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A Contemplative Biofeedback Intervention for Adults with Autism Spectrum Disorder: Feasibility of a Community-Based Treatment

Rachel S. Brezis[1] · Amitai Levin[1] · Yuval Oded[2] · Opher Zahavi[3] · Galit Gampel[4] · Nava Levit-Binnun[1]

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Abstract

As the number of diagnosed adults living with autism spectrum disorder (ASD) continues to grow, a lack of resources and lack of available interventions exacerbate their low quality of life, including low levels of education and employment, and high levels of co-morbid anxiety and depression. Here we build upon existing research showing the effectiveness of contemplative interventions on individuals with ASD, to provide a low-cost biofeedback-enhanced training which can be implemented by non-professional staff, and may help autistic individuals grasp abstract contemplative techniques. We hypothesize that the intervention will decrease participants' anxiety and autism symptoms, and increase their self-awareness, self-determination, and empathy. Fourteen adults with ASD, residing in assisted living, were provided with 16 weekly half-hour contemplative-biofeedback sessions with non-professional trainers, in which they learned to reduce their arousal levels through combined biofeedback and contemplative techniques, and apply those to everyday life. Quantitative and qualitative data was collected pre- and post-intervention, to determine changes in participants' self-awareness, self-determination, anxiety, autism symptoms, and empathy. Participants were capable of successfully improving their physiological arousal levels on the biofeedback setup, indicating feasibility of the technique. Further, we found initial indications for reduction in autism symptoms and increased self-determination. Qualitative reports by participants and counselors revealed that participants applied the techniques in many real-life situations, and these had far-ranging effects on their emotional regulation, work and social motivation, and self-determination. The study provides proof-of-concept for a low-cost, community-based intervention which can ameliorate the lives of adults with ASD.

Keywords Adults with ASD · Biofeedback · Contemplative techniques · Community-based · Self-awareness

Abbreviations

ASD	Autism spectrum disorder
BE	Beit Ekstein
GSR	Galvanic skin response
GAS	Glasgow Anxiety Scale
HR	Heart rate
HRV	Heart rate variability
RMET	Reading the Mind in the Eyes Test
SRS	Social Responsiveness Scale
TAS	Toronto Alexithymia Scale

Rachel S. Brezis and Amitai Levin are joint first-authors.

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✉ Rachel S. Brezis
brezisrs@gmail.com

[1] Sagol Center for Brain and Mind, Baruch Ivcher School of Psychology, Interdisciplinary Center Herzliya, P.O.Box 167, 46150 Herzliya, Israel

[2] Center for CBT-BF™, Tel Aviv, Israel

[3] Beit-Ekstein Organization, Kerem Maharal, Israel

[4] Private Psychotherapy Practice, Tel Aviv, Israel

Introduction

The growing population of children diagnosed with ASD is quickly aging into adulthood (Howlin and Taylor 2015). Yet the situation of adults with autism remains poor, with most adults suffering from social isolation and low levels of education and employment; alongside high levels of co-morbid psychiatric conditions, such as depression and anxiety (Magiati et al. 2014). Recent research suggests that beyond the diagnostic impairments in social and communication skills and repetitive behaviors, individuals with

autism also suffer from reduced self-awareness (Uddin 2011) and high levels of co-morbid anxiety (White et al. 2014). These latter symptoms can have profound consequences for adults with autism, restricting their daily lives and preventing them from achieving their goals and desires (Lawrence et al. 2010). The situation is further exacerbated by a lack of resources for adults with ASD in many countries, and a dearth of evidence-based interventions to improve their quality of life (Bishop-Fitzpatrick et al. 2013). For instance, a recent review found only 41 articles describing empirical interventions for adults with ASD, over a period of 37 years, compared to thousands of reported interventions for children with ASD (Pallathra et al. 2019).

