A Method for Tracking Eye Movements in the Study of Attention Selectivity in Social Anxiety

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Abstract

One of the key mechanisms of social anxiety is the distortion of the cognitive-perceptual activity. Cognitive-behavioral models of social anxiety, being the basis of anxiety disorder, determine the distortion of attention in regards to stimuli – social threats (by opposing types of disorders – vigilance or avoidance). The eye movement tracking method enables assessing the bias of attention to stimuli – facial expressions in teenagers with a high and low level of social anxiety. The study included 30 test subjects aged 16-18. We used the eye tracker SMI RED 250 mobile tracking technology. The test subjects were divided into groups based on the results of the questionnaire of social anxiety and social phobia. We discovered signs of severer disorganization of the target activity during the perception of both presumptive positive and negative facial expressions (higher amplitude of saccadic movements as a deviation from target priorities and multitasking) and a prolonged fixation of attention on stimuli fragments with negative expression (average and maximum duration of fixations on the path of visual scanning). During the attribution of characteristics, we often found typical cognitive distortions, which are most significant in regards to the presumptive positive stimulus (the “happy face” condition was attributed negative characteristics and mistakes were made in determining the emotion). Eye movement registration would enable a more pinpoint and continuous measurement of attention. The eye-tracker method is very promising for the understanding of information processing in case of affective disorders. Eye movements are an indicator of clear attention and perception (zones of interest, fixation, duration and sustainability of fixations, saccadic movements, eye trajectory sequence, etc.).

Keywords: Tracking eye movement method (“Eye Tracker”), Social anxiety disorder, Selectivity of attention, Vigilance and avoidance, Social threat, Facial expressions.

Introduction

Clinical observations and experiments show that people with anxiety disorders have a special type of thinking and remembering, as well as paying attention to sources of opacity from outside. Cognitive-behavioural models of social anxiety (SA) and social anxiety disorders (SAD) assume that biased (distorted) attention plays a role in symptom maintenance [1-2].

The two main SAD models give different predictions is regards to the nature of attention distortions. For instance, Rapee, Heimberg [2] argue that with SAD, test subjects quickly identify signals related to negative evaluation and then find it hard to switch their attention. Meanwhile, Clark and Wells [1] argue that social anxiety stimuli are avoided.

The common thing in these two models is that distorted attention selectivity leads to an overestimation of risk in social situations, which triggers avoidance behaviour (SAD symptom maintenance factor).

The typical attention pattern with SAD is “vigilance and avoidance” at different stages of stimuli (social dangers) perception. The method is used to study empirical markers of cognitive distortions in case of SA, specify SA and SAD models, and predict the development of the disorder. The method can also be used to plot eye trajectories in real
time and draw “heat maps” that show “attention zones”. Eye movements measured with the “eye tracker” allow judging about attention and thinking processes and the peculiarities of information processing in general [3, 4, 5], verify empirically the hypotheses regarding the vigilance/avoidance of attention in regards to threatening stimuli of negative evaluation (the hyper vigilance-avoidance hypothesis) [5].

Eye fixations are empirical indicators of the parts of the environment that are important to the subject, while saccadic movements are indicators of a switch of the perceived object or part thereof.

All experimental studies that used eye tracker have been based on the idea of distortion of information processing under affective disorders. The development of cognitive SAD models [1, 2] involved a series of studies that used hardware-based methods of studying attention selectivity with SAD.

The examination of the attention process in SA patients yielded contradicting results, which showed the specific sensitivity to emotional stimuli with different forms of anxiety disorders [6]. On the one hand, people with SAD were afraid of finding themselves in an embarrassing situation and avoided contact with unpleasant stimuli; on the other hand, test subjects with anxiety tended to focus on people’s faces or presumptive negative information (for instance, information found in a text) to keep an eye on changes in their expression and anticipate disapproval [7, 8, 9].

When the eye tracker technology was used in experiments, in some studies, test subjects tried to “avoid” threatening stimuli, while in other studies they fixated their vigilance on threatening stimuli and that their attention was absorbed by them (while ignoring other materials or interpreting presumptive “positive” and “neutral” stimuli in a distorted fashion). Vigilance distortion dominates when the test subjects browse a simple story without restraint, while distorted “switches / involvement” takes place during complicated search tasks with conflicting instructions.

Attention disorders make the everyday life of patients more difficult [11, 2].

Certain results allow assuming that SA related attention distortions are characterized primarily by vigilance to threatening stimuli, selectivity in regards to negative stimuli, monitoring of “hidden” signs of disapproval in social stimuli [12, 10-13, 14], and problems with switching / disengaging attention “from threats” (disengaging threats) [15, 16].

