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De Relatie tussen Emotionele Reactie, Veerkracht en Intrusieve Herinneringen aan Trauma: een Analoog Onderzoek met behulp van het Traumafilmparadigma

The Relationship between Emotional Reaction, Resilience, and Intrusive Memories of Trauma: an Analogue Study using the Trauma Film Paradigm

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Abstract

Worldwide 70% of people experience a traumatic event, with some developing post-traumatic stress disorder (PTSD), mainly characterized by intrusive memories. The development and persistence of intrusive memories may be related to an individual's emotional state, while resilience may serve as a potential variable in facilitating recovery from such memories. In this thesis a relationship between an elevated emotional state and a higher number of intrusive memories after watching a traumatic film is hypothesised. Furthermore, it is expected that this relationship will be moderated by resilience. Study participants are undergraduate psychology students (n=147). The study follows an experimental design, including a trauma film to induce intrusions. The trauma film serves as an analogue for PTSD by showing participants films containing traumatic content, such as scenes of blood, interpersonal violence, and death, that are consistent with events listed in the Diagnostic and Statistical Manual of Mental Disorders (DSM). Intrusive memories were measured through a prospective intrusion diary and retrospective intrusion ratings. Emotional state was assessed with a pre- and post-film Visual Analogue Scale (VAS). Resilience was measured using the Connor-Davidson Resilience scale (CD-RISC 25). Results were analysed using hierarchical multiple negative binomial- and linear regression analysis. The findings of this thesis demonstrate a significant increase in emotional state of participants following exposure to a traumatic film. As expected, emotional state positively predicted the occurrence of intrusions, both in the prospective diary and the retrospective intrusion ratings. However, resilience did not have a significant moderating effect on these relationships. In the regression models that incorporated the moderation analysis, emotional reaction lost significance as a predictor of image-based diary intrusions but remained a significant predictor of retrospectively assessed intrusions. Regarding future research, is suggested that future studies researching intrusions use appropriate statistical methods to accommodate their data to draw more valid and reliable results.

Keywords: intrusions, emotional reaction, emotional response, peri-traumatic responses, resilience, post-traumatic stress disorder, traumafilm paradigm

Background

Worldwide, it is estimated that 70% of the population experiences at least one traumatic event in their lifetime (Benjet et al., 2016). While most individuals recover from such experiences, a significant minority suffers from enduring severe psychological and emotional distress resulting in post-traumatic stress disorder (PTSD) (Snijders et al., 2018).

Intrusions

Among the various symptoms that can result from traumatic experiences, one of the most distressing and debilitating is the development of involuntary and unwanted memories known as intrusions or flashbacks (American Psychiatric Association, 1994; Brewin et al., 2000). Intrusions are a hallmark symptom in the development of PTSD, characterized by a re-experiencing of the traumatic event through intrusive thoughts, memories, or nightmares that cause significant distress and interfere with daily functioning (American Psychiatric Association, 1994). Intrusive memories intrude, apparently spontaneously, into consciousness and are opposite to the deliberate recollection of memories or ruminations in one's mind (Arntz et al., 2005; Conway, 2001). Unlike deliberate recollections or ruminations, which are consciously retrieved, intrusive memories spontaneously enter consciousness without conscious effort or intention (Brewin & Holmes, 2003). Intrusive memories are characterised by the vivid re-experiencing of the trauma in the form of sensory mental images or thoughts and are characterised by a significant degree of distress (American Psychiatric Association, 1994; Brewin, 1998; Brewin & Holmes, 2003). Intrusive memories are predominantly composed of sensory mental images rather than verbal thoughts (Ehlers & Steil, 1995; Van Der Kolk & Fisler, 1995), as experimental research suggests that imagery can elicit stronger emotional responses than corresponding verbal cognitions (Holmes & Mathews, 2005; Holmes et al., 2008). An example of such an intrusive sensory mental image is the trembling of the earth, wind noise and the sight and sound of a hurricane moments before it hits.

Cognitive theories of trauma suggest that intrusive memories result from abnormal information processing peri-traumatically; during or directly after the traumatic event, and therefore maintain the sense of current threat (Brewin et al., 1996; Ehlers & Clark, 2000). Peri-traumatic responses, including emotional, cognitive, behavioural, and physiological reactions, may disrupt information processing and contribute to the development of PTSD (Bovin & Marx, 2011; Gorman et al., 2015). These responses may be triggered by the traumatic event itself, as well as by the individual's cognitive and emotional reactions to it. For example, a person's cognitive appraisal of the event as life-threatening may trigger a cascade of emotional and physiological responses that can interfere with information processing. Therefore, disruptions in information processing and peri-traumatic responses are intertwined and may interact to contribute to the development of PTSD (Bovin & Marx, 2011; Gorman et al., 2015).

Emotional reactions

Historically, peri-traumatic emotional responses have been studied as part of the traumatic stress response required for PTSD *Criterion A2* in the Diagnostic and Statistical Manual of Mental Disorders, edition IV (DSM-IV) (American Psychiatric Association, 2000; Bovin & Marx, 2011; Gorman et al., 2015). Associations have been found between higher peri-traumatic levels of fear, anger, sadness, disgust and numbness and the subsequent development of PTSD and later PTSD symptomatology (Bovin & Marx, 2011). The results of a meta-analysis studying PTSD predictors suggest that these peri-traumatic responses, not prior characteristics are the strongest predictors of PTSD development (Ozer et al., 2003). The findings from the studies included in Ozer's meta-analysis indicate that individuals who reported experiencing strong negative emotional reactions, either during or immediately after the traumatic event, tended to have significantly higher levels of PTSD symptoms or a higher likelihood of having current PTSD (Ozer et al., 2003).

During a traumatic event, the body's natural stress response is activated, leading to the release of stress hormones such as adrenaline and cortisol. This physiological response is known as adrenergic arousal (Roozendaal et al., 2007). The intense emotional experience

during the traumatic event leads to stronger encoding of the memory, with heightened attention and sensory input (McGaugh, 2004). Research suggests that memories formed under high emotional arousal conditions are encoded differently in the brain than those formed under non-arousing conditions (LaBar & Cabeza, 2006; LeDoux, 2003; McGaugh, 2004). Specifically, they are more vivid, detailed, and enduring. The amygdala, as a brain region involved in emotional processing, plays a crucial role in the formation of these memories (LeDoux, 2003; McGaugh, 2004). In the case of PTSD, the traumatic event can become deeply ingrained in a person's memory, leading to recurrent and intrusive memories (Brewin, 2014). For example, in individuals with PTSD, the amygdala and other brain regions involved in emotional processing may be overactive, leading to heightened emotional responses and difficulty in suppressing intrusive memories. Additionally, the prefrontal cortex, which is involved in regulating emotional responses, may be impaired in individuals with PTSD, leading to difficulty in down-regulating emotional arousal. Thus, the degree of emotional arousal or reactions, during or immediately after the traumatic event, may be crucial for the development of intrusions (Clark et al., 2015).

Resilience

Despite the high prevalence of traumatic events, there is considerable variation in how individuals respond, which may be attributed to the natural heterogeneity of human stress response (Macedo et al., 2014). Recovery from intrusive memories, including those associated with PTSD, may be facilitated by resilience (Charney, 2004; Connor et al., 2003; Leppin et al., 2014).

