INVESTIGATING THE EFFECTS OF EXECUTIVE FUNCTIONS AND SOCIAL COGNITION ON THE RELATIONSHIP BETWEEN AUTISTIC TRAITS AND MENTAL HEALTH

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Introduction

Nowadays, digital interventions have become more popular day by day to use in different areas including mental health problems, executive functions including working memory (WM), cognitive flexibility and inhibitory control, and social cognitive skills in both clinical and non-clinical populations (Sandgreen et al., 2021). In terms of non-clinical populations, the studies have indicated that executive function training could be effective for both the enhancement of cognitive functions as well as mental health conditions (Beloe & Derakshan, 2020; Sari, et al., 2020). For example, Beloe and Derakshan (2020) have reported that adaptive WM training decreases anxiety and depression symptoms in adolescents and the effects of training lasted for a month. Another study by Roughan and Hadwin (2011) showed that WM training reduces school-related difficulties and associated mental health problems in adolescents. Another study conducted smartphone compassion training for Swedish university students, which resulted in improved self-compassion and emotional awareness compared to the wait-list group (Andersson et al., 2021). Bendtsen and colleagues (2020) developed a mobile health intervention program to promote the mental health of university students. In their randomized control trial (RCT) study, participants showed improvement in positive mental health and reduced depression and anxiety symptoms compared to a control group. Olfers and Band (2018) applied game-based training to improve flexibility and attention and measured in Electroencephalographic (EGG) activity. Their results showed that flexibility and attention show increased performance in healthy young adults compared to the control group. In addition, response selection was improved due to flexibility training. This was indicated by a larger N2 amplitude compared to the control group. Additionally, conflict monitoring was more efficient, as shown by reduced Nc/CRN and larger Pe amplitude (Olfers & Band, 2018). Although studies in Türkiye included both social cognitive training and mental health, which are rare, Sari and colleagues (2020) observed reduced trait anxiety and test anxiety in university students after WM training.

Ben-Zion et al. (2018) have found that cognitive flexibility is a significant predictor of post-traumatic stress disorder (PTSD) and have suggested neurocognitive skills intervention could be an important prevention. Roepke and colleagues (2015) conducted an RCT to examine the effects of smartphone training for depression and depression scores of participants declined after the

training compared to the control group. Similarly, the digital intervention of cognitive behavioral therapy (iCBT) was also shown to be effective in anxiety and depression compared to the control group after 8 weeks of training (Richards et al., 2020). Similarly, smartphone-based CBT was also found to be effective for depression compared to the control group (Lukas et al., 2021). Previous research shows the effectiveness of computer-based social cognitive training in schizophrenia by focusing on emotion recognition, social perception, social discrimination, and theory of mind (Sacks et al., 2013). In other studies, computer-based social cognitive training shows the efficacy of social cognition and social functioning in schizophrenia (Nahum et al., 2021) and the same training program was also effective for ASD and healthy older adults (Nahum et al., 2013). In another study, a randomized control trial (RCT) conducted with ASD participants found an overall improvement in WM, cognitive flexibility, social behavior, ADHD behavior, and quality of life, and the authors suggested a need for further research into the usefulness of cognitive interventions (de Vries et al., 2015). A recent study has shown that game-based cognitive training in school- aged children with ASD provides an improvement in attention, WM, emotion regulation, flexibility, social skills, and communication (Macoun et al., 2021). Moreover, computer-based social cognitive training in adolescents and adults with ASD increases amygdala and fusiform area activation which are associated with facial affect response skills (Bölte et al., 2015). Virtual Reality Social Cognition Training for Autism by Didehbani and colleagues (2016) designed for 5 weeks including emotion recognition, social understanding, and empathy skills shows improvements in emotion recognition, ToM skills, and executive functions. Another digital intervention called the MindChip for socio-emotional skills in autism showed improvements in cognitive empathy and affective empathy skills. A significant difference in self-efficacy, autistic traits, and mental health outcomes was found within the analysis; however, there are no significant differences in self- efficacy, autistic traits, and mental health outcomes between experimental and control groups (Tang et al., 2021). The recent meta-analysis study for digital intervention in ASD by Sandgreen and colleagues (2021) summarized that digital interventions are mostly designed in computer- based format and targeted to social skills. It was found .32 effect size according to Cohen's *d*, which is a positive but small effect. However, due to the limitation of digital intervention, more studies are needed to see whether these interventions are effective in both clinical and non-clinical populations (Sandgreen et al., 2021) and specifically, there is limited research in Türkiye for digital

mental health intervention to suggest conducting different studies in the recent systematic review by Akgün et al. (2019).

Accordingly, the primary aim of the current study is to test the efficacy of the online training program on mental health (DASS-21 and its subscales) regarding autistic traits. The secondary aim of the current study is to test the efficacy of the online training program on executive functions (working memory, inhibitory control, and cognitive flexibility), and social cognitive skills (cognitive empathy and affective empathy).

