EUROPEAN JOURNAL OF PSYCHOTRAUMATOLOGY
2023, VOL. 14, NO. 2, 2172258
https://doi.org/10.1080/20008066.2023.2172258

EUROPEAN JOURNAL OF PSYCHO-TRAUMATOLOGY
THE OFFICIAL JOURNAL OF THE EUROPEAN SOCIETY FOR TRAUMATIC STRESS STUDIES

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BASIC RESEARCH ARTICLE

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The influence of the behavioural inhibition system on the development of PTSD-like symptoms after presentation of a traumatic film in healthy subjects

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ABSTRACT

Background: The Behavioural Inhibition System (BIS) as a neural system controlling motivation and behaviour, has previously been linked to multiple mental disorders, including Post-traumatic Stress Disorder (PTSD). BIS-sensitivity could increase the likelihood of PTSD development after trauma. However, previous studies have largely measured BIS-sensitivity retrospectively (i.e. after trauma, or even after onset of PTSD).
Objective: The study aims to confirm the relationship between BIS-sensitivity prior to trauma and PTSD symptoms.
Method: After assessment of BIS-sensitivity, $N = 119$ healthy participants watched a film with visually disturbing material. After 72 h, participants completed a questionnaire on PTSD-related symptoms (PCL-5).
Results: In a multiple linear regression model, BIS-sensitivity significantly predicted PTSD symptoms, even after controlling for the decrease in mood, as well as for participants' age and sex, two factors that had previously been shown to influence BIS-sensitivity.
Conclusions: This is the first study to measure BIS-sensitivity before the occurrence of the (experimental) trauma and strengthens its role as a potential pre-traumatic risk factor.

La influencia del sistema de inhibición conductual en el desarrollo de síntomas similares al TEPT después de la presentación de una película traumática en sujetos sanos

Antecedentes: El Sistema de Inhibición del Comportamiento (SIC) como un sistema neuronal que controla la motivación y el comportamiento, ha sido relacionado previamente con múltiples trastornos mentales, incluido el Trastorno de Estrés Postraumático (TEPT). La sensibilidad-SIC podría aumentar la probabilidad de desarrollo de TEPT después de un trauma. Sin embargo, los estudios previos han medido en gran medida la sensibilidad-SIC de forma retrospectiva (es decir, después de un trauma o incluso después del inicio de TEPT).
Objetivo: El estudio tiene como objetivo confirmar la relación entre la sensibilidad-SIC antes del trauma y los síntomas del TEPT.
Método: Después de la evaluación de la sensibilidad-SIC, $N = 119$ participantes sanos vieron una película con material visualmente perturbador. Luego de 72 horas, los participantes completaron un cuestionario sobre síntomas relacionados con el TEPT (PCL-5).
Resultados: En un modelo de regresión lineal múltiple, la sensibilidad-SIC predijo significativamente los síntomas del TEPT, incluso después de controlar por disminución de ánimo, así como edad y sexo de los participantes, dos factores que previamente han demostrado influir en la sensibilidad-SIC.
Conclusiones: Este es el primer estudio que mide la sensibilidad-SIC antes de la ocurrencia del trauma (experimental) y fortalece su rol como un potencial factor de riesgo pretraumático.

行为抑制系统对健康受试者创伤性影片放映后 PTSD 样症状发展的影响

背景：行为抑制系统 (BIS) 作为一种控制动机和行为的神经系统，以前与多种精神障碍有关，包括创伤后应激障碍 (PTSD)。 BIS 敏感性可能会增加创伤后发生 PTSD 的可能性。 然而，以前的研究主要是回顾性地测量 BIS 敏感性（即，在创伤后甚至在 PTSD 发作后）。
目的：本研究旨在确认创伤前 BIS 敏感性与 PTSD 症状之间的关系。
方法：在评估 BIS 敏感性后，119 名健康参与者观看了一部带有视觉干扰材料的电影。 72 小时后，参与者完成了一份关于 PTSD 相关症状 (PCL-5) 的问卷调查。

ARTICLE HISTORY
Received 8 June 2022
Revised 27 September 2022
Accepted 31 December 2022

KEYWORDS
Behavioural inhibition system; reinforcement sensitivity theory; post-traumatic stress disorder; PTSD; trauma film

PALABRAS CLAVE
Sistema de inhibición conductual; Teoría de la sensibilidad al refuerzo; Trastorno de estrés postraumático; TEPT; película de trauma

关键词
行为抑制系统; 强化敏感性理论; 创伤后应激障碍; PTSD; 创伤电影

HIGHLIGHTS

- Main research question: What factors predict the development of posttraumatic symptoms after exposure to a traumatic event?
- The candidate investigated here is the Behavioral Inhibition System (BIS), a neural system controlling motivation and behavior. Our study provides evidence that the BIS is a potential risk factor, prediciting the development of posttraumatic symptoms after exposure to an experimental trauma in healthy participants.