In the literature, resilience is a multifaceted phenomenon (Joyce et al., 2018). The definition of the key constructs related to resilience encompasses a range of possibilities, including positive adaptation to adversities or stress and hardiness (Kalisch et al., 2015, 2017; Macedo et al., 2014). This complexity presents a challenge when studying the construct of resilience. Some researchers define it as the ability to adapt positively to stressful circumstances, while others view it as the ability to remain functionally stable despite ongoing stress (Joyce et al., 2018; Macedo et al., 2014). From the perspective of trauma

researchers, resilience embodies the personal capacity to adapt well, 'bounce back' or thrive in the face of adversity or trauma (Agaibi & Wilson, 2016; Connor & Davidson, 2003). This definition aligns with the concept of resilience as a continuum, ranging from poor (low bounce-back ability) to high (strong capacity to recover) and even extremely high, which is referred to as 'thriving' in the literature and denotes an individual's ability to achieve a superior level of functioning after a stressful event (Agaibi & Wilson, 2016; Joyce et al., 2018; Macedo et al., 2014).

Research has shown that individuals with higher levels of resilience are more likely to experience positive outcomes following exposure to trauma (Bonanno, 2004; Southwick et al., 2014). This may include a decreased risk of developing PTSD or other trauma-related disorders, as well as improved overall functioning and well-being (Connor et al., 2003; Tugade & Fredrickson, 2004). Additionally, resilience may play a role in the management of PTSD symptoms, such as intrusive memories, by helping individuals to cope with the emotional and cognitive demands of these experiences (Charney, 2004; Macedo et al., 2014; Tugade & Fredrickson, 2004). It is important to note, that a diagnosis of PTSD cannot be made until at least a month after the traumatic event (American Psychiatric Association, 2022). This waiting period allows for the possibility that resilient individuals may recover from their initial stress reactions and avoid developing PTSD. Therefore, resilience may play a crucial role in preventing the development of PTSD or intrusive memories following traumatic events (Macedo et al., 2014).

Furthermore, resilience could influence the process of meta-cognition of individuals in response to emotions. An experimental study of Yi et al. (2020) studied the underlying mechanisms of resilience and found that individuals with high resilience disengaged much quicker from both positive and negative emotional information than those with low resilience. Resilient individuals may use various coping strategies, such as positive reappraisal, cognitive restructuring, and social support, to regulate their emotions and maintain psychological well-being (Tugade & Fredrickson, 2004). Therefore, resilience may

be an important factor in promoting adaptive emotion regulation and reducing the risk of negative emotional outcomes (Fletcher & Sarkar, 2013; Kalisch et al., 2015; Yi et al., 2020).

Given the linkages described above between resilience, emotion regulation and intrusive memories, it would be reasonable to expect that the relationship between emotional reactions and intrusions may be moderated by resilience, such that the relationship between peri-traumatic emotional reactions get weaker at higher levels of resilience, and vice versa. There are some studies investigating the moderating role of resilience in the relationship between trauma exposure and PTSD symptoms (Fincham et al., 2009; Green et al., 2010; Lee et al., 2014; Lies et al., 2017). However, a thorough examination of the literature yielded no studies that have explored this particular relationship.

Current study: trauma analogue study using the traumafilm paradigm

The traumafilm paradigm is a method to study intrusions in an experimental setting and serves as the analogue for PTSD without exposing individuals to real trauma (Holmes et al., 2009; James et al., 2016). This paradigm involves showing participants films containing traumatic content, such as scenes of blood, interpersonal violence, and death, that are consistent with events listed in the DSM (Kessler et al., 2020).

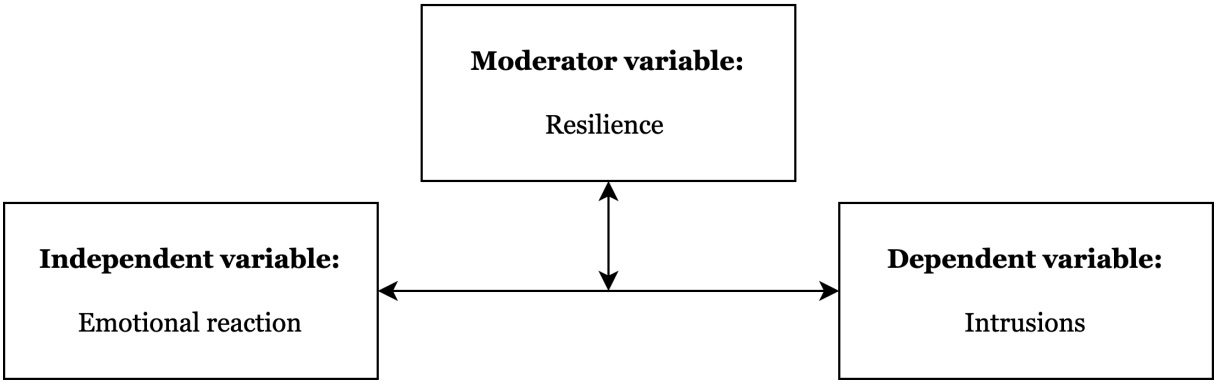
The current thesis makes use of this traumafilm paradigm and is part of a larger study that investigates two different traumatic films on the development of intrusive memories. Both films functioned as an experimental analogue of viewing traumatic events in real life.

Research hypothesis

Building on the previously discussed concepts in this thesis, a relationship is hypothesised between an elevated emotional reaction and a higher number of intrusive memories after watching a traumatic film. Furthermore, it is expected that this relationship will be moderated by resilience (Figure 1).

Figure 1.

Relationship between emotional reactivity, and intrusive memories moderated by resilience



Methods

Statement of Transparency

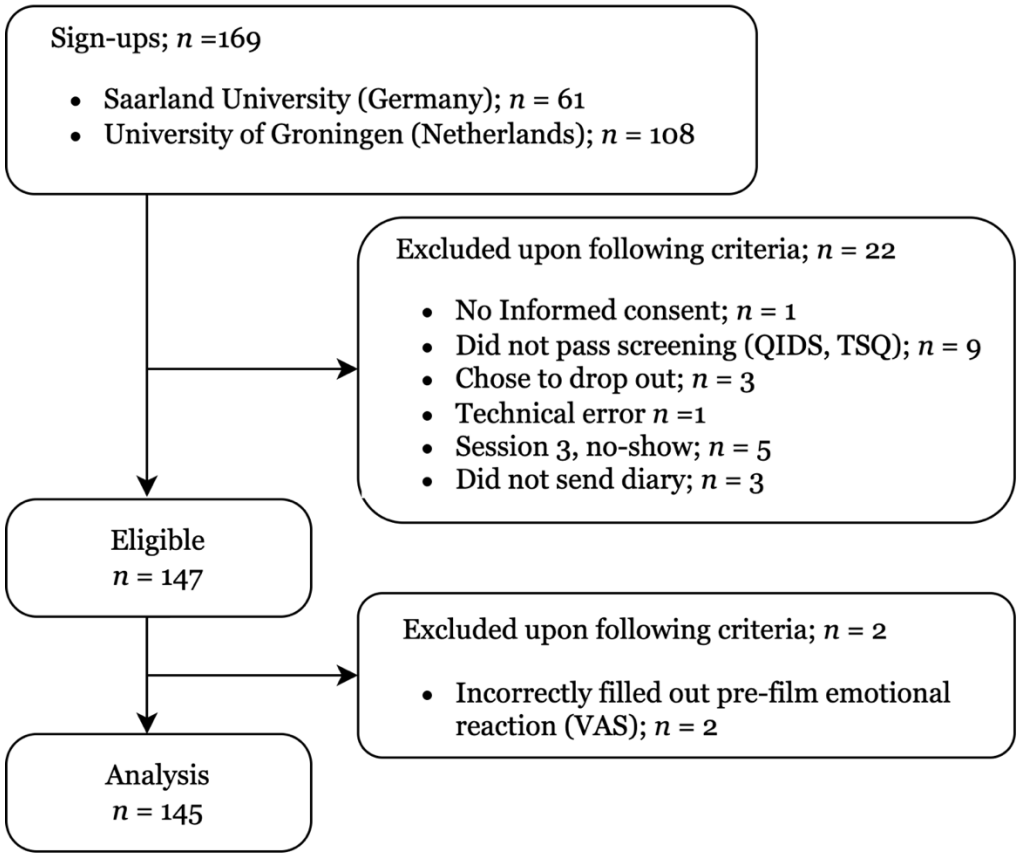
This thesis is part of a larger multicentre prospective experimental study that aims to investigate the impact of two different films with traumatic content on the development of intrusive memories. Prior to data collection all research questions, hypotheses, and analytic strategies were pre-registered on the Open Science Framework. A detailed account of the study methodology is publicly accessible at: https://osf.io/w7384. Only methodological aspects relevant to the current thesis will be presented in subsequent sections. At the time of this writing, data processing was ongoing at the Angelina Ruskin University in the United Kingdom. Due to time constraints, the data for the current thesis was analysed before the completion of data processing in the United Kingdom.