Self- and Body-Awareness in Autism

Recent research has shown that individuals with autism have difficulties not only in understanding others, but perhaps more primarily in self-understanding (Lind and Bowler 2008; Uddin 2011). These difficulties are manifest in reduced emotional self-awareness, or alexithymia (Bird and Cook 2013), poorer autobiographical narratives (Brezis 2015), and difficulty with future decision-making (Lind and Bowler 2010). Such difficulties in self-awareness can have wide-ranging practical consequences for the daily lives of individuals with autism. For instance, an individual who is not aware of his own emotions will have difficulty regulating his emotional responses in everyday situations; and an individual who does not have a clear sense of his preferences will find it hard to make important decisions about his education and employment. As adults with autism emerge into the wider educational and vocational worlds, they must be given the skills to recognize and advocate for their needs (Lawrence et al. 2010).

Importantly, most behavioral and neuropsychological studies of self-awareness in ASD have focused on cognitive, conceptual levels of the self (Lind and Bowler 2008). Yet emergent research is showing that individuals with high-functioning autism have an atypical *bodily* self-awareness (Fiene and Brownlow 2015). This reduced somatic self-awareness has been hypothesized to lie at the basis of their difficulty in emotional regulation and anxiety (White et al. 2014), their difficulties in empathizing with others (Bird and Viding 2014; De Jaegher 2013), and their own self-determination. Based on neuroscientific findings suggesting the strong overlap between self- and other-processing networks (Bird and Viding 2014; Lombardo et al. 2010), we hypothesize that strengthening ASD adults' self-awareness, through increased awareness of the bodily processes involved in arousal and self-regulation, will lead to a concomitant enhancement of empathic skills.

Contemplative Biofeedback Intervention for Adults with ASD

Empirically-tested interventions for adults with ASD are few and far between, and the majority of studies target either specific social skills, such as face and emotion recognition or conversation skills (Pallathra et al. 2019), or focus on the development of workplace skills (Hedley et al. 2017). Only a handful of studies have targeted anxiety and depression in adults with autism, using either cognitive behavioral therapy or mindfulness-based therapy (Pallathra et al. 2019; Conner and White 2018).

Recently, contemplative practices have been shown to reduce depression, anxiety and aggression in individuals with ASD (for reviews see Cachia et al. 2016; Hwang and Kearney 2013; Hartley et al. 2019). Contemplative practices refer to practices that enhance awareness to one's present-moment experience, such as bringing mindful awareness to one's breathing, or mindful scanning of sensations arising from the body. The majority of mindfulness-based interventions studies have targeted either children or adolescents with ASD and/or their parents or caregivers. To our knowledge, to date only four studies have targeted *adults* with ASD. In the first study of its kind, Spek et al. (2013) showed that a 9-week mindfulness-based group therapy reduced depression, anxiety and rumination, and increased positive affect in a group of adults with ASD. In a follow-up study, Kiep et al. (2015) demonstrated that these gains can be maintained 9 weeks after the end of a similar group treatment. Finally, Conner and White (2018) demonstrated the feasibility and initial efficacy of an individually administered mindfulness-based therapy in targeting emotional regulation difficulties in adults with ASD (See also Sizoo and Kuiper 2017).

Nevertheless, the application of these programs at a wider scale remains a challenge, given the difficulty of individuals with ASD to grasp the abstract techniques taught in contemplative practice, such as mindfulness-based interventions; alongside the reliance on experienced professionals with mindfulness training to provide treatments, which may be difficult to hire and finance. Here we propose to harness the recent advances in biofeedback technology to provide an accessible, contemplative-based treatment that can be easily implemented by minimally-trained staff, and can be readily grasped by individuals with ASD.

Biofeedback interventions, in which participants practice various relaxation techniques while receiving immediate feedback regarding their physiological arousal—e.g., heart rate (HR) and skin conductance—have been used successfully to reduce stress and increase emotional regulation in a wide range of contexts (Schoenberg and

David 2014), including individuals with ASD (McCoy et al. 2014; Sugarman et al. 2013; Thompson et al. 2010). The autonomic nervous system in autism is atypical, with studies overall suggesting a hyperarousal of sympathetic response and hypofunction of the parasympathetic branch, albeit with great heterogeneity, which may reflect different sub-types of autism (Song et al. 2016; Kushki et al. 2014). Autonomic dysregulation in autism, and its resulting hyperarousal, have been proposed to lie at the basis of both social and communication deficits, and restricted and repetitive behaviors (which may serve as a behavioral response to mitigate overarousal). Hence, self-regulation therapy using biofeedback has been suggested to be highly effective in reducing ASD symptoms (Sugarman et al. 2013; Goodman et al. 2018). In our treatment protocol we further enhanced the biofeedback self-regulation treatment by introducing a contemplative component, guiding participants to bring awareness to bodily sensations and internal changes, all while observing their physiological changes on the biofeedback setup (See Levit-Binnun et al. 2010 for further discussion of the theoretical basis for the approach).

