

Intermediating the Effect of Inter-Stimuli Interval in Repetition Suppression of Face Images among Adults with High and Low Levels of Autistic-Like Traits

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Abstract

Purpose: Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder, characterized by pervasive symptoms, as in DSM-V. It is identified and associated with a number of atypicalities, including difficulties in face memory, centralized interest, and abnormal body movements. Individuals high in ASD show problems in face processing, gaze, and expression that arise from inappropriate brain functioning in social behaviors and communication skills. When a sensory stimulus is repeated, the excited neural signal is always smaller than its first observation. This phenomenon has been observed for many sensory states and stimuli using different methods.

Materials and Methods: The present study was conducted to investigate the repression of facial image reproduction with the mediating role of time in adults with low and high autism-like traits. This research was carried out with a quantitative method approach in the form of a descriptive design in two groups with low and high ASD. For this purpose, the autism spectrum quotient, cognitive task for suppressing repetitive face images, and EEG were used. The sample consisted of 30 male undergraduate and postgraduate students aged between 18 and 35.

Results: As a result, the research findings showed a significant statistical difference between the two groups with low and high ASD in terms of cognitive and EEG correlates in suppressing the repetition of facial images. Specifically, an interactive effect of time (short or long intervals), consistency of stimuli (repeated or not), and autism spectrum (high or low) was significant ($F(1, 28) = 4.53, p = 0.04$). This was indexed by a lack of N2 and P3 in those with high compared to low ASD.

Conclusion: The possible insensitivities to repetition might be due to unused extra neural resources in high ASD, close to brain areas involved in face processing.

1. Introduction

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder, characterized by pervasive developmental disorders in DSM-V. By definition, these disorders are associated with a number of atypicalities in face processing, including difficulties in face memory, centralized interest, and abnormal body movements [1]. Individuals with autism spectrum show problems in face

processing, gaze, and expression that arise from inappropriate brain functioning in social behaviors and communication skills [2, 3]. Studies conducted to identify the underlying cognitive-neurological processes of stereotyping behaviors in the brain of people indicate a malfunction of executive function, but specific cognitive processes associated with these behaviors have not been fully defined. One hypothesis has been a lack of

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Cognitive flexibility and reduction in the ability of these individuals to adapt to environmental changes. Autism is characterized by a decrease in attention to social stimuli, including a reduced interest and attention to human faces [4, 5]. This decreased response to stimuli may be caused by a malfunction of motivation, reward, and attention systems in the brain. Failure in face perception has a profound impact on social development and can affect the quality of communication [6].

Over the past several decades, the brain systems supporting these social cognitive processes have been carefully mapped out using functional neuroimaging. Atypical neural responses to the human faces in ASD are well documented in the functional magnetic resonance imaging (fMRI) literature. While the field of autism research has historically been dominated by theories positing malfunction of individual brain regions such as the Fusiform Gyrus (FG), amygdala, and superior temporal sulcus [6-8], there is increasing awareness that autism is characterized by widespread abnormalities throughout the brain, and particularly in the patterns of connectivity across cortical and subcortical regions [9, 10].

In cognitive and affective neuroscience, there is an increasing consensus that taking a network perspective to understanding brain function can provide more parsimonious explanations of the complex relationship between brain and behavior [11, 12] and in particular can elucidate key principals of functional brain organization underlying typical and atypical development [13]. This movement from focusing on brain regions to brain networks has also begun to critically inform social neuroscience. As recently reviewed by Kennedy and Adolphs [1], individual brain regions that have been historically linked to social processing (including face perception) can now be considered in the context of larger networks in which they are embedded, such as the “amygdala network”, “mentalizing network”, “empathy network”, and “action-perception network”.

It is thought that development of the face pathways occurs later due to the fact that faces are typically processed on the individual level (e.g., Bill Clinton, The Pope) because the social importance of identifying faces often leads most individuals to become experts in face-processing [14]. The relationship between brain regions

from childhood to adolescence strengthened this functional communication throughout the brain, leading to the development of high-level cognitive functions. Disruption of social interactions can affect public and grassroots communication by failing to understand face emotions and the differences between conversations.