Participants

A total of 169 undergraduate psychology students were recruited via the local university recruitment systems in exchange for course credits at each study site: the Netherlands (University of Groningen) and Germany (Saarland University). Ethical approval was given by the institutional ethics committees at each study site prior to data collection (reference numbers: PSY-2122-S-0050 and PSY-2021-S-0229). The final sample consisted of 147 eligible participants, see the flow of participants in Figure 2. Of these eligible participants, 86 were included from the University of Groningen (34 males, 51 females and 1 non-binary person, mean age = 20.5, *SD* = 2.8). Most participants were of Dutch (*n* = 27) or German (*n* = 23) nationality. Due to pregnancy leave of one of the German colleagues, demographics for the participants from the Saarland University could not be provided.

Figure 2.

Flow of participants.



Note. Abbreviations: QIDS, Quick Inventory of Depressive Symptomatology; TSQ, Trauma Screening Questionnaire; VAS, Visual Analogue Scale.

Materials

Eligibility screening

Participants were screened for eligibility by means of two questionnaires. The Quick Inventory of Depressive Symptomatology (QIDS)(Rush et al., 2003) is a 16-item questionnaire of depressive symptom severity referring to the past 7 days. Items are scored on a 4-point scale (0 = *absent*; 3 = *severe*); the total score ranges between 0 and 27. Participants with cut-off scores lower than 11, indicating no (score 0-5) to mild depression (score 6-10), were considered eligible. The Trauma Screening Questionnaire (TSQ)(Brewin et al., 2002) is a 10-item screening instrument measuring responses to a traumatic event with a high sensitivity to identify participants who will likely suffer from PTSD. Participants

indicate if they experienced (0 = *No*; 1 = *Yes*) any of the reactions at least twice in the past week, with a total score between 0 and 10. Participants with cut-off scores lower than 6 were considered eligible.

Trauma films

Two different films with real-life or acted traumatic content were used: the *Old Film* and the *New Film*. Both films had a length of approximately 12 minutes and contained 11 separate scenes depicting footage involving blood, injury, explicit physical and sexual violence, and death. Both films started with a black screen (5 seconds) displaying the instruction to set the video player to full screen format. After each scene participants saw a black screen for 6 seconds. In the both films an adapted version of the instructions, given by James et al. (2015), was used. The *Old Film* was exactly portrayed as in Holmes et al. (E. A. Holmes et al., 2009; EA. Holmes et al., 2010). The *New Film* consisted of a selection of scenes from two films that were used during a previous study by our research group (https://osf.io/45rsz). Participants were instructed to watch the film as if they were a bystander at the scene watching the events unfold in front of their eyes and to be really immersed and involved in what was happening.

Intrusions

Intrusive memories were prospectively reported in an involuntary memory diary during seven consecutive days (adapted from James et al., 2015). This diary was an electronic Word file with tables divided into morning, afternoon, and evening/night to note the number, content, and form (verbal thought, image, combination) of the experienced intrusions. Furthermore, retrospective intrusion ratings were collected with the Impact of Movie Scale (IMS) (James et al., 2015; adapted from Impact of Event Scale-Revised (IES-R) Weiss & Marmar, 1996). The IMS is a 22-item questionnaire measuring possible difficulties participants experience after watching a traumatic film (e.g., “Pictures about the film popped into my mind”). The IMS contains a 5-point Likert-scale ranging from 0 (*not at all*) to 4 (*extremely*) indicating how distressing each item had been during the past seven days.

Emotional state

Emotional state was measured with Visual Analogue Scales (VAS) asking: 'Right at the moment I am feeling'. Participants rated the extent to which they felt 'sad', 'hopeless', 'fearful', 'horrified', 'anxious', and 'depressed' ranging from 0 (*not at all*) to 100 (*extremely*) on six separate slider scales (adapted from James et al., 2015).

Resilience

The 25-item Connor-Davidson Resilience scale (CD-Risk 25) was used to retrospectively measure resilience on a 5-point Likert scale (0 = *not true at all*; 4 *true nearly all of the time*) (Connor & Davidson, 2003). The scale consists of 25-items with a total score ranging from 0-100, with higher scores reflecting greater resilience.

Procedure

For ethical considerations, the study recruitment information gave information about the nature of the film that contained scenes of potentially traumatic or distressing nature. Informed consent was given by all participants prior to testing. Participants were informed that they could end the experiment at any time and were reimbursed for their participation. The study was conducted online through three Google Meet sessions (https://meet.google.com/) using a standardized script to ensure consistency. Participants enrolled in different time slots through the SONA system platform at the university. All sessions, study materials and the randomisation procedures were digitalised in the computer software program Qualtrics (Provo, Utah, USA). Sessions 1 and 2 were held on the same day, and session 3 was held one week later. During session 1, participants were assessed for eligibility using the QIDS and TSQ, and only eligible participants continued with session 2, which immediately followed session 1. In session 2, participants received instructions for viewing a trauma film and were randomly assigned to either the *Old Film* or the *New Film*. The experimenter was blinded to the assigned condition. Before watching the film, participants completed the emotional state VAS. After setting the video player to full screen and putting on headphones (if applicable), participants watched the film and filled out a

second emotional state VAS. The experimenter gave instructions for a ten-minute filler task. Afterwards, participants sat quietly for ten minutes while recording any film-related intrusions. Participants also received instructions for the seven-day involuntary memory diary. Every morning at 5 am, they received an email reminder to fill out the diary. During session 3, diary compliance was assessed, participants completed the retrospective measure of intrusions (IMS), the CD-Risk 25, and additional questionnaires unrelated to the current thesis. Participants were asked to email their involuntary memory diary and played Tetris for three minutes as a neutralizer. Finally, participants were debriefed and answered questions about their experience as a participant in the study.

Data analysis

Data preparation

Data cleaning

Data were examined for missing values and incorrect entries.

