke a lot. I am really bad at reading those kind of things. … Therefore, I often ask others to write to me."
Social-contextual modulators	Easier with animals and children	"I have absolutely no problem with dogs. I find them quite easy to read."
	Easier when felt understood	"… if I feel that she understands what I mean and such, then [maintaining eye contact] makes it easier. If I feel understood."
	Roles may facilitate	"But then if I, let's say that, that I have a certain role... that is, if I meet my neighbor then that makes me 'the neighbor" that maintain eye contact and we can talk about the weather for 10 minutes. It can work quite well even though I might feel, maybe a little bit stressed out. Because I still know what is expected of me and I have this role that somehow protects me."
	Expectations of shared emotions complicates	"Happy, inviting eyes is one of the most stressful things there is. Because if I then, in some way, feel that this person … likes me or is interested in me or something like that then what immediately follows is that now something more is expected of me."
	Engaging conversations with clear purpose helps	"If you start mixing in the need to small talk and stuff like that, then it takes up so much energy, and then… then [eye contact] instantly becomes much more difficult."

them once the interpersonal connection had been formed through eye contact. In this sense, what also became evident in our interviews was the complexity of eye contact as experienced by the participants. Indeed, the ability to maintain eye contact was described as being intertwined with issues of identity (one's own and others' expectations of "being normal" and "trustworthy"), of relating to others, and of monitoring how they would be perceived by others. The experience of eye contact was also described to be modulated by social contextual factors, which facilitated it or made it more difficult. Numerous tactics were utilized to cope with eye gaze, which entailed both strategies to camouflage and to cope with their emotions. Despite the fact that eye contact itself caused discomfort, knowing how much weight people tend to put into eye contact meant that the participants constantly dealt with an internal negotiation between trying to tolerate strong sensory-emotional reactions and a wish to take part in "normal" interactions and/or to be perceived as "normal." The hope that eye contact could be easier to handle, and that it might be beneficial for their social functioning, was also stated by the participants as their main motivation for wanting to try out the training program: "I think it might take less energy if I get better at it, it would be easier to keep up…"

RQ2: Is there evidence of change in stress level during the training period as assessed through GSR signals and self-reports of positive and negative affect?

All five participants were able to complete the training period at home without excessive technical difficulties. One participant encountered technical difficulties with the software that required support via telephone.

As mentioned above, the stimulus presentation software had a built-in threshold level of 25% of total gaze time in the eye region. If that threshold was not met during a session, the same module was presented again the next time. This threshold criterion was used on some occasions: two of the participants repeated a total of seven sessions because they did not reach the eye gaze threshold. This means that all participants could eventually complete the 21 modules of the training period with at least 25% of total gaze time in the eye region.

The recorded eye gaze, GSR, and PANAS scores are displayed in Figure 3. A review of the psychophysiological data collected by the participants at home indicated that they were of sufficient quality in the large majority of cases. Specifically, there was less than 6.6% missing eye tracking data for each participant, and below 15.8% missing GSR data for all participants, except for Participant 6, for whom 31.0% of GSR data were missing.

The overall observation when inspecting the data in Figure 3 is that gaze time in the eye region increased for most participants during the first 3-4 modules, seemed to decrease in Module 4 (images of children with direct eye gaze), and then increased again until the completion of the training. The arousal level measured via GSR in some cases increased when the modules with direct