Moreover, cognitive deficits in Autism Spectrum Disorders (ASD) affect different aspects of information processing and time perception. Although the core symptom of autism is social inadequacy, autism might be due to deviant information processing in a non-social domain as well. Some researchers even take the view that a deficit in Executive Functioning (EF) is central in autism [15]. Therefore, dysfunction in executive quantifying, problems such as inappropriate social behavior, disruption of the decision and judgment, thinking and transfer of programs and positions dependent on different dimensions of memory. In the framework of social interactions, face expressions provide information about the emotions and beliefs of others. In addition, it effectively quotes important indicators for understanding the states and deducing the readiness of response and action. Questions about cognition and brain mechanisms involved in autism are a controversial topic in cognitive science.

Due to the ambiguous underlying mechanisms of suppression caused by the repetition of images and the previous research to record the brain activation by MRI, we used electroencephalography to take high accuracy and credibility to our findings and the previous works. In this study, we tried to investigate the role of time in the effects of repeated suppression of face images in adult cognitive function with low and high-autism intermediate traits by changing the time intervals between the stimuli.

2. Materials and Methods

2.1. Participants

The statistical population consisted of students who were studying at the University of Tehran. In this study, in order to identify the individuals with high and low autism-traits that were involved in the study, the announcement and screening using the Autism Spectrum Quotient (AQ) was used. The sample consisted of 30 male students aged between 18 and 35, undergraduate or

postgraduate students who were selected using the autism spectrum coefficient and recall questionnaire. The criteria for participating in the research included: being 18 to 35 years old, no drug use, no neurological and psychiatric diseases (epilepsy, seizure, depression, anxiety). The participants were selected with the interviews in the study which were reviewed through an individual interview with individuals.

Table 1. Demographic information (age of subjects)

Std. Deviation	Mean	N	Subjects
3.38	2.26	30	Students 18-35

Table 2. Descriptive statistics of research samples

Test score	N	Group		
Less than 19	16	Low	1	ASD
More than 19	14	High	2	

2.2. Research Design

This research was carried out with a quantitative method approach in the form of a descriptive design in two groups of people with low and high ASD. The cognitive tasks were included in the number of stimuli (4 face and 4 figure images) and repeated at a given time interval of 50 milliseconds.

2.3. Image Acquisition and Analysis

During the course of the assignment, the electroencephalography of the subjects was recorded individually for about half an hour. The Event-Related Potential (ERP) was evaluated by appearing N2 wave in response to factors of direction and time of presentation of the images. Electroencephalography signals were analyzed offline using EEGLab toolbox of MATLAB software. By this software, the brain signals were preprocessed and analyzed.

2.4. Materials and Tools

The employed tools were the Autism Spectrum Quotient (AQ), face repetition suppression task, and Electroencephalography (EEG).

2.5. Autism Spectrum Quotient (AQ)

In order to collect data on the autism-traits, the Persian language of the Autism Spectrum Quotient (AQ), which was designed by Baron Cohen et al. was used. This scale is for the investigation of the subthreshold symptoms of the spectrum disorders in normal adults (age 16 years old), by Baron Cohen, Wheel Wright, Skinner, and Clubley [2] at the Center for Autism Studies in Cambridge. This version belongs to the Cambridge Autism Study Centre and available at the Institute for the Psychomobalization, to facilitate the access of researchers interested in the field of autistic disorders. This scale contains 50 items, and includes social skills, change of attention, communication, attention to detail and the fantasy. In contrast to each phrase there are four options that are completed by the person.

2.6. Repetition Suppression of Face Task

In this task, a number of image stimuli are repeated with a specific interval and the same number is presented to the participant. A total of 4 face images and 4 figure images were used. The two stimuli can be congruent or incongruent in terms of direction (opposite direction). After displaying the images, a grey screen will appear for 100 milliseconds, followed by the image again for 50 milliseconds. The subject will be asked to identify the direction of the displayed image by clicking on the corresponding keys. The computer will promptly record the reaction time and error in any effort. The participants performed a target tracking test through keypresses for about ten minutes. Images were selected from the Radboud collection [3]. In this study, in addition to the variable between the groups, with two levels of low and high autism traits, there are three variables which include the interval of stimuli with two low and high (SOA1, SOA2), type of stimuli with three levels, including the shape of stimuli, face and shape combination (Stim3, Stim1, Stim2) and being congruent and incongruent stimuli in terms of direction (Cong1, Cong2).