Intrusions

The total film image-based intrusion count was determined from the intrusive memory diary by adding the image-based intrusion score and the score of intrusions that were a combination of images and verbal thoughts. In addition, the retrospective intrusion ratings IMS score was calculated by summing the 22-items. Regarding the IMS, one participant had a missing value on one of the individual items and was excluded from the analysis.

Emotional state and reaction

A mean score of all emotional state VAS scores combined (sad, hopeless, fearful, horrified, anxious and depressed) was calculated pre- and post-film. Furthermore, for each emotional state VAS score (sad, hopeless, fearful, horrified, anxious and depressed), a delta score was calculated for the difference in emotional state post- and pre-film (delta score = post-film VAS - pre-film VAS). Thereafter, the average of all emotional state delta scores was taken, resulting in the variable emotional reaction. Two participants provided incorrect pre-film VAS scale responses (incorrect interpretation of the scale), rendering it impossible to

calculate their mean delta scores pre- and post-film. As a result, they were excluded from the analysis.

Resilience

A total sum score was created for the CD-RISC 25 questionnaire by summing the scores of the 25 individual items.

Creation of centered variables for moderation analysis

To later examine the interaction effect of resilience as a moderator, centered variables were created for the variables emotional reaction and resilience. Centering was done by subtracting the (aggregated) mean score of each variable from each individual score. An interaction term was created by multiplying the centered variables for the variables emotional reaction and resilience (emotional reaction x resilience). This method of creating interaction terms is a common practice in moderation analysis (Hayes, 2017).

Assessment of outliers and normality

Outliers were identified using the outlier labelling rule (Moore et al., 2011), where significant deviations were defined as scores falling 1.5 times the interquartile range (IQR) below the first or above the third quartile. Variables without outliers were calculated, based on the outlier labelling rule. To assess normality of distributions, visual inspection of histograms and normal probability plots, as well as the Kolmogorov-Smirnov and Shapiro-Wilk statistical tests, were used for all variables, see Appendix A. Among the continuous variables examined, the following were found to not follow a normal distribution: film image-based intrusions reported in the involuntary memory diary and the IMS, all six emotional state VAS variables pre- and post-film, and the variable emotional reaction. The CD-RISC 25 resilience sum score was normally distributed.

Hypothesis testing

To facilitate comparison with existing literature, all results are reported as means and standard deviations (SD). Their corresponding medians and interquartile ranges (IQR) are

provided. For categorical variables, frequencies are reported as number of participants (*n*) and percentage (%). All analyses were performed using SPSS (IBM Corp, version 27).

To examine the change in emotional state of participants before and after watching the traumatic film, the Wilcoxon signed-rank test was applied, as the combined emotional state VAS score (all six emotions) at both time points can be seen as two related variables that are not normally distributed. See Appendix A, Figures 16-a till 17-b, for an evaluation of the normality of the variables.

Although no initial hypothesis was formulated, a Spearman's rho correlation was used to test the correlations between resilience, emotional reaction, the number of image-based intrusions from the involuntary memory diary, and the retrospectively reported intrusions (IMS). Spearman's rho correlation was chosen over Pearson's correlation due to the non-normal distribution of one or both variables involved in the correlation analysis.

To test the primary hypothesis on the relationship between the emotional reaction and intrusions, the number of image-based intrusions reported in the intrusive memory diary was considered a count variable. Linear regression analysis was not appropriate due to the count variables skewed distribution and overdispersion (i.e., the variance (45.65) exceeds the mean (4.74) and contains a large number of '0' values) (Long, 1997; Long & Freese, 2006). Therefore, a negative binomial regression analysis with an estimated value approach was used, which accounts for the overdispersion in the data and assumes that the distribution of counts follows a negative binomial distribution (Long, 1997; Long & Freese, 2006; Yang & Berdine, 2015). Appendix B provides a visualization of the count variable distribution, an illustration of a negative binomial regression distribution as shown in previous literature for comparison, and the relevant assumptions of the negative binomial regression model (see Figure B1 and B2). A manual hierarchal approach was used within the negative binomial regression analysis, as SPSS does not have a built-in function in this type of regression analysis. To account for the absence of a built-in stepwise function in SPSS for negative binomial regression analysis, a manual hierarchical approach was used. The first and second models tested the main effects of emotional reaction and resilience separately, although no a-

priori rationale was formed for the effect of resilience on the number of intrusions. In the third model, both main effects were tested simultaneously. Finally, in the fourth model, both main effects of emotional reaction and resilience were entered, along with the interaction term (emotional reaction x resilience). All independent variables (emotional reaction and resilience) and the interaction term were entered into the negative binomial regression model as centered variables.

Regarding the secondary hypothesis, most assumptions for linear regression were met, except for the normal distribution of the residuals of the IMS variable, see Appendix C, Figures C1 to C6. This can be attributed to a considerable number of participants experiencing zero intrusions after watching the traumatic film, which are considered true or natural zeros in the data. Normal log transformations were unsuitable for handling zero values. To normalize the skewed distribution of the IMS variable, as suggested by Box and Cox (1964) and Kutner et al. (2004), was used by taking the square root of the IMS variable. As a result of this transformation, the residuals of the retrospective intrusion ratings IMS were normally distributed, and the variable itself was normally distributed as well. Moreover, no outliers were present in the IMS. See Appendix C, Figures C7 to C9, for an overview of the normality of the residuals and the Box-Cox transformed variable. A hierarchical multiple linear regression analysis was performed, wherein the independent variables and interaction term were added in blocks. In the first block emotional reaction was added. In the second block resilience was added, although again no a-priori rationale was formed for the effect of resilience on the number of intrusions. In the third block the interaction term (emotional reaction x resilience) was added. All variables, except the IMS, were entered into the linear regression model as centered.

All analyses were repeated with the outliers excluded, to investigate whether the relationships between variables were affected. Specifically, six outliers were removed for the number of image-based intrusions in the intrusive memory diary, two outliers were removed for the number of retrospectively reported intrusions (IMS), five outliers were removed for the emotional reaction variable, and two outliers were removed for the resilience variable.

Results

In this thesis, the 145 participants reported a cumulative total of 653 intrusions in the involuntary memory diary, which was collected prospectively following their exposure to the traumatic film. On average, each participant experienced four intrusions (SD = 6.82) during the week that followed the film, and 25 participants (17.24%) did not report any intrusions. Additionally, participants reported an average of eleven intrusions retrospectively, as assessed by the IMS (SD = 8.36). Only five participants (3.47%) did not report any intrusions retrospectively. Table 1 displays the descriptive statistics of the six emotional states assessed separately and combined before and after the film, as well as the intrusions recorded in the involuntary memory diary and IMS.

Table 1.

