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# Neurocognitive Mechanisms of Attention Distortion with Social Anxiety: A Flanker Problem Experiment

O A Sagalakova[1,a*], D V Truevtsev[1,b], A V Tinekov[1,c] and O V Zhirnova[1,d]

[1] Altai State University, 61 Lenina pr., Barnaul 656049 Russia

[a]*olgasagalakova@mail.ru, [b]truevtsev@gmail.com, [c]tinekov.aleksandr@gmail.com, [d]olga.zhirnova.2015@mail.ru

*Corresponding author

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**Abstract:** The aim of the presented research is to study the neurocognitive mechanisms of attention distortion with social anxiety (SA). An experiment using the modified Eriksen flanker task is implemented. Facial expressions (congruent and incongruent stimulus sequences) are used as stimuli. When solving a problem, the SA severity, errors, or correct decisions, and the sequence of stimuli vary. The integrative platform "EEG + eye tracking" is used; it has the ability to synchronously register parameters and analyze activity in dynamics. During the experiment, we recorded the stimulus, time, and correctness of the response, parameters of oculomotor activity, as well as the EEG (error-related negativity, ERN). When low and high levels of SA are compared, we find a greater deviation from the target priority for the distractors, an increase in solution time, and a decreasing number of correct decisions (especially under incongruent conditions), as well as a greater frequency and duration of fixations, a total number and amplitude of saccades, an increased target detection period. In the case of erroneous decisions, the ERN component is excessively expressed in subjects with SA. The indicators found are the measures of the neurocognitive mechanisms of SA that characterize the features of distortion of attention and information processing in the context of evaluating target activities (threat monitoring, self-focusing, decreased productivity, multitasking).

## 1. Introduction

Social avoidant disorder (SAD) and severe social anxiety (SA) are characterized by the following symptoms: (a) experiencing fears of receiving a negative assessment from others in social situations (perceived as threatening in the absence of real danger); (b) the actualization of dysfunctional beliefs about their behavior as inappropriate and unacceptable, potentially having catastrophic consequences [1]. SAD is one of the most common mental illnesses at a young age [2]. Cognitive models of SA/SAD emphasize the role of attention distortion [3] and disruption of the process of objective processing of social information [4] in the development of the syndrome. Self-focusing attention, providing access to negative thoughts and feelings [1], monitoring of social "threats," reducing the possibility of differentiation of the pole of stimuli, are considered as factors in maintaining symptoms. The use of non-adaptive behavioral strategies in the form of avoiding situations and self-protective behaviors ensures the stability of the pathological process [5].

In the case of SAD, modern models of attention distortion are focused on the process of this phenomenon [6], which determines the dynamic context of attention consideration in SA and is associated with the ambiguity of research. On the one hand, [7] argue that permanent automatic orientation to threatening incentives is replaced by avoidant behavior that situationally reduces anxiety. On the other hand, [8] it suggests a lack of intrusive alertness to threatening stimuli, normative attention when first contacting them, and a subsequent focus on the threat when it is difficult to get out of the situation. The issue of valency and affective saturation of emotions as a socially significant component related to the intensification of the experience of SA is discussed [9]. A positive assessment for SAD can be as intimidating as a negative one, and it can actualize avoidance behavior and threat monitoring [10]. The first studies using the eye tracker for SAD consisted of recording the eye path to detect visual trends in people with SA while perceiving emotional (positive, negative) and neutral facial expressions, verbal stimuli [11]. Fernandes et al. [12] proceed from stating the connection between cognitive deviations and maintaining SAD to identifying the mechanisms of indicated distortions of attention in the form of a subsequent focus on a socially "dangerous" stimulus. "Eye tracking" allows one to track the dynamic characteristics of the activity process [13], as well as to differentiate concentration and “non-attentional freezing” [14]. Research data through "eye tracking" technology show a clear violation of the target component of the activity, the partiality of attention, distortion of the processes of anticipation, and the post-situational information processing in SA [13; 15].

A number of EEG studies show that ERN – the error-related negativity with symptoms of SAD tends to increase in amplitude compared to normal [16]. This is a sharp negative peak in the event-related potential in the front-center sections (FCz), which is detected when an error is made. ERN is generated in front of the cingulate gyrus. The severity of ERN increases with age with anxiety and persists after therapy, which may indicate the analysis of ERN as a phenotypic property of SA [15; 17]. Within the framework of the Moscow School of Psychology, the importance of taking into account the dynamic properties of attention and the psychological qualification of empirical facts is emphasized [17].