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结果：在多元线性回归模型中，即使在控制了情绪降低以及参与者的年龄和性别这两个之前被证明会影响 BIS 敏感性的因素后，BIS 敏感性也显著预测了 PTSD 症状，。
结论：这是第一项在（实验）创伤发生前测量 BIS 敏感性的研究，加强了其作为潜在创伤前风险因素的作用。

1. Introduction

Traumatic events occur frequently (Atwoli et al., 2015), and can lead to the development of Post-traumatic Stress Disorder (PTSD). However, not everybody who experiences a traumatic event develops PTSD.

This poses the question of who will and who will not develop PTSD, and which factors influence the likelihood of PTSD-occurrence after a traumatic event. There is a large body of literature investigating risk factors for PTSD development (Tortella-Feliu et al., 2019).

The study presented here contributes to a vein of research that has focused on personality factors related to a higher risk of PTSD development, based on J.A. Gray's Reinforcement Sensitivity Theory (J. A. Gray, 1970; J. A. Gray & McNaughton, 2003). The RST proposes the existence of distinct neural systems that control motivation and behaviour, especially in regard to reward and punishment: The Behavioural Inhibition System (BIS), and the Behavioural Activation System (BAS). According to RST, individuals with high BAS-sensitivity are primarily motivated to seek rewards, but they also tend to be more impulsive and may have difficulties inhibiting their behaviour when approaching a goal. Individuals with high BIS sensitivity, on the other side, are motivated to avoid punishment. They may also be more vulnerable to negative emotions. Several studies have found evidence for an association between high BIS sensitivity and PTSD symptoms in different populations (Contractor et al., 2013; Gudiño, 2013; Maack et al., 2012; Myers et al., 2012; Pickett et al., 2011). However, in all of these studies, BIS sensitivity was assessed *after* the traumatic events, so that post-traumatic changes in BIS sensitivity could confound the observed relationships, making causal inferences impossible.

The investigations into the relationship between BIS/BAS and PTSD can be viewed in the wider context of reward and punishment processing in PTSD. There is evidence of altered reward functioning in PTSD (Nawijn et al., 2015), and functional imaging studies have found altered neural responsivity to both reward and punishment after trauma (Ben-Zion et al., 2022). It has been speculated that heightened responsivity to punishment may pose a predisposing risk factor of PTSD, while diminished response to rewards may only be acquired after trauma (Admon et al., 2013).

The present study is the first to our knowledge to measure BIS/BAS-sensitivity *before* applying a so called 'trauma film' to investigate the relationship between pre-traumatic BIS sensitivity and induced PTSD symptoms.

2. Materials & methods

The study was conducted within the facilities of the Department of Psychosomatic Medicine and Psychotherapy, LWL-University Hospital Bochum, Ruhr-University Bochum. Data collection took place from April through November 2018.

2.1. Participants

The study sample consisted of $n = 119$ healthy subjects, 60.5% females ($n = 72$), with a mean age of 30.0 years (SD: 13.0 years; range: 18–78 years). Participants were recruited via a study participation portal for psychology students at Ruhr University Bochum, and an open call for participants was posted on social media. Those interested to participate underwent an online screening to ensure they did not meet any exclusion criteria, i.e. that they were mentally healthy (in particular, that they did not suffer from a trauma related disorder) and had not participated in a previous trauma film study. The study was conducted in accordance with the latest revision of the Declaration of Helsinki (World Medical Association, 2013) and was approved by the Ethics Commission of the Department of Psychology, Ruhr University Bochum.

Sample size calculation was based on another research question that was investigated within the study design and will be reported separately.