Descriptives emotional states pre- and post-film and number of intrusions (n = 145)

Emotional states (VAS)		**Mean** [a]	**SD**	**Median** [a]	**IQR**	**Range**
Pre-film	*Sad*	10.60	15.69	4.00	0.00 – 15.00	0.00 – 73.00
	Hopeless	5.79	11.95	1.00	0.00 – 6.00	0.00 – 71.00
	Fearful	11.41	16.15	5.00	0.00 – 14.50	0.00 – 81.00
	Horrified	2.74	9.15	0.00	0.00 – 1.00	0.00 – 74.00
	Anxious	13.97	18.75	8.00	1.00 – 17.50	0.00 – 84.00
	Depressed	5.53	11.63	1.00	0.00 – 5.00	0.00 – 72.00
	Combined [b]	8.34	11.02	4.00	1.50 – 12.33	0.00 – 65.00
Post-film	*Sad*	20.75	21.64	15.00	3.00 – 31.00	0.00 – 89.00
	Hopeless	11.79	16.42	5.00	0.00 – 19.00	0.00 – 91.00
	Fearful	24.06	22.15	20.00	5.00 – 38.50	0.00 – 92.00
	Horrified	38.48	27.12	30.00	17.50 – 60.00	0.00 – 100.00
	Anxious	26.88	26.34	18.00	6.00 – 39.50	0.00 – 100.00
	Depressed	16.06	20.08	10.00	0.50 – 24.50	0.00 – 100.00
	Combined [b]	23.00	18.48	18.33	8.50 – 31.17	0.00 – 90.00
Intrusions (diary)		4.50	6.82	3.00	1.00 – 5.00	0.00 – 48.00
Intrusions (IMS) [c]		11.31	8.36	9. 00	5.00 – 16.00	0.00 – 41.00

Note. Abbreviations: VAS = Visual Analogue Scales asking: 'Right at the moment I am feeling': 'sad', 'hopeless', 'fearful', 'horrified', 'anxious', and 'depressed' (0 = *not at all* to 100 = *extremely*) (adapted from James et al., 2015), IMS = Impact of Movie Scale (James et al., 2015; adapted from Impact of Event Scale-Revised (IES-R) Weiss & Marmar, 1996)

[a] All emotional state variables and diary intrusions are not-normally distributed, therefore the median was reported, for comparative purposes the mean was reported as well.

[b] All six emotional state VAS scores combined.

[c] One participant had a missing value on one of the individual items and was excluded from the analysis (*n* = 143 participants).

Emotional reaction to the traumatic film

The emotional state of participants after watching the traumatic film was significantly higher than the emotional state prior to watching the film ($p < .000$, $z = -9.46$). Participants scored on approximately 14 points higher after watching the traumatic film, which resembles a large effect size ($r = 0.56$ (Cohen, 1988), pre-film combined emotional states $Mdn = 4.00$, post-film combined emotional states $Mdn = 18.33$). See Table 1, specifically under the heading 'combined' for a detailed view of the scores before and after the traumatic film.

Correlation between resilience, emotional reaction, and intrusions

Resilience was not found to be correlated with the number of image-based intrusions from the involuntary memory diary ($r = -0.099$, $p = 0.236$), nor with the emotional reaction of participants after watching a traumatic film ($r = -0.089$, $p = 0.285$). Resilience was also not found to be correlated with retrospectively reported intrusions (IMS) ($r = -0.061$, $p = 0.461$).

Emotional reaction, resilience, and intrusions

The emotional reaction of participants predicted the number of image-based intrusions in the involuntary memory diary after watching a traumatic film; for every point increase in the difference between emotional state before and after the film, the number of intrusions increased by 0.01 (1%) (Table 2, Model 1). However, resilience alone did not predict the number of image-based intrusions (Table 2, Model 2). When emotional reaction and resilience were added simultaneously into model emotional reaction remained a significant predictor of the number of image-based intrusions (Table 2, Model 3). Furthermore, there was no significant moderating effect of resilience on the relationship between emotional reaction and the number of intrusions (Table 2, Model 4). Within the fourth model emotional reaction was no longer a significant predictor of the number of image-based intrusions.

In the fourth model, which included the interaction term, the Akaike's Information Criterion (AIC) was slightly higher (758.557) than in the model without the interaction term

(AIC = 756.774 for model 3), indicating that the fourth model was not a better fit to capture the relationship between the variables than the third model.

When testing the models without outliers, the emotional reaction of participants no longer predicted the number of image-based intrusions (p = .335) (See Appendices D, Table D1)

Table 2.

Results image-based intrusions in the involuntary memory diary, emotional reaction, resilience, and the moderating effect of resilience (n = 145)

Model	Variable	B	SE	Wald χ^2	Exp(β) (Wald 95% CI)	*p*
1.	Intercept	1.484	.0961	238.434	4.412 (3.654– 5.326)	<.000
	Emotional reaction [a]	0.013	.0062	4.227	1.013 (1.001 – 1.025)	.040*
2.	Intercept	1.493	.0966	238.523	4.449 (3.681 – 5.377	<.000
	Resilience [b]	- 0.12	.0077	2.580	0.988 (0.973 – 1.003)	.108
3.	Intercept	1.474	.0955	238.251	4.366 (3.621 – 5.265)	<.000
	Emotional reaction	0.012	.0062	3.913	1.012 (1.000 – 1.025)	.048*
	Resilience	- 0.011	.0075	2.237	0.989 (0.975 – 1.003)	.135
4.	Intercept	1.472	.0955	237.622	4.357 (3.613 – 5.253)	<.000
	Emotional reaction	0.012	.0064	3.228	1.012 (0.999 – 1.024)	.072
	Resilience	- 0.012	.0076	2.427	0.988 (0.974 – 1.003)	.119
	Interaction Emotional reaction x Resilience	0.000	.0006	0.189	1.000 (0.999 – 1.001)	.664

Note. Models were analysed with negative binomial regression.
[a] Emotional reaction: mean difference between post- and pre-film emotional states assessed by Visual Analogue Scales (VAS) asking: 'Right at the moment I am feeling': 'sad', 'hopeless', 'fearful', 'horrified', 'anxious', and 'depressed' (0 = *not at all* to 100 = *extremely*) (adapted from James et al., 2015),
[b] Resilience: sum score of 25-item Connor-Davidson Resilience scale (CD-Risk 25) (Connor & Davidson, 2003).
* Indicates a significant p-value < 0.05 level.

Emotional reaction, resilience, and retrospective intrusion rating

After participants watched a traumatic film, their emotional reaction was found to predict the number of retrospectively reported intrusions (IMS) (p = 0.001), as reported in Table 3, Models 1, 2, and 3. Specifically, for every point increase in the difference between their emotional state before and after the film, there was a corresponding increase of 0.02 (2%) in the number of retrospectively reported intrusions. However, no effect of resilience was observed, nor was there a moderating effect of resilience on the relationship between emotional reaction and the number of retrospectively reported intrusions (IMS), as shown in Table 3, Models 2 and 3.

The proportion of variance in the number of retrospectively reported intrusions (IMS) explained by the regression models beyond the mean model was 7.1%, 7.4%, and 8.5% for models 1, 2, and 3, respectively. However, only model 1 demonstrated a statistically significant effect on the proportion of variance explained. Therefore, only the model that included emotional reaction as a predictor variable was found to have a significant relationship with the number of retrospectively reported intrusions (IMS) (Model 1*:* R^2 = 0.071, F = 10.933, p = 0.001; Model 2: R^2 = 0.074, F = 5.655, p = 0.517; Model 3: R^2 = 0.085, F = 4.350, p = 0.196).

When testing the models without outliers the associations remained the same (See Appendices E, Table E1).

Table 3.