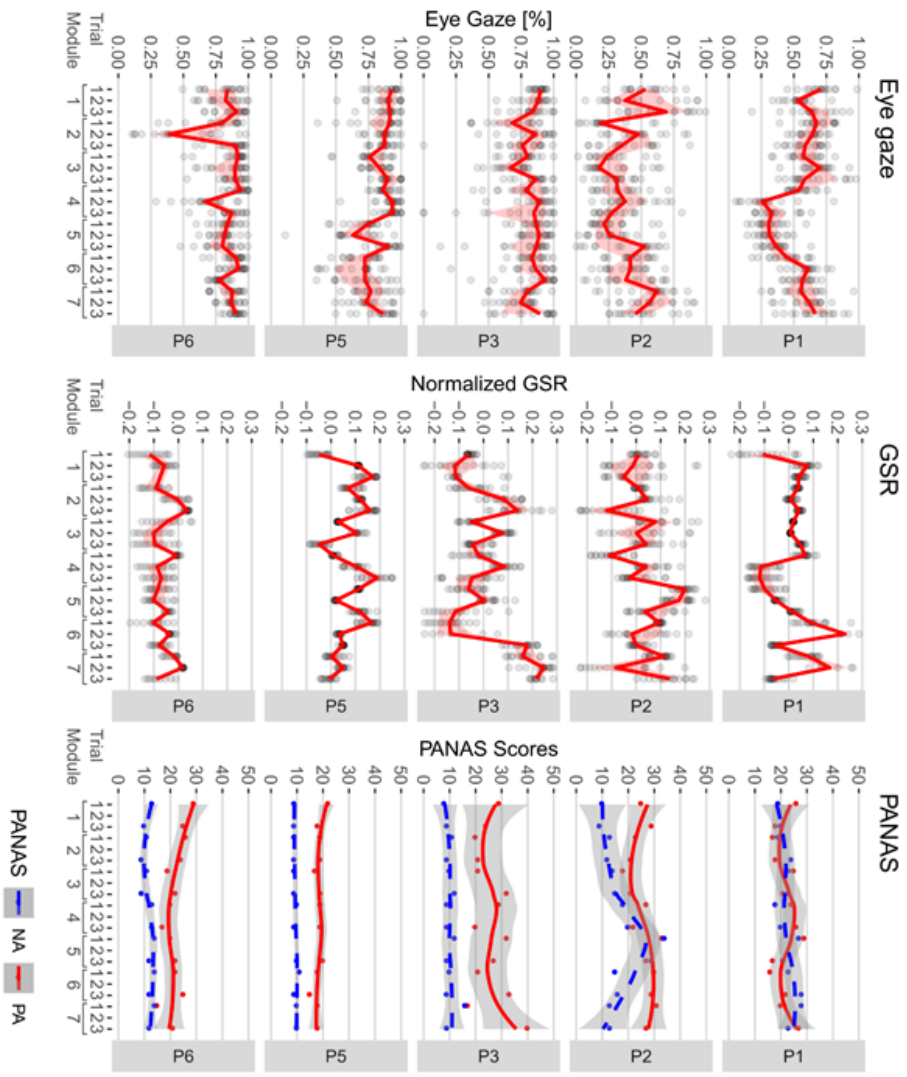


Figure 3. Eye gaze, galvanic skin reaction (GSR), and the Positive and Negative Affect Scale (PANAS) scores for each participant and each module repetition. For eye gaze and GSR, the faded points show the actual values for each stimulus presentation in the module repetition, and the red line shows the median, with interquartile intervals shaded in red. Outliers (calibrated skin conductance outside +/-2*SD* are omitted for readability). For the PANAS, positive (black) and negative scores (blue) are displayed, and a trend line is drawn for both with 95% confidence intervals as shaded gray area.

gaze began (Module 4) and subsequently leveled off. In other cases, it remained constant or variable. Participant 3 had noticeably high GSR levels in the last module, which was not evident in other participants.

In considering the PANAS ratings of emotional states, we observed that the negative (NA) scores stayed constant throughout the study, except for Participant 2 (P2), who reported an increase during the middle of the program (when the modules with direct gaze stimuli began) followed by a decrease. In general, the positive (PA) PANAS scores tended to stay constant or vary slightly.

The combination of these observations supports the tentative hypothesis that stress levels do not increase during the training period while gaze in the eye region tends to increase, which shows the positive effect of the training program on the ability to look in the eyes.

RQ3: Are there changes between pre- and post-training in i) spontaneous eye gaze and ii) emotional arousal and stress levels, and iii) self-reported perceived effect at follow-up?