2.2. Procedure

All prospective participants completed an online assessment which included, among others, demographic questions, and the BIS/BAS Scales (Carver & White, 1994; Strobel et al., 2001). Qualified participants were scheduled for the first study session (T1). In this first session, participants were informed about the study procedure and provided written informed consent. Afterwards, they watched the trauma film. Then, a second appointment was scheduled to take place 72 h after the first appointment (T2), in which participants completed the PCL-5 and received an intervention intended to study another research question that will be reported separately. (Figure 1)

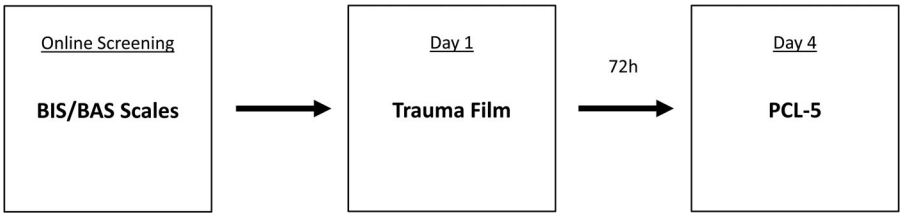

Figure 1. General study design.

3. Material

3.1. BIS/BAS scales

As part of their online screening before T1, participants completed the German version of the BIS/BAS scales (Carver & White, 1994; Strobel et al., 2001), a 24-items self-report questionnaire designed to measure BIS- and BAS-sensitivity. It consists of 4 subscales: BIS, BAS drive, BAS fun seeking, and BAS reward responsiveness. Answers are recorded on a 5-step Likert scale ranging from 1: 'very false for me' to 5: 'very true for me'. Internal consistency of the German version of BIS/BAS scales was measured at 0.78 (Cronbach's alpha) for the BIS subscale (Strobel et al., 2001). The BIS/BAS scales are freely available on the internet, for example items see: https://local.psy.miami.edu/people/faculty/ccarver/availbale-self-report-instruments/bisbas-scales/ (last accessed on 09-07-2022).

3.2. PTSD checklist for DSM-5 (PCL-5)

The German version of the PTSD Checklist for DSM-5 (Weathers et al., 2013) is a 20-item self-report questionnaire based on the symptoms of PTSD according to DSM-5. It measures symptoms from all four symptom clusters: re-experiencing, avoidance, negative alterations in mood/cognition, and hyperarousal. Answers are given on a 5-point Likert scale ranging from 0 ('not at all') to 4 ('extremely'). The German version of PCL-5 shows an internal consistency (Cronbach's alpha) of 0.95 and a test-retest-reliability of r = 0.91 (Krüger-Gottschalk et al., 2017). The PCL-5 was completed in the online screening only by participants who reported having experienced at least one traumatic event within their lifetime. Individuals with a sum score ≥ 33 were considered suffering from clinically relevant symptoms and were therefore excluded from the study. Additionally, the PCL-5 was administered to all participants 72 h after the traumatic film as a measure of analogue PTSD symptoms. When used as a measure of analogue PTSD symptoms after film presentation, participants were told to answer the questions in regard to the traumatic film.

3.3. Trauma film

At the first appointment, participants watched a 14:52 min film that consisted of 16 different distressing/disturbing scenes, including depictions of accidents, injuries/corpses, acts of violence, and surgical procedures. The film was presented without sound in a darkened room on a computer display. Participants were alone in the room during film presentation and were instructed to watch the whole film attentively, without looking away or closing their eyes. The same film had previously been used in other studies in our lab and has consistently induced intrusive memories in healthy participants for a limited duration (Kessler et al., 2020).

3.4. Statistical analysis

All analyses were performed using IBM SPSS statistics software, version 26.

Main variables of interest were BIS scale score and PCL-5 sum score. Changes in mood during viewing of the trauma film were also considered in additional analyses. To investigate the relationship between BIS sensitivity and PCL-5 scores, a Pearson product-moment correlation was performed.

Since some – but not all – previous studies have reported correlations between BIS-scores and age (J.D. Gray et al., 2016; Jorm et al., 1998; Strobel et al., 2001), as well as sex differences in BIS-scores (Jorm et al., 1998; Strobel et al., 2001), an additional regression analysis was performed to control for effects of age, sex, and mood decrease on BIS-scores.

In all analyses, a significance level of $\alpha = 0.05$ was used, and tests were performed as two-tailed tests.

4. Results

Participants' mean BIS-score was 2.55 (SD 0.52). Mean PCL-5 sum-score was 4.79 (SD 5.04; range 0–27).

There was a significant positive correlation between participants' BIS-scores and PCL-5 sum scores ($r = 0.35$; $p < .001$).