Here we used a finger-sensor biofeedback setup (Alive™) in which physiological measures were displayed on a laptop, in the form of graphs, movies or video games (Fig. 1). Participants were guided in using the biofeedback setup using concurrent breathing and contemplative techniques. This tangible representation of their internal state is particularly beneficial to individuals with ASD who are strongly attuned to visual stimuli (Grandin 2009), and may thus facilitate contemplative practices. At the same time, the biofeedback setup allows semi-professional caregivers a glimpse onto participants' internal sensations and feelings, enabling more focused therapeutic work towards emotional regulation.

We present preliminary results from a contemplative-based biofeedback intervention conducted in group-home settings of adults with ASD, aimed at increasing participants' self-awareness and self-determination, decreasing their anxiety and autism symptoms and increasing their empathy.

Methods

Recruitment

Fourteen adults with ASD (12 males) were recruited for the study from the Beit-Ekstein (BE) organization, which provides assisted living and job placement for individuals with ASD. All participants completed baseline and post-test measures, before and after the 16-week intervention (none dropped out). See Table 1 for participants' background information. ASD diagnosis was confirmed using the Autism Diagnostic Observation Schedule, Module 4 (Lord et al. 2012). Participants' level of receptive and expressive language was such that they could hold a conversation and understand the study goals and instructions. All participants lived in supported living settings, with various degrees of support: some lived in a large group-home with live-in counselors, while others lived in independent apartments with roommates, with weekly visits from counselors. Participants' degree of support at work also varied, wherein some held independent jobs, while others worked in supported vocational centers. The study was approved by the IDC ethical review board and by the Israel Ministry of Social Welfare. All participants (and caregivers, where required) provided informed consent.

Table 1 Participants' demographic variables

Characteristic	Mean (SD), range/percent
Age	29.71 (8.44), 19–48
Gender	
Male	86%
Female	14%
Living situation	
Semi-independent apartments	36%
Group home setting	64%
VIQ	12.64 (3.272), 8–19
PIQ	10.86 (3.592), 5–17

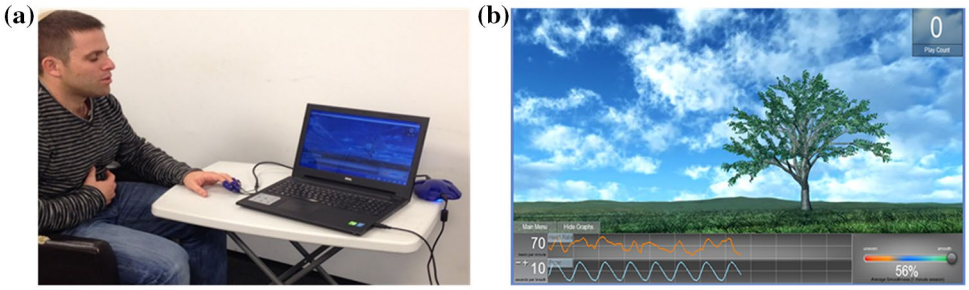

Fig. 1 The biofeedback setup, in which **a** a participant is connected to finger sensors of heart-rate and galvanic skin response, and can view his or her measures on a laptop computer or tablet, in the form of **b** either graphs or dynamic movies

Intervention

Participants received 16 weekly 30-min private biofeedback sessions from trainers who completed a 3-day biofeedback and contemplative methods training course. Trainers included an MA student in clinical psychology (A.L.), a social worker at BE, and a biology major with experience in mindfulness and biofeedback.