Results retrospective intrusion ratings (IMS), emotional reaction and the moderating effect of resilience (n = 144)

Model	Variable	B	SE	*t*	95% CI	*p*
1.	Intercept	3.092	.107	28.887	2.880 – 3.304	<.000
	Emotional reaction [a]	0.022	.007	3.307	0.009 – 0.036	.001*
2.	Intercept	3.092	.107	28.830	2.880 – 3.304	<.000
	Emotional reaction	0.022	.007	3.279	0.009 – 0.035	.001*
	Resilience	- 0.006	.009	- 0.649	- 0.023 – 0.011	.517
3.	Intercept	3.092	.107	28.927	2.885 – 3.308	<.000
	Emotional reaction	0.023	.007	3.401	0.010 – 0.036	.001*
	Resilience	- 0.003	.009	- 0.326	- 0.020 – 0.015	.745
	Interaction Emotional reaction x Resilience	0.001	.001	1.289	0.000 – 0.002	.196

Note. Models were analysed with hierarchical multiple linear regression; emotional reaction, resilience and the interaction term were added to the model as centered variables.
[a] Emotional reaction: mean difference between post- and pre-film emotional states assessed by Visual Analogue Scales (VAS) asking: 'Right at the moment I am feeling': 'sad', 'hopeless', 'fearful', 'horrified', 'anxious', and 'depressed' (0 = *not at all* to 100 = *extremely*) (adapted from James et al., 2015),
[b] Resilience: sum score of 25-item Connor-Davidson Resilience scale (CD-Risk 25) (Connor & Davidson, 2003).
* Indicates a significant p-value < 0.05 level.

Discussion

The findings of this thesis demonstrate a significant increase in emotional state of participants following exposure to a traumatic film. As expected, emotional reaction was found to positively predict the occurrence of intrusions, both in the prospective intrusive memory diary and retrospective intrusion ratings (IMS). Specifically, for each point increase in the difference between emotional state before and after the film, the number of image-based diary intrusions increased by 1%, and the number of retrospectively reported IMS intrusions increased by 2%. However, contrary to what was expected, resilience did not have a significant moderating effect on these relationships. In the regression models that incorporated the moderation analysis, emotional reaction was no longer a significant predictor of image-based diary intrusions, while it remained a significant predictor of retrospectively assessed intrusions (IMS). After removing outliers, the associations examined in the models assessing retrospective intrusion ratings (IMS) remained unchanged. However, for the diary-based intrusion models, the predictive power of emotional reaction was lost once outliers were excluded.

Emotional reaction

Emotional reaction was found to be a significant predictor in the presence or absence of intrusions in both outcome measures (diary and IMS) for our main and secondary hypotheses. This was in line with our expectations and other studies studying the influence of emotional reactions or responses on the development of intrusions (Bardeen et al., 2013; Clark et al., 2015; Creamer et al., 2005; Holmes et al., 2005; Holmes & Mathews, 2005). Although there was a significant relationship, the effects between emotional reaction and the number of intrusions were small (1 and 2% in both outcome measures). A meta-analysis of (Ozer et al. (2003), that reviewed 2.647 studies on PTSD, concluded that a combination of psychological processes around the time of trauma most likely explain or predict the development of PTSD (Ozer et al., 2003). This might indicate that not a single psychosocial

process around the time of trauma, such as emotional reaction, can predict PTSD or intrusions as the hallmark symptom of alone (Brewin et al., 2000; Ozer et al., 2003).

Resilience

Against expectations, our analyses did not find that resilience moderated the relationship between emotional reactions and the number of intrusions. To the best of our knowledge there are currently no studies studying this exact relationship. There are however several studies that look at the relationship between resilience and PTSD symptom severity (Agaibi & Wilson, 2016; Connor et al., 2003; Hoge et al., 2007; Snijders et al., 2018) or look at resilience as a moderator (Lies et al., 2017; Reyes et al., 2022), with mixed results.

In our study, resilience was assessed using a validated questionnaire, the CD-RISC 25 (Connor & Davidson, 2003) , that received high ratings in psychometric properties in a methodological review of different resilience measurement scales (Windle et al., 2011). Thereby the questionnaire has been shown to be a reliable and valid measure of resilience in previous research. It is therefore less likely that the lack of effect was due to issues with the psychometric properties of the questionnaire or the construct itself as a set of observable and measurable indicators.

However, it is important to note that the primary study, as described in the Open Science Framework (OSF), was not designed to detect a moderating effect of resilience. It is therefore possible that the lack of a moderating relationship was due to a small sample size, other factors influencing the results or that no such relationship exists. To elaborate on the first, the minimal detectable effect size with a current sample size of 145 participants would have been 0.399 or larger (small effect size (Cohen, 1988)), with an alpha level of 0.05 and a statistical power of 0.80. To elaborate on the second point made, the results in this thesis could implicate that resilience does not play a moderating role in the relationship between emotional reactions and intrusive memories. If this finding is supported by other research studies, it could suggest that the theory that resilience moderates the relationship between emotional reactions and intrusions may need to be revised or rejected. Therefore, further research studies are needed to explore the role of resilience in the relationship between

emotional reactions after watching a traumatic film and intrusions, to better understand the factors that influence the relationship, and to evaluate the theory in light of new evidence.

Analysing intrusion outcomes

There may be valuable insights to glean from the analyses on the intrusion outcome data in this thesis. In the current thesis intrusions measured by the prospective intrusive memory dairy were considered as a count variable and therefore a negative binomial regression analysis was used. The distribution of counts followed a negative binomial distribution, mainly due to many participants experiencing zero intrusions. Furthermore, in the retrospective intrusion ratings (IMS) measure assumptions were violated regarding normality of the residuals, for which a square root transformation was performed to normalize the residuals.

Looking at the field of research studying intrusive outcomes, using (nearly to) exact same outcome measures as used in the current thesis, it can be noticed most of these studies consider the intrusion measure as normally distributed continuous data. Twelve out of seventeen studies using the prospective intrusive memory dairy use analyses which assume that the residuals follow a normal distribution (i.e. AN(C)OVA, regression analysis, t-tests, Pearson's correlation) and/or report means, with no mentioning of transformations to normalize the data (Asselbergs et al., 2018; Bisby et al., 2009, 2010; Bourne et al., 2010; Brown et al., 2012; Hagenaars et al., 2010; Holmes et al., 2009; Krans et al., 2010; Logan & O'Kearney, 2012; Pearson, 2012; Schaich et al., 2013; Woud et al., 2013). Five out of seventeen studies do account for non-normally distributed variables and/or residuals (Brennen et al., 2021; James et al., 2015; Kessler et al., 2020; Krans et al., 2009; Marks et al., 2012). With one paper mentioning using a negative binomial regression model due to zero reported intrusions (Brennen et al., 2021). With regard to the retrospective intrusion ratings (IMS), two out of six studies use analyses which assume that the residuals follow a normal distribution and/or report means, with no mentioning of transformations to normalize the data (Logan & O'Kearney, 2012; Nixon et al., 2007). And four out of six studies do account for non-normally distributed variables and/or residuals.

Especially regarding the diary intrusion measure it seem to be more appropriate to use statistical tests that can cope with presumably non-normally distributed distributions and or residuals in those studies. Consequences of using tests in which assumptions of normality are violated, such as the normality of the residuals can lead to incorrect results and conclusions.

Specifically, if the residuals are not normally distributed, the p-values produced by the test may not be accurate, and you may incorrectly reject or fail to reject the null hypothesis. In addition to incorrect results, violating the assumptions of a test can also affect the validity and reliability of the conclusions drawn from the analysis. For example, if the residuals are not normally distributed, the estimates of the parameters may be biased, and the confidence intervals may be too wide or too narrow (Box & Cox, 1964; Gelman & Hill, 2019; Wilcox, 2016). It is therefore suggested that future studies researching intrusions use appropriate statistical methods to accommodate their data.