Participants' mood worsened significantly throughout the trauma film ($t_{118} = 19.63$; $p < .001$), and the decrease in mood was significantly correlated with higher BIS-scores ($r = 0.32$; $p < .001$). Mood decrease was also significantly correlated with PCL-5-scores ($r = 0.35$; $p < .001$).

The regression model to predict PCL-5 sum scores (see Table 1) was significant ($F_{3,115} = 8.09$; $p < .001$),

Table 1. Multiple linear regression model to predict PCL-5 Sum Score (DV: dependent variable). $R^2 = 0.221$; $F_{3,115} = 8.092$; $p < .001$. B: Unstandardised Regression Coefficient; S.E.: Standard Error of B; 95%-C.I.: 95% Confidence interval around B; β: Standardised Regression Coefficient.

DV: PCL-5 Sum Score	B	S.E.	95%-C.I.	β	T	*p*
Constant	−1.270	2.477	[−6.178; 3.637]		−0.513	.609
BIS	2.304	0.889	[0.543; 4.065]	0.239	2.591	.011
Mood decrease	0.100	0.037	[0.027; 0.173]	0.239	2.708	.008
Age	−0.072	0.033	[−0.137; −0.007]	−0.186	−2.196	.030
Sex	0.269	0.913	[−1.539; 2.076]	0.026	0.294	.769

and explained about 22% of variance ($R^2 = 0.22$). BIS-scores significantly predicted PCL-5 sum scores (β = 0.239; $t_{115} = 2.59$; $p = .011$), as did mood decrease (β = 0.239; $t_{115} = 2.71$; $p = .008$), while sex did not significantly predict PCL-5 sum scores in this model. Age also had a significant effect in this model (β = −0.186; $t_{115} = -2.20$; $p = .030$), with lower age predicting higher PCL-5 sum scores.

5. Discussion

The study presented here investigated the relationship between BIS sensitivity and the development of PTSD-like symptoms in healthy participants following the presentation of a trauma film. Corroborating our hypothesis, BIS-sensitivity prior to analogue trauma in our study sample predicted PTSD symptoms at 72 h post-analogue-trauma. This relationship remained significant when controlling for age, sex, and decrease in mood. These results are in line with previous findings that suggest a relationship between BIS-sensitivity and PTSD development (Contractor et al., 2013; Gudiño, 2013; Maack et al., 2012; Myers et al., 2012; Pickett et al., 2011). However, our study is the first to our knowledge to measure BIS-sensitivity *before* the analogue trauma, thus ruling out changes in BIS-sensitivity post-trauma as a possible confounding factor.

Our findings are in line with Contractor et al. (2013), who observed significant positive correlations of BIS-scores with all 4 PTSD symptom clusters (although they found the effect of BIS on PTSD dysphoria to be completely mediated by PTSD avoidance).

There are several limitations to the study presented here. First, all data were derived from a sample of healthy participants who were subjected to an experimental trauma. While the trauma film paradigm used in this study has been employed by many previous studies (Holmes et al., 2010; James et al., 2015; Kessler et al., 2020) to model aspects of trauma and PTSD, a core necessity is – of course – to not actually traumatise the healthy participants. Therefore, results may not be completely transferrable to samples of actually traumatised individuals. Second, PTSD development can be a prolonged process, with symptoms sometimes developing after a year-long delay (in late-onset PTSD), and changing over time. It is very likely that important aspects of this process cannot be captured by the condensed 72h-design of the study presented here. Third, PCL-5 scores varied between participants but were all within the range below the cut-off for a clinical PTSD (33 points for the German version). Hence, inferences about 'PTSD symptoms' as measured by PCL-5 in our sample have to be considered with caution.

Considering the limitations of the study design, our results nonetheless provide further evidence of a relevant relationship between BIS and the development of PTSD-like symptoms after experimental trauma, suggesting a role of BIS as a pre-traumatic risk factor of PTSD. This finding is consistent with both conceptualizations of PTSD development (Brewin, 2014; Ehlers & Clark, 2000) and findings from other studies (Contractor et al., 2013; Maack et al., 2012; Myers et al., 2012; Pickett et al., 2011). To further substantiate these results, larger, longitudinal epidemiological studies are warranted, to establish the role of BIS when individuals are confronted with 'real' traumatic events, as opposed to experimental analogue trauma. If supported further, assessment of BIS-sensitivity could prove a simple and cost-effective way to identify persons-at-risk, e.g. in specific professional contexts.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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