## 2. Materials and Methods

In order to detect neurocognitive mechanisms of attention distortion and information processing disorders in ST, an experiment with the Eriksen flanker task was carried out. The study uses the integrative platform “EEG + eye tracking.” All participants of our research (18 people aged 17-19 years, the leading hand is the right one) were tested on the SA and Sociophobia Questionnaire [13] and the Questionnaire of Fearing a Negative Assessment [18]. The overall severity of SA is significantly correlated with the fear of a negative assessment and reliably characterizes the sample. People are divided into groups according to the severity level of SA.

The following programs were used to analyze data: The Python version 3.7.3; program R version 3.6.1; IBM SPSS Statistics 23; Statistica 10. The experiment was performed in the graphic designer of the experimental schemes “OpenSesame” [19]. The logic of the experiment is described using scripts in the python programming language. When writing scripts, the PyGaze [20] and SciPy [21] libraries were used to work with an eye movement sensor (smi red 250 mobile) and send messages to an EEG (ant neuro eego sport) via an LPT port. Synchronous registration of oculomotor activity and EEG provided.

The experiment is based on a modified flanker task developed by B. and C. Eriksen [22]. Subjects are presented with alternate rows of five facial expressions. Incentives are represented by a set of emotional facial expressions (Angry, Happy, Neutral). The stimulus set source is the Karolinska Directed Emotional Faces (KDEF) [23]. The distance between the images is 6 mm. The test subject is located at a distance of 50-60 cm from the screen, for which the angular dimensions of the photographs were approximately 3.7 × 5 degrees.

Lateral expressions within one presentation on the screen are identical (two flank stimuli to the right and left of the central expression). The central stimulus can either coincide with the others (congruent stimulus - HHHHH, etc.) and differ from them (incongruent stimulus – HHAHH, AAHAA, etc.). In particular, the instruction states, “Persons with different emotions will be shown on the monitor. As soon as possible, determine the emotion on the face in the center of the row using the arrows on the keyboard <…>. Be accurate; try to make as few mistakes as possible.” After presenting a number of stimuli, the "error" feedback appears within 500 ms if the central expression is incorrectly identified, and “true” appears when the central expression is correctly identified. Each combination is shown three times. Before the next stimulus is presented, a fixation cross is shown on the screen for 500 ms (Fig. 1). The order of stimuli is determined pseudo-randomly to control the effect of the sequence. During the experiment, the severity of ST, an erroneous or correct decision, types of stimuli vary, the following parameters are fixed: (1) stimulus (in what order facial expressions are displayed), (2) time and correctness of response, (3) oculomotor activity (sampling frequency is 250 Hz). In parallel with the registration of eye movements, EEG activity is measured in order to determine the electrocortical correlates of the reaction to erroneous decisions (ERN). An analysis of the bioelectric activity associated with the FCz lead is carried out.

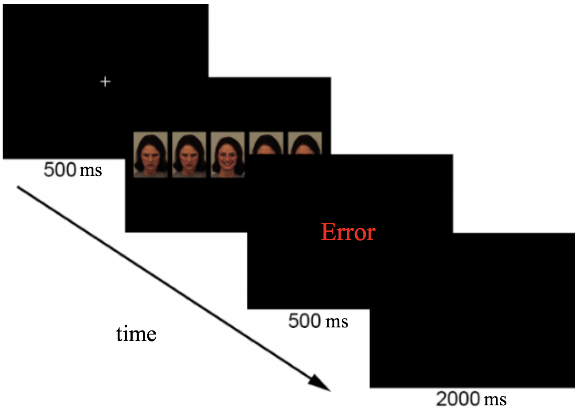


**Fig. 1.** Scheme for presenting stimuli in an experiment using a modified Eriksen flanker task (an example with feedback "error").

## 3. Results

As a result of the analysis of tracking eye movements when performing target activities, the following results were obtained. The correlation analysis (Spearman's rho = 0.5, p <0.04) showed a direct relationship between the severity of SA and the number of fixations (using the example of the incongruent stimulus AAHAA). At high SA indicators, the number of focuses of attention in the flanker task increases, despite the need to concentrate exclusively on the target stimulus, modulated by the instruction. The activity is characterized by greater multitasking due to the distribution of attention to a larger number of "zones of interest" that are not related to the goal. There is a pronounced negative effect of the context, inhibiting, and disorganizing the target activity.

At the same time, the vigilance of attention to the threats conducive to multitasking in the distribution of attention is manifested not only in the frequency of fixations per se. It is also in the proportion of deviations of attention from the target, a decrease in concentration on the target priority. Both indicators characterize the violation of the component of focus in terms of evaluating activities in which communicative stimuli (facial expressions) are involved. The data indicate a higher proportion of deviations of attention from the target in SA (Spearman's rho = 0.51, p <0.03) and a decrease in the ability to concentrate on the target, regardless of the sequence of stimuli in the task.