Figure 4 shows the changes from pre- and post-training for the percentage of eye gaze (Panel B), pupillary dilation (Panel C), GSR as the measure of arousal and stress levels (Panel D), and two qualitative indices of participants' descriptions of the meaningfulness and generalizability of the training (Panel E).

All participants displayed limited spontaneous eye gaze at the pretraining session compared to how typically developing individuals have been shown to gaze at similar photos (around 70% of the time in Pelphrey et al., 2002). The percentage of gaze time in the eye region was relatively much higher for most participants at post-training. A Wilcoxon signed-rank test at the level of photo stimuli for each individual separately showed significantly increased eye gaze for four of the five participants (p = .001, p = .002, p = .001, and p = .001,

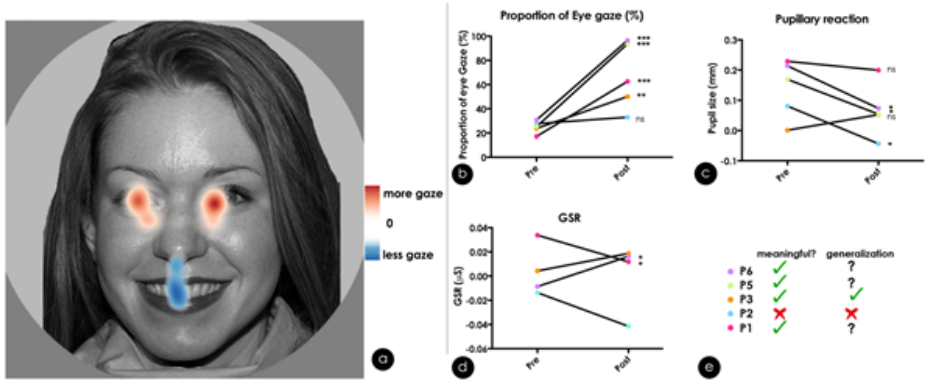


Figure 4. Visualization of the pre- and post-training results. Panel A: heat map depicting cumulative gaze across face stimuli for all participants. Panel B: change in proportion of eye gaze in the pre- and post-training. Panel C: pupillary reaction. Panel D: GSR. Panel E: reported meaningfulness and generalization of the training effects, presented for each participant separately.

respectively), and trended towards significance in the fifth one (p = .074). Figure 4, Panel A also depicts a contrast heat map detailing cumulative gaze across face stimuli for all five individuals in the pre- versus post-training. The data show that increased eye gaze was mainly accompanied by a reduction in gaze at the mouth area. Results further reflect no change in pupillary reactions for two of the participants between pre- and post-training (p = .408 and .424, respectively), whereas three participants displayed significantly smaller average pupil sizes in post-training compared to pretraining (p = .005, p = .003, and p = .002, respectively). Finally, GSR was found to significantly decrease for Participant 1 in the post-training (p = .009), while Participant 6 showed a significant increase in GSR after training (p = .009). There were no significant changes in GSR for other participants (all ps > .05). Considered collectively, these results suggest that four of the five participants gazed considerably more towards the eye region at post-training. This was achieved without any signs of increased heightened arousal, except for Participant 6, whose data indicated an increase in GSR. However, the interpretation of this increase in GSR for P6 is made complicated by the fact that this participant showed a reduction in arousal levels according to pupillometric data.

Regarding the perceived meaningfulness of the training, four out of five participants reported the training to be meaningful (Figure 4, Panel E). In terms of perceived generalization of the effects of training, only one participant reported the effects to not have generalized, three participants thought they "possibly" generalized to everyday life, and one reported they actually did. As was evident in RQ1, the bases of eye gaze discomfort are highly complex, and this is also reflected in the current results.

In the qualitative post-training interview, the participant who did not show any increase in spontaneous eye gaze also did not report any change in how he experienced eye contact after completing the training program said: "I'm still astonished by [eye contact] and wonder what the deal is."

The other four participants reported experiencing a positive change after completing the training program. All of them described that after the initial interview and during the training program at home, they started to reflect more on eye contact and for whose benefit eye contact is made. It was also mainly this topic, as well as questions about how to maintain eye contact, that were brought up at the scheduled check-ups during the training.