Limitations and Strengths

The study was conducted online due to social distancing measures during the COVID-19 pandemic. Although online studies are advantageous in terms of feasibility and planning, they also have limitations. To standardize the participants' environment, a standardized script was used, which provided specific instructions on room setup, lighting, and reducing distractions during the study. However, it was not possible to exercise complete control over the participants' environment. The validity of the findings may have been influenced by external factors such as background noise, cellphones, and roommates acting as sources of distraction, as well as variations in participants' overall environment, including differences in room lighting and computer equipment.

The sample of the study comprised solely of young university students, which could limit the generalizability of the results to the wider population.

It is possible that the trauma films used did not evoke enough intrusions, as participants reported a low number of diary intrusions on average (M = 4.50, SD = 6.82;

Mdn = 3.00, *IQR* = 1.00 – 5.00). This is comparable to the findings of Asselbergs et al. (2018), but lower than the reported average of seven intrusions of Holmes et al. (2009). It is also possible that the recruitment process for the study may have resulted in a selective sample that is less sensitive to stressful scenes and less prone to developing intrusions due to explicit warnings about the study's stressful nature. Some participants suggested in the comments section that the film scenes were not traumatic enough. A few participants in the comments section suggested that the film scenes were not traumatic enough. Knowing about the scenes from movies and series could potentially have lessened their traumatic impact.

Explicit warnings about the stressful nature of the study, which were necessary for ethical considerations, may have had another effect. They could have shaped participants' expectations about the traumatic film before watching it. This could be seen in the data because some participants expressed a high emotional state before the film, but a low emotional state afterward (Negative difference score post/pre-film: total score *n* = 11 , 'sad' *n* = 38, 'hopeless' *n* = 20, 'fearful' *n* = 23, 'horrified' *n* = 2, 'anxious' *n* = 29 and 'depressed' *n* = 18). Additionally, individuals who know that they are emotionally sensitive to traumatic content may have chosen not to participate in the study due to the warnings provided.

With regard to the independent variable emotional reaction, the main interest lies in the direct effect of traumatic content on emotions. In the present study, emotional reaction was not assessed during the film, but before and after viewing the film. Furthermore, it indirectly measured through self-report with the use of VAS scales. To complete the VAS scales, participants must possess insight into their own emotional experiences and be capable of accurately assessing their emotional states. However, more direct measures of emotional reactions, such as physiological responses (e.g., pupil dilation, heart rate (variability), skin conductance, brain activity) or observable behavioural indicators (e.g., approach or avoidance behaviour, facial expressions recorded via electrodes attached to facial muscles), might be more effective in measuring emotional responses to the film (Bradley & Lang, 1994; LaBar & Cabeza, 2006; Richardson et al., 2004).

The current study also has several strengths. First, this thesis used appropriate statistical methods that accommodated the data. Furthermore, the study was conducted across different research sites in the Netherlands, Germany, and the UK, making the sample more diverse and representative of different countries and (Western-European) cultures. This provides more insight into possible differences or similarities between individuals with different cultural backgrounds. Lastly, The use of the 'trauma film paradigm' is advantageous in studying the development of traumatic memories because it allows for a standardized and controlled way of studying traumatic processes and intrusive memories, without exposing participants to actual trauma (Holmes et al., 2004).

Future research

The current study has demonstrated some strengths and limitations that could be taken into account for future research. One suggestion is to conduct a similar experiment in a laboratory setting to control for confounding variables and ensure that circumstances are similar for each participant. Another recommendation is to use a broader sample to improve the generalizability of the study beyond university students. Additionally, direct measures of emotional reaction, such as physiological responses and observations od facial expressions, may be more effective in measuring emotional responses to a traumatic film than relying on self-reported VAS scales. Future research could incorporate such direct measures. Furthermore, the non-significant results for the moderation between resilience, emotional reaction, and intrusions indicate a need for further investigation in future studies to gain more insight these findings. Lastly, it is suggested that future studies researching intrusions use appropriate statistical methods to accommodate their data to draw more valid and reliable results.

Conclusions

This thesis found that participants' emotional state significantly increased after watching a traumatic film. Emotional reaction was positively associated with the development of intrusions, but resilience did not moderate this relationship.

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Appendices

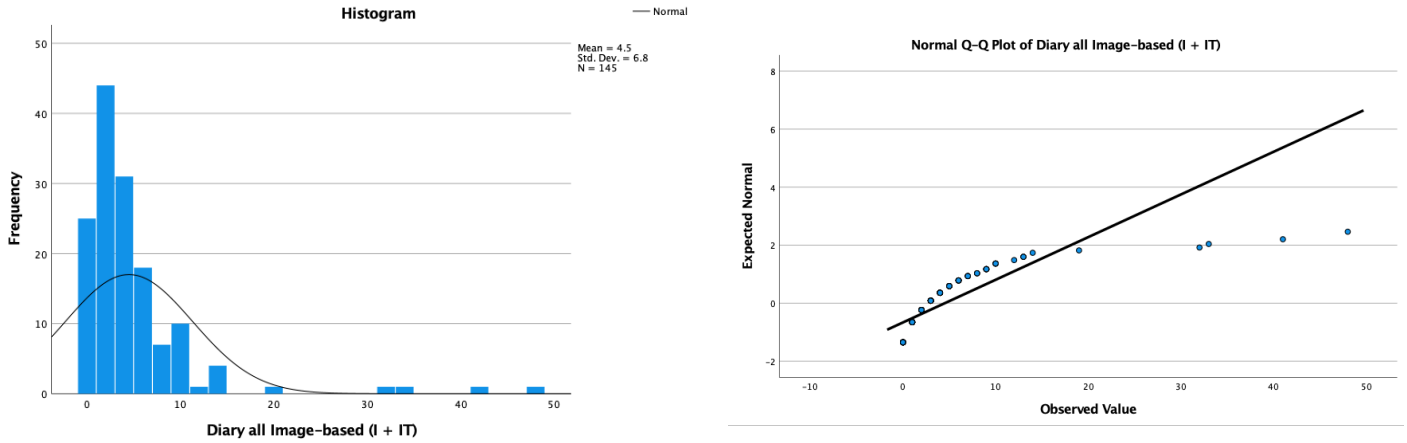
Appendix A

Evaluating normality of variables with graphical and statistical methods: histograms, Q-Q Plots, and tests

The figures below evaluate normality using three methods: histograms, Q-Q plots, and statistical tests. Histograms visually assess normality with symmetric, moderate tailed distributions indicating normality, and include a normal distribution line for comparison. Q-Q (Quantile-Quantile) plots compare observed data to expected values for normality, with points close to the line indicating normality. The Kolmogorov-Smirnov and Shapiro-Wilk tests assess normality statistically, with a significant test result ($p < 0.05$) indicating non-normality Although it is argued by the scientific community that the Kolmogorov-Smirnov test in most cases is not a valid way to evaluate normality, with the Shapiro-Wilk test being a better alternative (Marozzi, 2013; Steinskog et al., 2007).

Figure A1-a.