The following two hypotheses were addressed in the current study:

1. **Online training on executive functions and social cognitive skills will promote mental health by reducing DASS-21 and its subscales scores in the current sample.**
2. **Online training on executive functions and social cognitive skills will promote executive functions (working memory, inhibitory control, and cognitive flexibility) and social cognitive skills (cognitive empathy and affective empathy) in the current sample.**

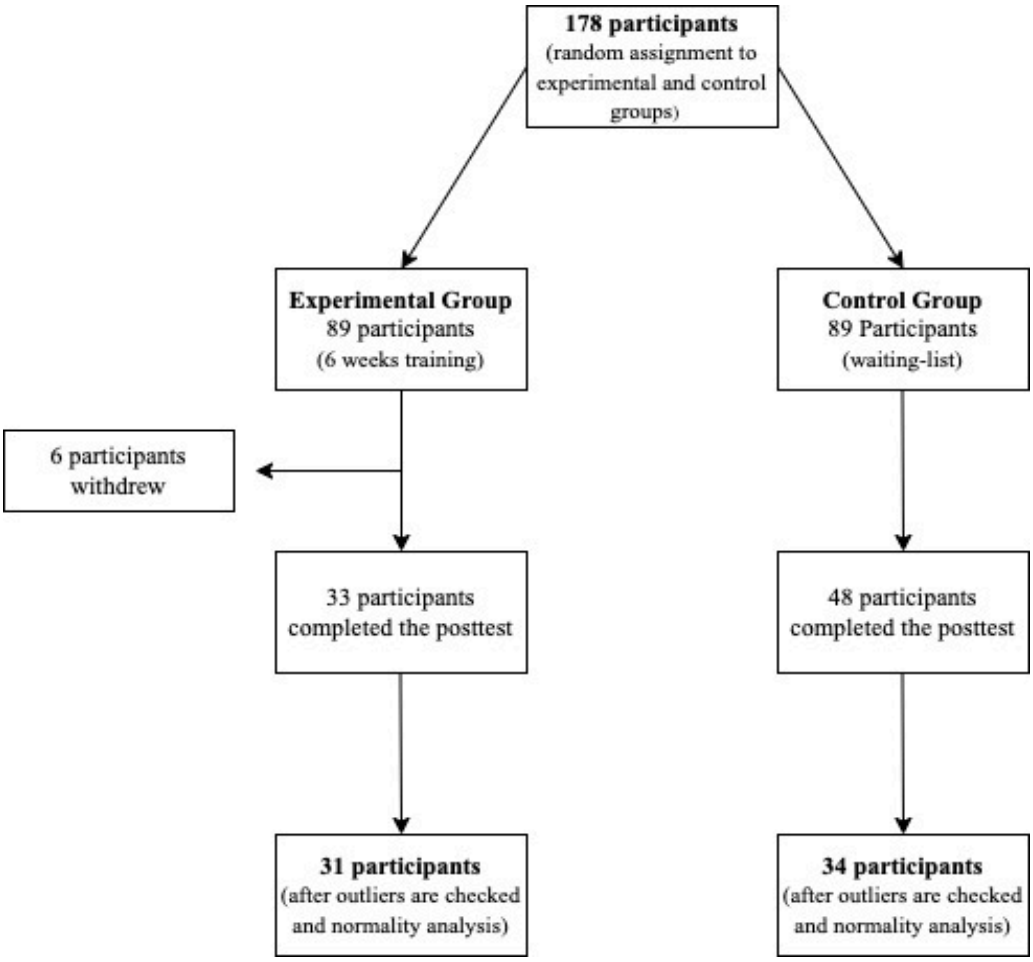
Methods Study Design

The present study adopted a multifactorial design including pretest and posttest conditions to test the efficacy of combined EFs and social cognition online training via computers, tablets, or smartphones for mental health symptoms (depression, anxiety, and stress) in the experimental and control groups. Multifactorial design also called mixed design refers to including both within- participant design (testing the same participants over time) and between-participant design (comparing different groups, Breakwell et al., 2012). The independent variable for this study is online training while the dependent variables are mental health scores (depression, anxiety, and stress symptoms), executive functions (cognitive flexibility, inhibition, and working memory), and social cognition (cognitive empathy and affective empathy). According to our previous findings

(Chapter 4), autistic traits are included in this study as covariates, which are defined by characteristics that might affect the study's outcome (Cambridge University Press, n.d.).