It is important to note that the participants did not necessarily enjoy eye contact after the training. Rather, they described it in terms of being more tolerable. In addition, they reported an increased self-acceptance around eye contact being difficult for them. When they chose to make eye contact, they reported that it took less energy, which gave them more opportunity to concentrate on the context they were in. Below are three illustrative quotes for these conclusions:

"I don't get nearly as worried… or get that weird feeling inside. It´s not like

I sit there staring into someone´s eyes anyway, but a few seconds can pass by."

"I mean, it´s not as hard looking at these faces as doing it in real life, but I can still feel a bit more confident now when I know that I have looked at them."

"I have lowered my demands on myself. And accepted that ok, this is hard for you and you find this a bit difficult... but that´s ok. And that makes it easier."

Interestingly, the training also seemed to have led them to more consciously choose when not to make eye contact and to be explicit with others as to why they chose not to, which is indicative of an increased disclosure of the challenge. Finally, all participants also described that the training raised more questions about eye contact and how to actually do it in practice. Indeed, when they experienced eye contact as less stressful, they began to think more about how to sustain it: for how long, where specifically to look, and in what way. As one participant described: "I thought about how to do it, looking into someone´s eyes. I mean, you can't look into both eyes at the same time because then you end up squinting. But should you then pick one eye, right or left, and try to... or I don't know?"

Discussion

The primary purpose of the present study was to examine the usefulness and feasibility of a novel training program specifically designed for autistic individuals who struggle with eye contact and who are motivated to increase their tolerance of eye contact through practice. The program utilizes eye tracking and biometric sensor technology to measure autonomic nervous system reactions and arousal during eye contact. Tolerance of eye contact is trained by gradually exposing and habituating participants across at least 21 individual sessions, presenting seven unique modules comprised of photos of animals, children, and adults with direct and indirect eye gaze. In the course of three to four weeks, each participant was able to train making eye contact in the comfort of their home. Prior to the training, interview data and questionnaires were used to better understand the discomfort related to eye contact that the participants experienced in everyday life, while post-training interviews were used to discuss the perceived meaningfulness and generalizability of the training effects. Gaze patterns and physiological measures indexing stress and arousal were collected before, during, and after the training.

During the initial interview, all participants who eventually completed the training program expressed an overwhelming discomfort when making eye contact. However, the complexity of the experienced challenge brought on by eye contact was striking. The basic discomfort was intertwined with issues of social anxiety, perceived deviation from normality, and a wish to contribute to social exchange through eye contact. All participants also indicated a desire to be able to make eye contact with others without feeling stressed by it. We interpret

this as a constant negotiation between social expectations in the face of strong sensory-emotional reaction. Objective measures of eye contact further confirmed the discomfort expressed in the interviews. When presented with photos of emotionally expressive human faces with direct eye gaze, all participants showed low levels of fixations to the eye regions of the photos. It is also important to note that all participants who completed the program were motivated to improve this aspect of their behavior.

The Ögonblick© program is the first of its kind where the participants can complete a computerized, research-motivated program at home, whilst simultaneously allowing for the collection of objective gaze pattern data using an eye tracker and physiological data indexing the autonomic nervous system and arousal. There were many methodological unknowns involved with the program's design. First, because all individuals inevitably represent a range of technical skills and experience with technology in general, one concern was whether the participants would have difficulty using the software and the hardware at home. Second was the related concern about the quality of obtained data. Finally, as with any training program, there was the question of whether the participants would be able to adhere to the program. To address the first concern, the pre-lab visit included an extensive training as well as a trial session in which the participants put on the GSR sensor, attached the eye tracker to the laptop, and started the program with the researcher present in the room. Ultimately, all participants managed to use the equipment at home and only one participant had some technical difficulties which were possible to resolve over the phone. Regarding data quality, while some outliers were recorded (mostly for GSR), it was not much beyond what one would expect in the lab under the direct supervision of an experienced technician. The participants were also able to finalize the training program, which is an important finding in and of itself. In order to support completion of the training, we followed treatment procedures recommended in NICE (2012), including visual support and scheduled follow-ups.