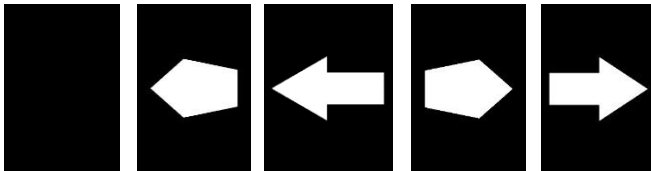
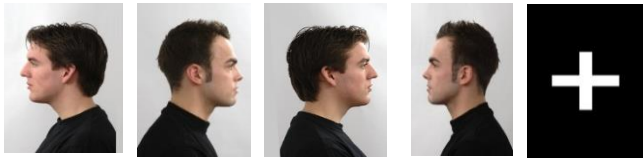


Figure 1. Selected pictures from Radboud images collection and simple shapes used in the study

2.7. Electroencephalography (EEG)

In this study we used 19 channels of G.HIamp.Biosignal 80 Channel Booster of the G.Tec Company, Approved by the FDA and CE. The G. HIamp has a wide range of input sensitivity and enables to record various bio-signals such as EEG, EOG, EMG and ECG without going to saturation. Different side sensors can also be connected to its input channels. Real-time data filtering is done via the internal floating-point DSP of the G. HIamp. The possibility of real-time analysis of channels is also provided through the G.Tec High-speed Processing Library for the Simulink Toolbox, which is especially important for studies of human-computer interface systems and neurofeedback.

3. Results

Analysis was performed on Reaction Rate (RT) and errors were not reported due to rarity. Mixed analysis of variance with repeated measures of $2 \times 3 \times 2 \times 2$ on two groups namely, the operating levels between, and the factors included in the distance between stimuli, type of stimuli, both faces, both shapes, and shape and face combination (heterogeneous) were performed.

According to Table 3, the results showed that the main consistency effect was statistically significant ($F(1, 28) = 28.100, P = 0.00$), that is, when the supplied stimuli are matched, the reaction time is faster than the time the stimuli are unmatched. The interactive effect of autism spectrum was significantly different from the interval

($F(1, 28) = 3.28, P = 0.08$), and it could be a little difference between the reaction time of the subjects' low autistic-traits to dissimilar stimuli. The interactive effect of time and stimulus was significant ($F(1, 28) = 4.52, P = 0.01$), which means that in short time intervals, the difference of reaction time to the matched stimuli and dissimilar is low while in terms of heterogeneous stimuli, reaction time to equal stimuli is very fast.

The interactive effect of time and stimulus consistency was significant ($F(1, 28) = 4.94, P = 0.03$), in other words, reaction time to similar stimuli is faster than dissimilar stimuli. The interactive effect of time, the consistency of stimuli and autism spectrum was significant ($F(1, 28) = 4.53, P = 0.04$), in a short time interval in the subjects with low autistic-traits, reaction time to stimulus and dissimilar was very long while the time interval of reaction to stimulus was matched was faster than dissimilar stimuli.

The interaction effect of time, stimuli and stimulus consistency was significant ($F(1, 28) = 6.64, P = 0.01$). In a long distance, in matched stimuli, the difference of reaction time to similar and dissimilar stimuli is high, but in heterogeneous stimuli conditions this effect has a weaker consistency.

If it is seen in Figures 2-5, in a short time interval, in terms of matched stimuli the difference of reaction time to dissimilar stimuli is low and a strong consistency has not occurred, but in the conditions of heterogeneous stimuli (face and shape), reaction time to similar stimuli is much faster for dissimilar stimuli than when the stimuli are similar.

As seen in the charts, the overall average of ERP is displayed for all subjects in the channel P3. In individuals with low autism-traits forming N1, N2, P3, it represents the process of full face processing while high autism-traits have been suppressed due to the lack of the waveform of N2 to the size of the group has low autism-traits. In other words, the reason for the lack of interaction and the effective communication of people with high autism -traits is the lack of complete processing. In general, it can be said that in the task of the lateral occipital area and parietal of individuals with high autism-traits, it is more active than those with low autism-traits (Figures 6, 7).