Other data show that SA exacerbation is associated with avoidance of threatening information [17, 18, 19, 20]. In addition, some published studies gave contradicting results that did not support any attention selectivity pattern (hypervigilance vs avoidance/deviation) [20].

Within the framework of the cultural-activity approach of the Vygotsky-Luria school [21, 22], we offer a new perspective on this contradiction in the investigation of mental activity selectivity processes: attention avoidance and attention hyper involvement (absorption, vigilance) as stages of a single systemic process that are observed in the perception of social stimuli. The search and detection of threats alternate with an occasional deviation from them, which is the cause of a self-sustaining continuous cycle of attention breakdown.

So, researchers raise the issue, indicators that affect specific distortions of attention in relation to threatening incentives - violations in the formulation or implementation of attention objectives (execution) [23]. In our previous study, younger test subjects with severe SA (nonclinical sample) confirmed the fact of a systemic interrelation of the phenomena of attention vigilance and avoidance in regards to social stimuli in the form of mimic expressions with a clear image variant [24].

The purpose of this study is to validate the hypotheses regarding attention bias using the eye tracker technology by the example of adolescents with high and low social anxiety:

- Test subjects with social anxiety had a more pronounced target activity disorganization during the perception of both presumptive positive and negative
facial expressions and a lengthier attention absorption by individual fragments of stimuli with negative expression.

- The interplay of the “social anxiety” and “expression type” factors is insignificant: the general amplitude of saccadic movements during the visual scanning of faces is greater with a high level of social anxiety regardless of the expression type.

- In thought attribution tasks (“what are they thinking about”), test subjects with a high level of social anxiety attribute thoughts about negative assessment to faces with different expressions (including “happiness”). In expression (emotion) identification tasks, test subjects with a high level of social anxiety identify negative emotions more accurately than the ones with a low level of social anxiety do, while the “happiness” emotion triggers contradicting responses.

Method
The sample included test subjects aged 16-18 (N=30, mean=16.9 years, SD=0.96, 60% female sample, 15 test subjects – with high level of social anxiety, 15 – with low level of social anxiety, residing in the Altai Krai).

The study used an eye tracker technology used (eye tracker SMI RED 250 mobile, (Senso Motoric Instruments, Germany). The stimuli used in the study – facial expressions (anger, disgust, happiness, fear) – were presented to the test subjects with low and high social anxiety at random for 6000 ms. The groups were divided based on the results of the questionnaire of social anxiety and social phobia; the significance of differences was verified using ANOVA, significant at p<0.001 [24]. Expressions were selected as the most typical ones for social interaction [25] (Figure 1).

During the visual scanning of faces, the objective was to figure out what the person in each image was thinking about (attribute thoughts), memorize each facial expression, and, after the experiment was over, tell the results for each of the four expressions in succession. In order to complete the task efficiently, it was necessary to analyze the so-called semantically prioritized aspects of the stimulus (eyes, nose, and mouth). Independent variables were as follows: 1) level of social anxiety (high or low); 2) types of facial expressions (anger, disgust, happiness, and fear).

Dependent variables included the parameters of the eye movement activity during the visual scanning of facial expressions (general amplitude of saccadic movements and maximum duration of fixations). The empirical indicator of activity (multitasking) disorganization and avoidance/deviation of attention from social stimuli was the deviation from the target priority – the task that was communicated by the experimentalist (general amplitude of saccadic movements), while the indicator of vigilance to stimulus elements was the average and maximum visual fixation duration.

In order to verify the first hypothesis regarding the intensity of the general amplitude of saccadic movements and fixation duration (average and maximum) in test subjects with high social anxiety in comparison to ones with low social anxiety, we used the one-way analysis of variance – ANOVA. In order to verify the second hypothesis regarding the lack of interaction between the factors of “expression type” and “social anxiety level”, we used the “4x2” factorial design with results processing via repeated measures ANOVA.

The within-subjects factor was the expression type (four levels); the between-subjects factor was the level of social anxiety (two levels). In order to verify the hypothesis regarding the difference between the frequencies of responses during the stage of thought attribution to different facial expressions, we used the contingency table method (based on Pearson’s chi-squared test). Experimental data were processed using SPSS Statistics 23 software (IBM, USA).

Results
The general amplitude of saccadic movements in test subjects with high social anxiety turned out to be significantly higher than that in test subjects with low social anxiety. Successive tests of saccadic movement amplitude height in test subjects with low and high levels of social anxiety found that the most significant differences between groups in case of the “happy” face condition (p<0.001) (Figure 3, Table 1).
While the perception of a happy face by test subjects with a low level of social anxiety was more ordered (the scan line trajectory was of a more organized nature on average), it did not cause a more ordered effect in test subjects with high social anxiety when compared with other types of expression.