Along with the ability to perform the training at home, the ultimate goal of the program was to encourage the participants to focus on the eye region of the stimulus as much as possible, although they were also told to stop when it became "too much." To do that, the training program had a built-in threshold level of at least 25% of total gaze time in the eye region. Otherwise, the same module would be presented again during the next session. Because of this threshold, two participants had to repeat a total of seven sessions. For all participants, the data from the training showed a gradual increase of eye contact in the modules depicting children and animals, with a slight drop around Module 4 when stimuli depicting direct human eye gaze began to be displayed, followed by a steady increase. The GSR varied from day to day among the subjects with no clear general pattern, while self-reported affect remained relatively the same. In general, while increasing the gaze in the eye region, the stress indicators as well

as self-reported emotional states remained relatively stable, which is what one would hope for in this training paradigm.

All five participants ultimately completed the program. At the post-training lab visit when the same eye tracking protocol was used as in the pretraining session, there was a clear increase in eye contact for all except one participant (the one who had experienced technical equipment difficulties during the training period). Thus, despite the complex nature of the difficulties with eye contact according to the initial interview data, the preliminary findings of this relatively simple training regime show that it is beneficial and that it was experienced as useful and meaningful by the participants. They reported that the training gave them tools to handle aspects of this complexity since the discomfort itself took less energy and mental space.

There are important limitations to the current study that need to be addressed in the future. Most importantly, while the principles behind the training (psychoeducation and exposure) are well established, randomized controlled trials with larger samples are needed to determine treatment effects and their generalization to other individuals on the spectrum. The present study does provide first evidence showing the feasibility of collecting eye tracking and physiological data in the context of home-based training for autistic people. This alone offers many possibilities, one of which is the ability to include and reach individuals for whom simply regularly visiting and being in a laboratory setting while speaking to complete strangers is a challenging act. Also, the fact that the quality of the psychophysiological data recorded at home seems to be sufficiently high also support the validity and feasibility of this approach.

Several participants seemed to have especially appreciated the opportunity to discuss their difficulties with eye contact, so it is not certain that the kind of training described here would have a value as a stand-alone intervention. It should also be highlighted that the current participants were particularly suited for this initial study because they represented relatively high functioning individuals. An essential feature of the current study was that we aimed at understanding how the individuals conceptualized their problems with eye contact and how participating in the study affected them in this regard. It is important to note that, similar to the complexity of the perceived problems, the outcome of participation in the training was also complex. Indeed, any possible training effects were complemented by issues of self-acceptance and increased self-disclosure regarding alternative ways of communicating nonverbally. Although certainly not suited for all, we believe that the procedures described here could also prove helpful for other individuals experiencing eye gaze discomfort and wanting to alleviate it.

Conflict of Interest Disclosure

SJ and PM are employed part time by iMotions A/S. NH and JÅJ have copyright on the training program.

Funding

This work is funded by the Innovation Fund Denmark (IFD) under File No. 6152-00005B and VR grant 2018-02397.

Research Ethics Statement

The procedures were conducted in accordance with the Declaration of Helsinki (1964) and were approved by the regional ethics review board in Göteborg, Sweden (ref no. 897-17). Written informed consents were obtained from the participants.

References

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Creswell, J. W. (2014). *A concise introduction to mixed methods research.* SAGE Publications.

Creswell, J. W., & Báez, J. C. (2020). *30 essential skills for the qualitative researcher*. SAGE Publications.