Sessions proceeded at an individualized pace, introducing a variety of contemplative and relaxation techniques. By way of introduction, participants were told that "our heart rate increases in stressful or scary situations, and that we will try to learn techniques that increase bodily relaxation and reduce heart rate". Sessions first focused on familiarizing participants with the biofeedback software (Alive™) environment, and exposing them to various relaxation techniques—in order to identify the most effective techniques for attaining self-regulation (Fig. 1). Participants were trained on feedback from both heart rate variability (HRV) and galvanic skin response (GSR). The initial stage in HRV training included practicing paced breathing (viz., abdominal effortless breathing with a long exhalation) such as to achieve at least 75% HRV coherence. Once the 75% HRV coherence target was maintained for at least 5 min, the training proceeded to HRV games in gradually challenging environments. Here, too, participants advanced only when achieving at least 75% coherence. To teach arousal regulation, GSR was used as the main target variable. Training began with a mind–body demo which increased participants' understanding of the connection between cognitive processes, bodily movement and changes in arousal. Participants were taught to self-regulate their arousal through individually adapted relaxation and mindfulness techniques, such as body scan, mindful awareness of one's breath, backwards counting of one's breath, progressive muscle relaxation etc. HR feedback was also used as part of the self-regulation feedback.

After a few sessions of learning and training, the trainers identified the feedback measures and techniques which were best fitted to the participants' learning style and built an individualized training plan. The treatment sessions then focused on deepening participants' awareness of the bodily sensations, thoughts and emotions that accompany the changes in the biofeedback display, in order to develop a personal bodily marker for stress and relaxation (e.g., "What did you feel in your body when a stressful thought came to mind? How was this displayed on the graphs? What did you do to move the graph towards a more relaxed state? How do you feel in your body when you become relaxed?"). Finally, sessions aimed to develop the participants' meta-awareness, helping them identify stressful moments in their everyday lives in order to use the techniques pre-emptively. Each session began with a short discussion on how the participant has felt in the past week, whether there were any stressful events, and whether the participants had independently identified their arousal state using bodily cues, and used the contemplative techniques, such as breathing, in these situations. The session then proceeded with guided biofeedback training, according to the participant's level (see above). Each session then ended with a short discussion on what had happened during the training, any challenges that arose, and how the techniques could be used in everyday life.

Measures and Analysis

1. *Physiological data* were recorded continuously during sessions. We examined both intra-session data (measures of change from the beginning to end of each session, on average) and inter-session data (comparing the first and last treatment session). Our physiological inter-session data were a measure of *Proximal outcomes*. The following measures were used for analysis:

   (a) Intra-session:

      1. Average change in HR (i.e., HR in the last 15 s of the session—HR in the first 15 s of the session), over sessions. Negative values indicate a greater relaxation over time, within each session.
      2. HRV coherence was computed as Low Frequencies (0.04–0.15 Hz)/All Frequencies. Average change in HRV signal coherence, over sessions (i.e., coherence in the last 15 s of the session—coherence in the first 15 s of the session). Positive values denote an increase in coherence during sessions.

   (b) Inter-session: Change in HR throughout the treatment (i.e., average HR in the last session—average HR in the first session).

Data Analysis

To determine whether participants succeeded in learning to self-regulate using the biofeedback setup, we examined the intra-session data (HR and HRV coherence) descriptively, looking at the directionality of change. To determine the *rate* of change in each participant, we computed the slope of the regression line for HR and HRV coherence over the 16 sessions. To determine whether these physiological values were related to our psychological outcome measures, we further computed correlations with the variables below.

To determine whether participants' HR decreased significantly over time, inter-session data (change in HR over the treatment period) were examined using paired *t-tests*. As a

proximal outcome measure, we hypothesized changes to be statistically significant.

2. *Psychological measures* of change were assessed using a combination of quantitative and qualitative methods, integrating both the participants' and caregivers' reports. Caregiver reports were collected from counselors, who spent an average of 3.75 h ($SD = 1.19$) with the participants a week, have known the participants for an average of 7.5 months ($SD = 3.7$), and whom were kept blind to individuals' participation in training. Psychological data were our *Distal Outcome* measures. The following measures were collected:

    (a) *IQ* was measured using the Vocabulary and Matrices sub-scales of the WAIS (Wechsler 1998), at baseline only. We present age-normed scores for these sub-scales.
    (b) *Autism Symptoms* were measured using both the adult self- and caregiver-report versions of the Social Responsiveness Scale (SRS; Constantino 2012).
    (c) *Anxiety* was measured using the Glasgow Anxiety Scale (GAS; Mindham and Espie 2003), a self-report measure adapted for individuals with intellectual disability.
    (d) *Alexithymia* was assessed using the Twenty-item Toronto Alexithymia Scale (TAS-20; Bagby et al. 1994).
    (e) *Self-determination* was measured using the Arc's Self-Determination Scale (Wehmeyer 1995).
    (f) *Cognitive Empathy* was measured using the Reading the Mind in the Eyes Test (RMET; Baron-Cohen et al. 2001).
    (g) *Response to Challenging Situations* was assessed in a semi-structured interview, co-developed by the researchers and BE staff, in which participants described what they would do in five different challenging situations based on real-life situations from the group home (Supplementary Materials). A coder blind to the time of response (i.e., pre- or post-intervention) coded their responses for their degree of adaptiveness, based on a coding scheme co-developed by BE staff.

Data Analysis

Given the relatively stable nature of psychological questionnaires, and the small sample size of our preliminary feasibility study, we did not hypothesize statistically significant changes before and after treatment. We therefore did not conduct inferential testing, but rather examined the effect size of the change (Cohen's *D*), which is a clinically indicative measure. We consider an effect size of $d \geq 0.2$ as indicative of change. As mentioned above, to explore the relation between physiological and psychological changes, regardless of significant change, we also computed the correlations between the change in psychological measures (pre-post) and the slope of the regression line for HR and HRV coherence.

3. Further quantitative and qualitative reports on the participants' experience of the intervention were collected at various intervals:

    ((a) Weekly session reports: At the end of each session, the participants and the trainers completed a brief report about their experience. This included a rating-scale of "how did I feel during today's training?", with an emotional slider ranging from sad-face (= 1) to happy-face (= 5). (see Supplementary Materials).
    (b) Post-treatment questionnaire: During the last session, participants completed a questionnaire regarding their view of the intervention; and counselors reported on any observed changes (Supplementary Materials).
    (c) A focus group was held with the counselors to assess the changes they perceived in participants.

Data Analysis

Responses were analyzed both qualitatively and quantitatively, using one-sample *t*-tests, comparing the responses to the items' mean, where appropriate.

Results

Participants Learned to Modulate Their Arousal Through the Intervention, and Showed Gains in Hypothesized Domains

Proximal Outcomes

Participants' HRV coherence increased, on average, during each session ($M = 6.92$, $SD = 8.3$); and their HR decreased, on average, during each session ($M = -.592$ bpm, $SD = .865$), indicating greater relaxation. Their HR decreased significantly through the time of the intervention by an average of 8.38 bpm ($M_0 = 85.7$; $M_1 = 77.4$; $t(12) = 2.86$, $p = .014$).

Distal Outcomes

Participants' changes in psychological measures before and after the intervention are reported in Table 2. In line with our hypotheses, and based on effect-size analyses, participants showed a reduction in ASD symptoms in both SRS Self- and Caregiver-report) and an increase in self-determination (ARC). They did not show changes in anxiety (GAS), alexithymia (TAS), adaptive behaviors, or empathy (RMET).

We further found a correlation between a decrease in anxiety symptoms (GAS pre-post) and the rate of increase in coherence ($rho = -.694$, $p = .008$; Fig. 2). No other correlations were significant ($p > .05$).

Participants Reported Enjoying and Benefiting from the Intervention

During weekly session reports, participants reported using the techniques an average of 2.1 times a week ($SD = .77$); and on average, they reported feeling significantly more positive ($M = 4.0$, $SD = .78$) than the scale mean (3, $t(13) = 4.86$, $p < .001$).