![Figure 1: Peculiarities of the scan path and zones of facial expression fixation by test subjects with high social anxiety (High SA) and low social anxiety (Low SA) (typical sample results)](image)

For test subjects with social anxiety, the “happy face” turned out to be a similarly threatening social stimulus as other expressions were, which confirms the results of previous studies [19] (Figure 1 and Table 1). This can be interpreted as follows: such test subjects perceive the slime as “mockery” rather than affection or goodwill. High saccadic activity is indicative of severer social anxiety and target deviation from the performed activity (disorganization) in the group. Test subjects with severe social anxiety acted in multitasking mode. At that, a target priority that would be sustainable throughout the entire activity is not formed. Temporary target priorities are related not so much to the performance of the task as to the search for and detection of social treat stimuli.

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Table 1: ANOVA results for the parameters of tracking eye movement in the perception of facial expressions: 1) Saccade Amplitude Total, 2) Fixation Duration Average, 3) Fixation Duration Maximum

Significance of differences in groups: * - p<0.05, ** - p<0.01, *** - p<0.001.
Alongside synchronous “tracking” of threats, abrupt eye movements (high saccade amplitude) on the path of the expression visual scan, test subjects with high social anxiety had greater attention fixation duration. Fixations are zones of interest and an indicator of attention absorption by certain aspects of the stimulus. Both the average (p<0.01) and maximum (p<0.05) fixation durations turned out to be statistically higher in the experimental conditions of “anger” and “fear” in the group of test subjects with social anxiety (Table 1).

We used the Environment x Person (4x2) factorial design to assess the interaction between the independent variables (“expression type” and “social anxiety level”) in their effect on dependent variables (eye movement activity parameters). The results showed an insignificant interaction of factors across all measured parameters of eye movement activity. The general amplitude of saccadic movements and the average and maximum fixation duration was higher with a high level of social anxiety than with a low level of social anxiety, regardless of the within-subjects factor – the type of expression (anger, happiness, disgust, fear) (Table 2).

During the last stage of the study, the test subjects reported about the expressions and “thoughts” that matched each expression (attribution of thoughts to the expressions they were shown). We recorded the frequency of certain answers; difference patterns in the frequency of answers were validated statistically (via the contingency table method). Test subjects with high social anxiety often attributed negative evaluative thoughts to the “happiness” expression (they identified “happiness” as mockery or insincere goodwill) (χ²=10; p<0.01).

In case of high social anxiety, there could have been more than several answers, which were hypothetical, and contradicting (“maybe happiness or maybe a mocking grin”). In the group with low social anxiety, the attribution of thoughts to expressions (“what are they thinking about”) corresponded semantically to the emotions expressed by the face, without contradicting answers (χ²=11; p<0.01). No significant differences were found in the groups during the formal identification of emotions in regards to anger (p<0.05), however, during the identification of the “happy” face, test subjects with high anxiety, while correctly understanding the emotion in the image in general, mentioned not only the “emotion”, but also mimic features of the face (“smiling”, “grinning”, “stretched lips”) more often than test subjects with low anxiety did, while the latter were more prone to identifying the emotion (happiness or joy) flawlessly (χ²=11,4; p<0.01). The most significant cognitive-perceptive distortion was found in test subjects with high anxiety during the perception of the positive facial expression (“happiness”).

Discussion

When generalizing the results of the study conducted with the eye tracker method, one can state with full confidence that distortions of attention selectivity play a major role in the understanding of the nature of SA. One of the contradictions regarding attention distortion with SAD that is most commonly encountered in literature is the “avoidance vs vigilance” dilemma, which corresponds with the two approaches to the mechanisms of [1,2].

Nowadays, researchers have drawn close to understanding that this contradiction is arbitrary. SAD is characterized by both vigilance to threatening stimuli and avoidance thereof, especially when it comes to the expression of negative evaluation [19], everything depends on the design of the

Table 2: Results of repeated measures ANOVA Measurements of the effect of the within-subjects “expression type” factor and the between-subjects “social anxiety level” factor on the parameters of eye movement tracking

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<th>Repeated measures ANOVA</th>
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<th>Alternative Univariate F-test. The Greenhouse-Geisser correction</th>
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<td>F</td>
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<tr>
<td>Saccade Amplitude Total</td>
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<td>Fixation Duration Maximum</td>
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<td>0.25</td>
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<td>Fixation Duration Average</td>
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experiment. Under conditions of obstructed perception of faces with an angry expression in case of SA, studies found increased attention vigilance to emotionally informative parts of the face [26]. The remaining partial contradictions in the results could be related to the examination of various properties of attention (selectivity, distribution, and switch).