Dalton, K. M., Nacewicz, B. M., Johnstone, T., Schaefer, H. S., Gernsbacher, M. A., Goldsmith, H. H., et al. (2005). Gaze fixation and the neural circuitry of face processing in autism. *Nature Neuroscience, 8*(4), 519–526. https://doi.org/10.1038/nn1421

Díaz-García, A., González-Robles, A., Mor, S., Mira, A., Quero, S., García-Palacios, A., ... & Botella, C. (2020). Positive and Negative Affect Schedule (PANAS): Psychometric properties of the online Spanish version in a clinical sample with emotional disorders. *BMC Psychiatry, 20*(1), 1–13. https://doi.org/10.1186/s12888-020-2472-1

Dunn, D. S., & Andrews, E. E. (2015). Person-first and identity-first language: Developing psychologists' cultural competence using disability language. *American Psychologist, 70*(3), 255–265. doi: 10.1037/a0038636

Emerson, R. W. (1876). *The prose works of Ralph Waldo Emerson (Vol. 2)*. James R. Osgood and Company.

Fenn, K., & Byrne, M. (2013). The key principles of cognitive behavioural therapy. *InnovAiT, 6*(9), 579–585. https://doi.org/10.1177/1755738012471029

Foxx, R. M. (1977). Attention training: the use of overcorrection avoidance to increase the eye contact of autistic and retarded children. *Journal of Applied Behavioral Analysis, 10*(3), 489–499. https://doi.org/10.1901/jaba.1977.10-489

Gernsbacher, M. A. (2017). Editorial perspective: The use of person-first language in scholarly writing may accentuate stigma. *Journal of Child Psychology and Psychiatry, 58*(7), 859–861. https://doi.org/10.1111/jcpp.12706

Guetterman, T. C., Fetters, M. D., & Creswell, J. W. (2015). Integrating quantitative and qualitative results in health science mixed methods research through joint displays. *Annals of Family Medicine, 13*(6), 554–561. https://doi.org/10.1370/afm.1865

Hadjikhani, N., Åsberg Johnels, J., Zurcher, N. R., Lassalle, A., Guillon, Q., Hippolyte, L., . . . Gillberg, C. (2017). Look me in the eyes: Constraining gaze in the eye-region provokes abnormally high subcortical activation in autism. *Scientific Reports, 7*, 3163. https://doi.org/10.1038/s41598-017-03378-5

Joseph, R. M., Ehrman, K., McNally, R., & Keehn, B. (2008). Affective response to eye contact and face recognition ability in children with ASD. *Journal of the International Neuropsychological Society, 14*(6), 947–955. https://doi.

org/10.1017/S1355617708081344

Jaswal, V. K., & Akhtar, N. (2018). Being vs. appearing socially uninterested: challenging assumptions about social motivation in autism. *Behavioral and Brain Sciences*, 1-84. https://doi.org/10.1017/S0140525X18001826

Kanner, L. (1943). Autistic disturbances of affective contact. *Nervous Child, 2*, 217–250.

Kliemann, D., Dziobek, I., Hatri, A., Baudewig, J., & Heekeren, H. R. (2012). The role of the amygdala in atypical gaze on emotional faces in autism spectrum disorders. *Journal of Neuroscience, 32*(28), 9469–9476. https://doi.org/10.1523/JNEUROSCI.5294-11.2012

Kose, L. K., Fox, L., & Storch, E. A. (2018). Effectiveness of cognitive behavioral therapy for individuals with autism spectrum disorders and comorbid obsessive-compulsive disorder: a review of the research. *Journal of Developmental and Physical Disability, 30*(1), 69–87. https://doi.org/10.1007/s10882-017-9559-8

Kylliäinen, A., & Hietanen, J. K. (2006). Skin conductance responses to another person's gaze in children with autism. *Journal of Autism and Developmental Disorders, 36*(4), 517–525. https://doi.org/10.1007/s10803-006-0091-4

Lord, C., & Risi, S. (2003). *Diagnostic criteria for the Collaborative Programs of Excellence in Autism [Paper presentation]*. Meeting of the NIH Collaborative Programs of Excellence in Autism, Los Angeles, CA.

Maratos, F. A., Gilbert, P., & Gilbert, T. (2019). Improving well-being in higher education: adopting a compassionate approach. In P. Gibbs, J. Jameson, & A. Elwick (Eds.), *Values of the university in a time of uncertainty* (pp. 261–278): Springer.