Table 3. Part of the results of repeated measurement variance analysis on the effect of group and cognitive task repetition suppression of images

Source	Observed Power ^a	Partial Eta Squared	Sig	F	Mean Square	Df	Type III Sum of Squares
SOA x ASD	0.417	0.105	0.081	3.28	699751.36	1	699751.36
Cong	0.999	0.50	0.000	28.100	569666.17	1	569666.17
SOA x Stimuli	0.749	0.13	0.015	4.52	36900.97	2	7280.94
SOA x Cong	0.574	0.15	0.034	4.94	96673.43	1	96673.43
SOA x Cong x ASD	0.538	0.13	0.042	4.53	88509.73	1	88509.73
SOA x Stimuli x Cong	0.701	0.19	0.015	4.64	119630.61	1	119330.61

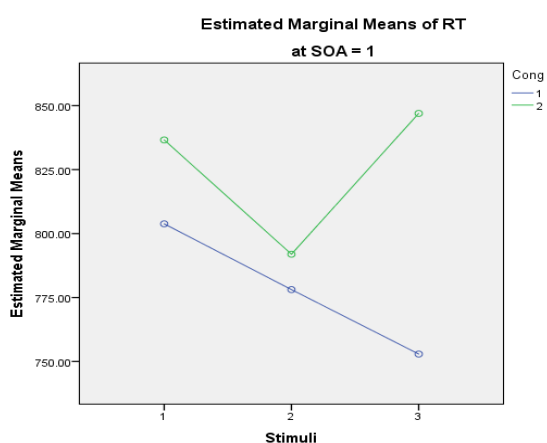


Figure 2. Reaction time to the stimulus type (matched and heterogeneous) in equal or dissimilar conditions in short time

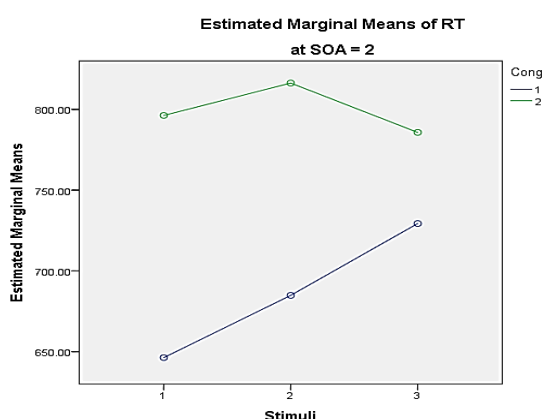


Figure 3. Reaction time to stimulus (homogeneous and heterogeneous) matched or dissimilar in long time (1 = both shapes, 2 = both faces, 3 = shape, face)

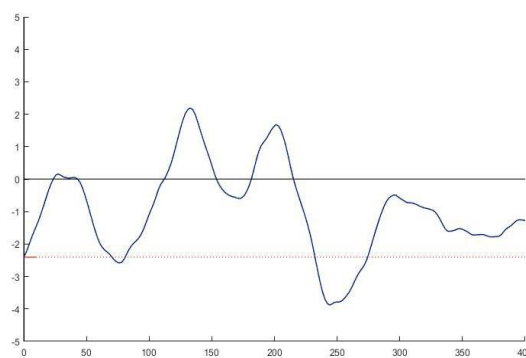


Figure 4. The overall average of ERP for subjects with autism-like traits showing N2 component in response to stimuli in the task of repetition suppression of images (when stimuli were two faces) on the P3 channel above the face processing area

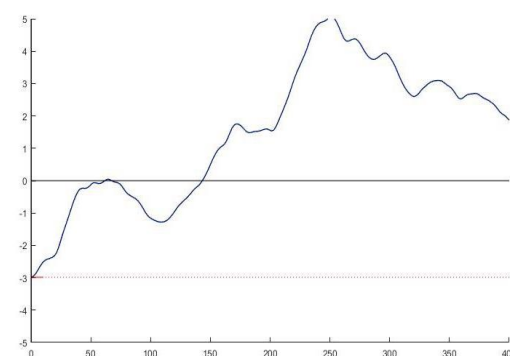


Figure 5. The general average of ERP for subjects with high autism-like traits showing no N2 component in response to stimuli in the task of repetition suppression of images (when stimuli were two faces) in channel P3 channel above the face processing area