At the end of the intervention, participants reported enjoying the intervention ($M = 3.3$, $SD = .75$; $t(13) = 4.22$, $p = .001$) and thought that it helped them ($M = 3.15$, $SD = .89$; $t(13) = 2.68$, $p = .018$). A great majority of the participants (93%) indicated they would like to continue the intervention either now (31%) or possibly in the future (62%). And a great majority (85%) of participants noted that

Table 2 Change in measures prior (Time 0) and post-intervention (Time 1)

Measurement scale	Mean (SD)—Time 0	Mean (SD)—Time 1	Cohen's D
Social Responsiveness Scale (ASD symptoms)—self report	59.9 (8.4)	58.2 (9.4)	− 0.20
Social Responsiveness Scale—caregiver report	67.0 (7.0)	63.3 (5.9)	− 0.53
Toronto Alexithymia Scale	46.1 (10.8)	47.6 (13.0)	0.14
Glasgow Anxiety Scale	19.4 (6.8)	18.8 (4.5)	− 0.09
Reading the Mind in the Eyes Test	22.5 (4.9)	22.8 (5.8)	0.05
ARC Self-Determination Scale	69.5 (8.1)	71.7 (10.6)	0.27
Challenging situations—adaptive behavior rating	1.0 (0.4)	1.1 (0.2)	0.13

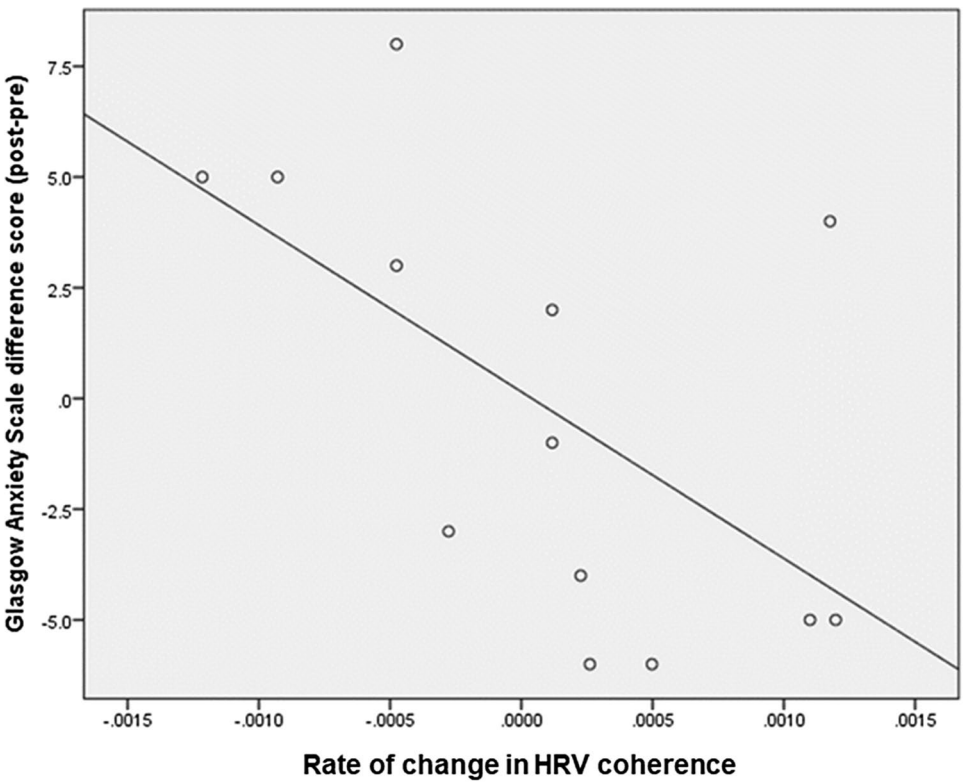

Fig. 2 Correlation between participants' ratings of anxiety symptoms, pre-post treatment, and their rate of change in HRV coherence (i.e., the slope of the regression line of change in coherence, over time, denoting each participant's rate of change in the amount of coherence they increased by each session). These results suggest that participants who succeeded in increasing their coherence on the biofeedback apparatus more quickly throughout the 16-week training, also showed a greater decrease in their levels of anxiety symptoms

they will continue to use the techniques either a lot (31%) or occasionally (54%).

Trainers' weekly ratings revealed that participants were highly cooperative ($M = 8.5$, $SD = 1.1$; $t(12) = 10.67$, $p < .001$); that they enjoyed the sessions ($M = 7.9$, $SD = 1.3$; $t(12) = 8.10$, $p < .001$); that they showed mastery of the techniques ($M = 7.8$, $SD = 1.0$; $t(12) = 9.88$, $p < .001$); and that they were focused during the sessions ($M = 8.0$, $SD = 1.4$; $t(12) = 7.97$, $p < .001$).