McGlensey, E. (2016). 16 People with autism describe why eye contact can be difficult. Retrieved from http://themighty.com/2016/02/why-eye-contact-can-be-difficult-for-people-with-autism/

Merz, E. L., Malcarne, V. L., Roesch, S. C., Ko, C. M., Emerson, M., Roma, V. G., . . . Sadler, G. R. (2013). Psychometric properties of Positive and Negative Affect Schedule (PANAS) original and short forms in an African American community sample. *Journal of Affective Disorders, 151*(3), 942–949. https://doi.org/10.1016/j.jad.2013.08.011

National Institute for Health and Clinical Excellence. *Autism: recognition, referral, diagnosis and management of adults on the autism spectrum. (Clinical guideline 142.) 2012*. Retrieved from http://guidance.nice.org.uk/CG142.

Nyström, P., Falck-Ytter, T. & Gredebäck, G. (2016). The TimeStudio Project: An open source scientific workflow system for the behavioral and brain sciences. *Behavioral Research 48*, 542–552. https://doi.org/10.3758/s13428-015-0616-x

Onghena, P., Maes, B., & Heyvaert, M. (2019). Mixed methods single case research: State of the art and future directions. *Journal of Mixed Methods Research, 13*(4), 461–480. https://doi.org/10.1177/1558689818789530

Ortiz, L., & Sjölund, A. (2015). *Motiverande samtal vid autism och ADHD*. Natur Kultur Akademisk.

Pelphrey, K. A., Sasson, N. J., Reznick, J. S., Paul, G., Goldman, B. D., & Piven, J. (2002). Visual scanning of faces in autism. *Journal of Autism and Developmental Disorders, 32*(4), 249–261. https://doi.org/10.1023/A:1016374617369

Perihan, C., Burke, M., Bowman-Perrott, L., Bicer, A., Gallup, J., Thompson, J., . . . Sallese, M. (2020). Effects of cognitive behavioral therapy for reducing anxiety in children with high functioning asd: A systematic review and meta-analysis. *Journal of Autism Developmental Disorders, 50*(6), 1958–1972. https://doi.org/10.1007/s10803-019-03949-7

Seltzer, M. M., Krauss, M. W., Shattuck, P. T., Orsmond, G., Swe, A., & Lord, C. (2003). The symptoms of autism spectrum disorders in adolescence and adulthood. *Journal of Autism Developmental Disorders, 33*(6), 565–581. https://doi.org/10.1023/B:JADD.0000005995.02453.0b

Tottenham, N., Tanaka, J. W., Leon, A. C., McCarry, T., Nurse, M., Hare, T., . . . Nelson, C. (2009). The NimStim set of facial expressions: Judgments from untrained research participants. *Psychiatry Research, 168*(3), 242–249. https://doi.org/10.1016/j.psychres.2008.05.006

Trevisan, D., Roberts, N., Lin, C. J., & Birmingham, E. (2017). How do individuals with Autism experience eye contact? A qualitative analysis of first-hand accounts. *PLoS One*, *12*(11), e0188446. https://doi.org/10.1371/journal.pone.0188446

Ung, D., Selles, R., Small, B. J., & Storch, E. A. (2015). A systematic review and meta-analysis of cognitive-behavioral therapy for anxiety in youth with high-functioning autism spectrum disorders. *Child Psychiatry & Humand Development, 46*(4), 533–547. https://doi.org/10.1007/s10578-014-0494-y

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology, 54*(6), 1063–1070.

Wright, J. (2006). Cognitive behavior therapy: Basic principles and recent advances. *FOCUS, 4*(2), 173–178. https://doi.org/10.1176/foc.4.2.173

Zhou, J., Sun, J., Chen, F., Wang, Y., Taib, R., Khawaji, A., . . . Li, Z. (2015). Measurable decision making with gsr and pupillary analysis for intelligent user interface. *ACM Transactions on Computer- Human Interaction, 21*(6), 33. https://doi.org/10.1145/2687924