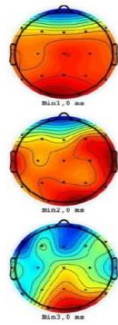


Figure 6. Brain Mapping related to EEG the task of repetition suppression of images that have been recorded from the subjects with high autism-traits during the task

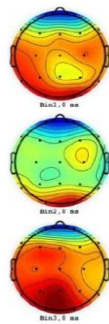


Figure 7. Brain Mapping related to EEG task replication suppression of images that have been recorded from the subjects with low autism-traits during the task

4. Discussion

In neurotypical individuals, repeated presentation of the same face is associated with a reduction in activity, known as Repetition Suppression (RS). RS refers to the decrease in neural activity observed when a stimulus is presented repeatedly, relative to when different stimuli are presented [4]. Moreover, given that the RS paradigm used here involved brief presentations of faces separated by a delay, similar to behavioral tests of face recognition memory, our results appear to accord with evidence of face identity recognition difficulties in ASC in tasks that include a delay between target and test stimulus [5]. The findings of this study showed that when the supplied stimuli are matched (in the same direction), Reaction Time (RT) is faster than the time the stimuli are dissimilar, in fact, the compatibility of information or incongruence, such as stimuli, will affect reaction time. In the behavioral level, a prolonged observation of a

particular stimulus is associated with changes in perception, which is generally known as an after-effect perceptual. After-effects are also found for higher level features, including facial identity [6] gaze [7] and facial expressions [8]. The possible insensitivities to RS might be due to supposedly unused extra neural resources in high ASD, due to lack of neuronal pruning process in brain areas involved in face processing.

Like all neurological and psychological standards, there are significant individual variations in the magnitude of both RS and perceptual after-effects [9, 10]. One suggestion is to reduce the after-effects caused by flexible perceptual coding in autism [11]. Since ASD is considered as a normal end of distribution, the effect of autism characteristics in the company -neurotypical is a complementary approach for ASD studies that can be complicated with clinical comorbidity [12]. When stimuli are matched, the suppression phenomenon occurs because in this case the reaction rate becomes slower. This is a more pronounced reaction rate in case of facial stimuli. Since repeated suppression occurs on multiple time scales, it is found in multiple brain regions and for low-level features and higher perceptual classes such as faces. Dalton et al. showed that reducing response in the fusiform gyrus shape in ASD indicates a reduction in the eye area rather than reducing the fixation in the region [13]. The experiments showed that the repression on face was repeated, but showed that the relationship between autism characteristics and repetition could not be justified by changes in the overall response to the faces, as shown by artificial intelligence analysis or with differences in face selection.

According to the results of this study, the characteristics of the high autism-traits spectrum in the task of repetition suppression of the images of the face-processing process are not fully shaped, which is probably the reason for effective communication and interaction with others, this is while the subjects of low autism-traits have processed the face completely. In individuals with low autism-traits forming the P1 waves, P2, P3 represents the process of full-face processing while individuals with high autism-traits have been taken due to the lack of N2 wave formation and P3 suppression. It can be said that in the mentioned task, the lateral occipital area and parietal of people with high autism-traits are more active than those

with low autism-traits. Finding neurological and perceptual markers of high autism-traits can help in the advancement of research and diagnostic and treatment areas. Because people who are able to make eye contact with their own nerves are in trouble, their visual memory may be influenced due to cortex suppression.

Therefore, the research examining factors affecting visual memory can be efficient in memory, learning and training of high autism-traits individuals from childhood to adulthood. Considering the importance of this issue, we examined the factors affecting visual memory, including time in two groups of adults with low and high autistic-traits. The results of this study showed that processing of information in visual memory in people with high autism-traits is not fully shaped. Developing new interventions to enhance face processing might be worth considering.

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