An analysis of oculomotor activity during the execution of the flanker task showed that a higher number of fixations and an escalation of the share of deviations from the target priority in SA inevitably lead to a decrease in formal indicators of activity productivity (time, accuracy). The average duration of fixations (in mc) is significantly associated with the share of deviation of attention from the target priority and distraction to distractors. Both indicators are higher in SA and are interconnected, forming indicators within the framework of cognitive attention syndrome (Spearman's rho = 0.5, p <0.04). Distraction by distractors, especially under incongruent conditions, is dynamically combined with the deviation of attention from the target stimulus.

An increase in the length of time spent on solving the problem with high rates of deviation of attention from the target stimulus in SA is characteristic, which is associated with a longer way of scanning the presented stimuli. An unreasonable goal, cautious and vigilant threat tactics are observed. Log-Linear analysis is applied to evaluate the relations of three categorical variables (the level of SA, stimulus, and answer correctness). SA makes a significant contribution to the distribution of responses (chi-square of the maximum likelihood method = 63; p << 0.0001). Subjects with a high SA make more errors when solving a flank task than with a low one. The effect is very strong when presenting incongruent stimuli.

Using the ANOVA, the results of experimental design 2 (SA) x 2 (Congruence) were analyzed. The time spent (in ms) on making a decision on each type of problem conditions (congruent or incongruent), with high and low SA measured. At the level of the statistical trend, the factor interaction "SA x Congruence" (F = 3.96; p <0.07) was found. At high ST, slowing solutions mainly due to conflicting stimuli. In general, congruent conditions are recognized faster in both groups (F = 11.8; p <0.004). At the same time, regardless of the type of condition, recognition is slower at high SA, but the differences do not exceed the significance threshold ($F = 3.4$; $p < 0.09$).

It was found that under the conditions of solving the target problem, with high SA, there is a tendency to increase the number of saccades (fast coordinated eye movements) associated with scanning and analysis of visual material, as well as the total amplitude of saccades. The parameter "proportion of deviations of attention from the target," which is a predictor of high ST, and Saccade Amplitude sum are significantly interconnected (Spearman's rho = 0.55, $p < 0.02$). At the same time, the single-factor ANOVA showed greater severity of Saccade Velocity Peak [°/s] ($F = 4.74$; $p < 0.05$) with a low level of SA compared with a high. An analysis of the primary results of comparing the results of EEG and eye-tracking shows that excessive monitoring of errors provokes careful tactics and increases the likelihood of incorrect decisions. The identified parameters of oculomotor activity in the process of solving the problem with SA are associated with a more pronounced neurocortical equivalent of error monitoring (with a negative peak in the period 0-100 ms after the error).

## 4. Discussion

Students are characterized by participating in a variety of assessment situations in which primary symptoms can be supported by a dysfunctional style of processing significant information (cognitive attention syndrome), leading to maladaptation. Identification of objective correlates of SA symptoms can be especially crucial for improving preventive, therapeutic strategies, understanding the mechanisms of symptom pathogenesis.

It is likely that the identified features of attention distortion in SA are associated with a shift in the motivational structure of activity – from the motive to complete the task in accordance with the goal (success) to the motive "not to make a mistake" (avoidance of failure). Eriksen flanker task recreates those probabilistic conflict conditions of social situations that are an integral part of life and are especially significant in the case of SA/SAD. The experimental design made it possible to detect differences both in latent decision-making time and the total duration of the decision and in the frequency of valid and incorrect identifications made within the framework of the instruction. To strengthen a number of detected trends to the level of statistical significance and a generalized comparison of EEG and eye-tracking, an increase in the sample of subjects is required.

## 5. Conclusion

In the study of syndrome-forming indicators of attention disorders, and the cognitive style of information processing in SA, the original experimental design using the modified Eriksen flanker task was developed. As a result of the study, the authors show that multitasking and vigilance towards distractors (a negative effect of the context) can be considered a special cognitive type of processing socially significant information in SA, which is determined by monitoring threatening incentives and a tendency to analyze them based on internally generated information. These results are modulated by the performance evaluation (feedback) and the communicative type of stimulus (facial expression).

The peculiarity of information processing and distortion of attention in SA are most pronounced under incongruent conditions. Conflicting stimuli cause more indicative monitoring at SA, which affects the violation of focus, speed, and loyalty solutions. At low SA, even in conflict conditions, the correct solution is faster, while at high SA, the approximate stage increases, and target detection slows down. It is shown that ERN, a component of the evoked potential associated with the error, acts as a correlate of self-focusing attention and error monitoring. ERN reflects a normal error-monitoring system; however, with SA, it is significantly more pronounced. It is an indicator of increased sensitivity to internal sources of threat (fear of making a mistake) and the perception of errors as catastrophic (consequences), as well as compensation processes to control limited cognitive resources.

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