Participants

A power analysis (G*Power) was conducted to determine the number of participants needed to achieve this goal. For repeated measures analyses, 44 participants are required in order to reach a medium effect size of .25 with an adequate power of .80 at a = .05 (Faul et al., 2009) to determine interaction effects of between and within participants' factors. Convenience sampling via advertisement through social media, mail groups, and on campuses was used to collect participants. Initially, 178 adult participants were recruited for this study to reach adequate power for multivariate analysis. Participants randomly and equally were assigned to the experimental group (89 participants) and control group (89 participants) to see whether the combined training program was effective for the general population. 33 participants for the experimental group and 48 participants for the control group completed the posttest. However, after checking outliers and normality analysis, 31 participants for the experimental group (28 female, 3 male), and 34 participants for the control group (29 female, 5 male) were included in the further analyses. Please see the figure 6.1. the flow of participants through each stage of the study. The details of the participants were presented the Table 6.1. Demographic Characteristics. To reduce drop-out, incentives such as drawing for money/prizes were used. Inclusion criteria for adult participants are being aged 18 or above, being able to use computers, smartphones, or tablets, being native Turkish citizens, having no record of any psychiatric disorders, and having no record of any physical and neurological conditions that prevent to use of technological devices. Participants who are under the age of 18 and have any record of psychiatric and physical conditions that prevent to use of technological devices were excluded from the study.



Materials

Self-Report Questionnaires

Figure 1. The Flow of Participants

Demographic Information Form

Basic information such as age, gender, education level (i.e., undergraduate, postgraduate), and income was obtained from the participants, and it was developed by the researcher.

Autism Quotient (AQ) for Adults Turkish Version (Baron-Cohen et al., 2006; Baron-Cohen et al., 2001a; Köse et al., 2010)

To measure autistic traits, the Autism Quotient (AQ; Baron-Cohen et al., 2001) was used. AQ for adults is adapted to Turkish culture by Köse and colleagues (2010). The self-report questionnaire consists of 50 questions using a Likert-scale rating; “definitely agree”, “slightly agree”, “slightly disagree”, and “definitely disagree”. In the Turkish adaptation of the AQ for adults, Cronbach’s

alpha value for this scale is .64, and test-retest reliability is r = .72. The AQ is a widely used assessment tool that measures five subscales: social skills, communication, attention to detail, attention switching, and imagination. It is available in different languages (e.g., Turkish by Köse et al., 2010; Dutch by Hoekstra et al., 2008; Japanese by Wakabayashi et al., 2006).

Depression Anxiety Stress Scale 21(DASS – 21; Lovibond & Lovibond, 1995; Sarıçam, 2018)

DASS-21 is a self-report scale to examine depression, anxiety, and stress levels for adults by Lovibond and Lovibond (1995). The Turkish adaptation study for DASS-21 was conducted by Sarıçam (2018). This scale consists of three subscales, one for depression, one for anxiety, and one for stress. The total number of items is 21. For this scale, inter-scale reliability with Cronbach’s Alpha is .87 for depression, .85 for anxiety, and .81 for stress subscales. Test-retest reliability is r = .68 for depression, .66 for anxiety, and .61 for stress.

Performance Tasks

It was administered the following performance tasks to evaluate executive functions such as cognitive flexibility, WM, and inhibitory control, as well as social cognition including cognitive empathy and affective empathy. To ensure standardized measurement, we recorded the errors for each task based on previous intervention studies (Chooi & Logie, 2020; de Vries et al., 2015;

Macoun et al., 2021; Maraver et al., 2016). Each task begins with a non-scored trial to ensure that participants understand the task before scoring begins. The only exceptions are for the self-assessment manikin for affective empathy, and the Eyes Test for which detailed information was provided.

Wisconsin Card Sorting Task (WCST; Berg, 1948)

The Wisconsin Card Sorting Task (WCST) is a cognitive flexibility performance task that was first developed by Berg in 1948. During the task, 200 cards in two blocks are displayed on the screen and the sorting rule changes after every 10 cards. Participants are expected to learn from feedback and adapt the rules during the task by trial and error. They need to match the cards according to their color, number, and shape. The task measures the error rates of the participants. Participants receive feedback only on the accuracy of their sorting, which helps them understand and adjust the current sorting rule. Feedback is given after each card selection.

N Back Task (Kirchner, 1958)

Working memory was evaluated through the N Back Task (Kirchner, 1958) in three different conditions - one back, two back, and three back. In this study, the n = 2 rule was applied. A sequence of stimuli was displayed one by one, and participants had to decide if the presented stimuli were the same as the stimuli that appeared in N trials earlier. The complete stimulus sequence consists of 15 letters and each stimulus was displayed for 500 milliseconds. Participants had three seconds to react (3000 milliseconds) and a new letter appeared every three seconds (3000 milliseconds). The letters A, B, C, D, E, H, I, K, L, M, O, P, R, S, and T were used in the sequence. There were eight blocks, with each block containing 50 trials. False errors were measured.