Contradictions in the interpretation of the research results stem not so much from the differences in experimental procedures as from the methodological messages related to the subject reactivity paradigm [4, 27]. Mental “selection” is interpreted in fragments, not as an activity process. Systemic models that interpret regulation and integrative approaches to neuro-cognitive mechanisms of attention disorders are not studied [11].

We believe it is necessary to take the cultural-activity approach to understand attention selectivity in anxiety, which will allow, according to the principles of consistency, activity, unity of affect and intellect, motivational bias of the psyche, etc. to understand the dynamic process of attention regulation during the solution of socially mediated problems (the Vygotsky-Luria school).

The methodology of the systems approach expands the horizons of perception of mental activity orientation and the dynamics of its regulation during different SA stages in the experimental procedure with the use of the eye tracker. In follow-up studies, this approach can help to assess the effectiveness of pharmaceutical or psychotherapeutic treatment of anxiety at different stages of treatment. The systemic model of disorders will allow regulating the state of anxiety more effectively and with regards to the different stages of disorganization of the target activity of attention in certain situations.

The results of the experiment showed the peculiarities of attention bias and interpretation of presumptive positive expression. Test subjects with high SA were characterized by a distorted interpretation and selectivity in regards to information that is traditionally perceived as benevolent or neutral, which confirms the number of other studies [26]. Such peculiarities of attention bias towards social stimuli (expression) can make it difficult for test subjects with social anxiety to gain the positive experience of approval and objectively facilitates the disruption of organization and purposefulness of activity.

Alongside multitasking and “avoidance/deviation” of conceptual, in terms of the performance of instructions, stimuli, test subjects with social anxiety are also characterized by prolonged fixation on both conceptual and insignificant segments of the stimulus (this is different from the results of the study by Horley, Williams [19]. The duration of fixations is indicative of attention bias towards certain aspects of stimuli, which is important for socially negative expressions (anger and fear).

It was found that both vigilance to and monitoring of threatening stimuli and the disorganization of activity, multitasking, and avoidance of significant aspects of the stimulus were characteristic of test subjects with social anxiety at different stages of the visual scanning path. These results unite the described mechanisms of social anxiety maintenance in social anxiety models [1, 2] and allow viewing them not as different mechanisms, but as states of a systematic mechanism of the attention process that cause disorders of regulation of voluntary mental activity. The peculiarities of attention that have been described in the study serve as a foundation for the formation and maintenance of social anxiety and are the reason behind the formation of avoidance behaviour that aims to relieve anxiety.

The results are indicative of a special interpretation of presumptive positive social stimuli and attention bias towards socially significant stimuli (facial expressions). For test subjects with social anxiety, the group of stimuli that threaten their self-esteem and status includes a wider range of stimuli. They are characterized by distrust and vigilant analysis of stimuli that are traditionally perceived as goodwill. Such peculiarities of attention bias towards social stimuli (expression) can make it difficult for test subjects with social anxiety to gain the positive experience of approval and objectively facilitates the disruption of organization and purposefulness of activity.
Conclusion

Regardless of the “expression type” (anger, happiness, disgust, fear) factor, a high level of social anxiety is characterized not only by a significantly higher amplitude of saccadic movements, but also by greater average and maximum fixation duration in comparison to subjects with low social anxiety. The greatest differences between the groups were found under the “happy face” condition. For test subjects with anxiety, the “happy face” turned out to be as threatening a social stimulus as other expressions. Increased saccadic activity is indicative of a severer target deviation from the performed activity in test subjects with social anxiety.

Multitasking as a product of SA dysregulation explains that besides the arbitrary goal set in the experiment, test subjects with SA are “forced” to pursue additional target priorities that do not correspond with the content of the activity. They constitute that foundation of the need to detect threats to then “relieve” the growing anxiety – avoid them; after that, the stages recur, further destabilizing the target architecture of the mental activity. This creates a vicious circle of search for and detection of signs of a negative evaluation threat (vigilance), followed by their avoidance and return to the first stage – this is a never-ending process that becomes a rumination cycle.

In problems that involved the attribution of thoughts to a character behind various facial expressions (anger, disgust, happiness, and fear), test subjects with a high level of social anxiety generally attributed thoughts about an unkindly attitude, including to the “happiness” expression.

In expression (emotion) identification problems, the “happiness” emotion triggered contradicting responses. The most significant cognitive-perceptive distortion was found in test subjects with high anxiety during the perception of the positive facial expression (“happiness”). It was typical for the interpretation of this stimulus to be distorted cognitively [28-30].

Acknowledgements

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References