Participants and Counselors Reported Multiple Impacts on Participants' Everyday Lives

Participants reported that the trainings helped them "become calmer" and more "relaxed", and they were capable of using the techniques in everyday life. Examples: "I used [the relaxation technique] when my boss pressured me and it helped me calm down." "I can turn to people and tell them what I want without becoming anxious". Others reported broader effects, relating their greater awareness of their own bodily states with better response to external situations: "It gave me a sense of relaxation, like water flowing through my body." "I am more relaxed now, I can listen and focus, I can be at ease." "I learned how to be with myself, so it helps me a lot".

Counselors reported that participants attended more social events ($M = 0.3$ more events per week); and that their level of independence increased ($M = 0.29$ point increase on a 4-point scale); though these were not statistically significant. They further reported gains in emotional regulation and self-determination:

"Earlier Ruthi [pseudonym] was very reclusive… Now she is much more open, when something bothers her she complains immediately or asks for help"

"Yifat's work situation has improved, she started going to the gym and to a social group and she has a new [romantic] partner after she ended an 'imaginary' relationship."

"Alon has been able to keep a job in high-tech for 3 months now for the first time in his life… and is saving in order to live independently."

Finally, the group home manager reported that participants who received the intervention were later more open to other forms of therapy.

Discussion

Our study provides proof-of-concept for the feasibility of a contemplative-biofeedback intervention for adults with ASD in a community setting. During 16 weekly training sessions, participants learned to regulate their arousal through biofeedback exercises targeting heart-rate variability and galvanic skin response, guided by contemplative-based instructions. We demonstrated that participants learned to regulate their arousal, through increased HRV coherence and reduced HR within sessions, and reduced HR across treatment sessions (proximal outcomes). Participants further reported that they enjoyed and benefited from the intervention. As hypothesized, participants showed a decrease in ASD symptoms (in both self- and caregiver-reports), and an increase in self-determination, based on effect-size analyses (distal outcomes). However, we did not find changes in other psychological measures. Exploratory analyses further revealed that participants who increased more quickly in their degree of HRV coherence on the biofeedback program also showed greater decreases in anxiety symptoms, suggesting that the physiological techniques may have mediated their gain in psychological well-being.

Qualitative reports suggested reduced anxiety, better self-understanding, a greater ability to communicate and self-advocate for their needs, and better stability and depth in relationships and vocational pursuits. Participants and counselors provided ample examples for the intervention's impact on participants' daily lives, from helping them feel calmer and more focused, to using the techniques in specific situations. Surprisingly, in the short span of the intervention, some of the participants made even greater leaps: e.g., finding and keeping meaningful work, entering a new romantic relationship, and moving towards greater independence. These impacts were echoed by the BE staff, who plan to expand the treatment to multiple group homes, enabling tenants and counselors to use it on a daily basis.

Our small sample size limited our ability to conduct rigorous statistical analyses. However, our quantitative and qualitative results do point to the initial effectiveness of the intervention, and future research should put the intervention to a randomized-controlled test. A further limitation of our study was lack of baseline HRV data: future studies should provide pre- and post-measurements of baseline HRV, to better determine whether participants' spontaneous ability to self-regulate changed in response to treatment. Finally, it is possible that larger effects would have been obtained using a more intensive intervention, rather than just once a week. As the technology of biofeedback training becomes ever more accessible and low-cost, future studies should consider providing participants with biofeedback apps and sensors for personal devices, and training them to practice the biofeedback techniques, individually or with a trainer, on a daily basis, to determine the optimal dosage of the intervention.

In sum, this study demonstrates the feasibility of a contemplative-based biofeedback intervention for adults with ASD, even when conducted with minimally-trained staff in a community setting. The study joins a growing body of literature demonstrating the effectiveness of contemplative-based interventions in individuals with ASD (Cachia et al. 2016; Singh et al. 2011; Spek et al. 2013), while demonstrating that a combined contemplative- and biofeedback-based

approach can further enhance participants' ability to engage in the technique and apply it to everyday stressful situations. Given the many daily challenges of adults with ASD alongside the dearth of interventions and limited resources, this low-cost, community-based intervention provides much promise for ameliorating the lives of individuals with ASD.

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Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

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