Go / No Go Task (Donders, 1969)

Go / No Go Task was used to measure inhibition. The task requires participants to respond as quickly and accurately as to the presented target stimulus (“go” trials) but avoid responding to non-target stimulus (“no go” trials). Participants need to respond in 2000 milliseconds when the

“go” sign is presented and avoid responding when “no-go” is presented. There are 12 blocks of 50 trials each. Commission errors (i.e., incorrectly responding to no-go trials) were measured.

The Eyes Test - for Adults (Baron-Cohen et al. 2001b; Girli, 2014)

The Eyes Test is a performance task for emotion recognition which is widely regarded as an indicator of cognitive empathy. In this test, participants were presented with a series of 36 black-

and-white photographs of human eyes. For each photograph, participants were asked to choose which of 4 words best describes what the person in the photograph is feeling or thinking. The version used was adapted for Turkish by Girli (2014). The Cronbach alpha internal consistency coefficient for this test is greater than .70. Accuracy of the test was measured.

Self-Assessment Manikin (SAM; Bradley & Lang, 1994)

Self-Assessment Manikin was carried out to measure self-reported emotional responses to facial expression images for affective empathy. Karolinska Directed Emotional Faces (KDEF, Conley et al., 2018; Lundqvist et al., 1998) were used to express facial emotions. In total, 30 images (15 male, 15 female) were chosen and seven emotional expressions including happiness, neutral, anger, fear, and disgust were depicted. The task requires participants to examine each facial expression and rate how they feel it on a valence scale (more negative (1) to more positive (9). The tasks were adapted from Wai and Tiliopoulos (2012). Valence scores for each emotion were obtained by summing responses for all images.

Procedure

Approval from the ethical committee of Ibn Haldun University was obtained for this study (No. E-71395021-050.06.04-34359) and the protocol ID of clinical trials was obtained (NCT06213194). The participants for the study were recruited using convenience sampling through advertisements on social media, mail groups, and campuses. Once recruited, all participants completed pretest questionnaires and tasks before assigning them to the groups and undergoing training on the *MindZone* training website (www.mindzone.com.tr). 31 participants

for the experimental group (28 female, 3 male), and 34 participants for the control group (29 female, 5 male) were included for the study. The experimental group underwent an online 6-week training period through the website developed by the researcher (www.mindzone.com.tr), while the control group was placed on a waiting list. Posttests were collected at the end of the 6th week from both experimental and control groups. Additionally, the researcher and research assistant checked each participant's progress weekly, sent reminder messages, and made phone calls to improve training continuity if participants had not completed the requirements. Details about training are presented in Table 5.2. MindZone Manual (see Chapter 5). After the

completion of the research studies, the control group (on the waiting list) is scheduled to access the online training program in accordance with ethical guidelines.

Data Analysis

The data from the current study was analyzed using the SPSS 25.0 package. Initial analyses were performed to determine if the data showed a normal distribution. Before conducting parametric tests, the Shapiro-Wilk test, box plots, and skewness and kurtosis scores were used to check for normal distribution. The self-report questionnaires' data was found to be normally distributed according to the Shapiro-Wilk test ($p > .05$). As for the performance tasks, the skewness and kurtosis of the data fell within an acceptable range for applying parametric tests, as specified by Hair and colleagues (2010). Covariate analyses were conducted to account for the effects of autistic traits in the intervention model. Before including covariates in the analyses, correlation analyses and tests for homogeneity of regression slopes were performed according to the assumptions of covariance (Field, 2013). The results showed that only communication and attention-switching had significant correlations with dependent variables ($p < .05$) and met the assumptions for being used as covariates for mental health symptoms (Field, 2013). Regarding EFs and social cognitive skills, communication, attention to detail and imagination entered as covariates in the model ($p < .05$); however, only communication met the assumptions for homogeneity of regression slopes for EFs and social cognitive skills (Field, 2013). All correlation tables for these assumptions were presented in Appendix C, D, and E. Moreover, t-test analysis was carried out to see whether the pretests of dependent variables and AQ and its subscales for experimental and control groups

differ. Due to more than 8 variables; a conservative *p*-value was set ($p = .01$). The results showed no significant differences in all pretest scores and AQ (all $ps > .01$).

In the experimental study, 2 x 2 mixed design repeated measure ANOVAs were conducted to examine the group (experimental and control group) and the effects of time (pretest and posttest) on mental health (DASS-21 and its subscales), as well as executive functions (working memory, inhibitory control, and cognitive flexibility), and social cognitive skills (cognitive empathy and affective empathy). In terms of performance tasks, to ensure standardized measurement, errors

were used in the analyses for each EF task based on previous intervention studies (Chooi & Logie, 2020; de Vries et al., 2015; Macoun et al., 2021; Maraver et al., 2016). While accuracy was used for cognitive empathy and summing scores of images in affective empathy entered as dependent variables.