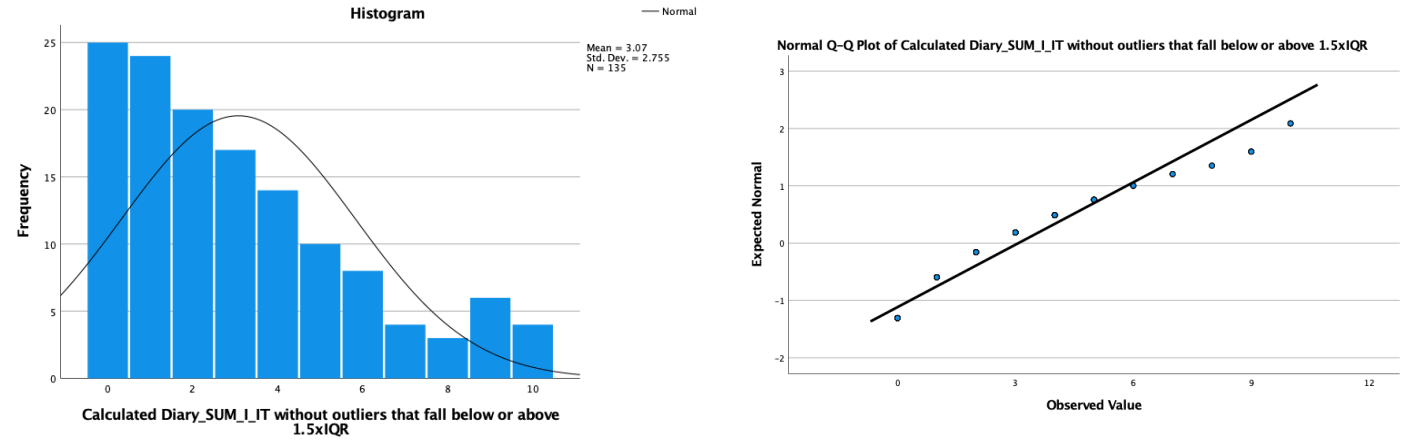
Evaluating normality of the variable image-based intrusions sum score (involuntary memory diary)



Note. Tests of normality: Kolmogorov-Smirnov test: p = <0.000 and Shapiro-Wilk test: p = <0.000.

Figure A1-b.

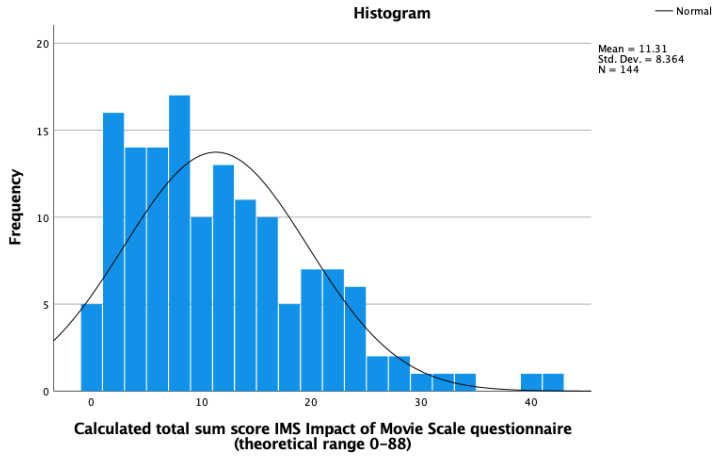
Evaluating normality of the variable image-based intrusions sum score (involuntary memory diary) without outliers

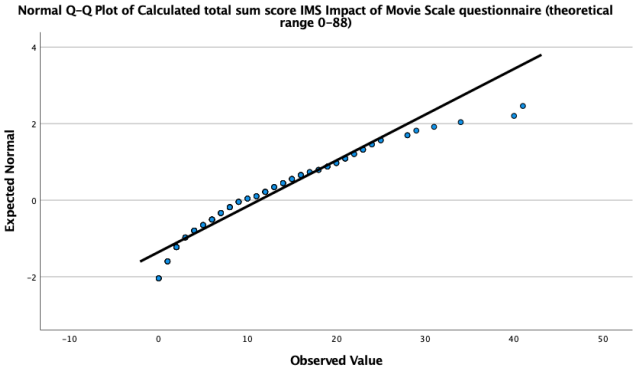


Note. Tests of normality: Kolmogorov-Smirnov test: p = <0.000 and Shapiro-Wilk test: p = <0.000.

Figure A2-a.

Evaluating normality of the intrusion variable Impact of Movie Scale (IMS) sum score

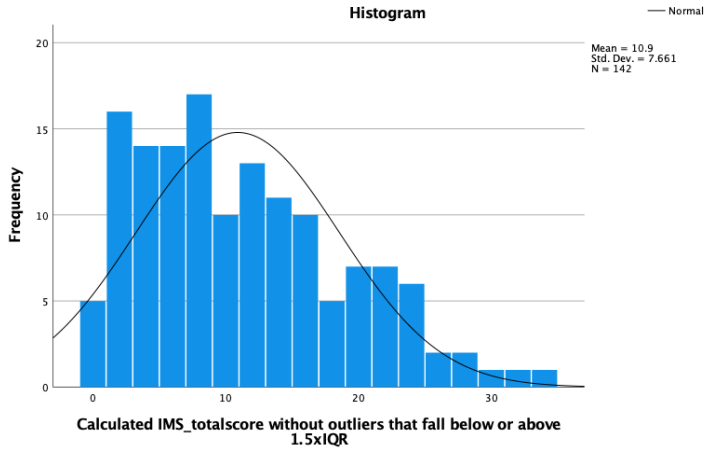


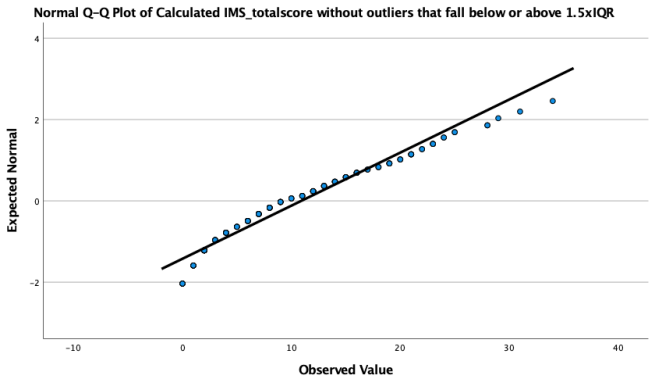


Note. Tests of normality: Kolmogorov-Smirnov test: p = <0.000 and Shapiro-Wilk test: p = <0.000.

Figure A2-b.

Evaluating normality of the intrusion variable Impact of Movie Scale (IMS) sum score without outliers

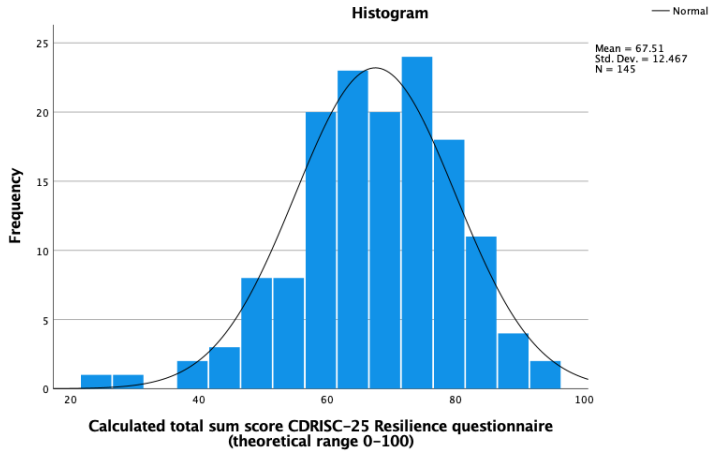


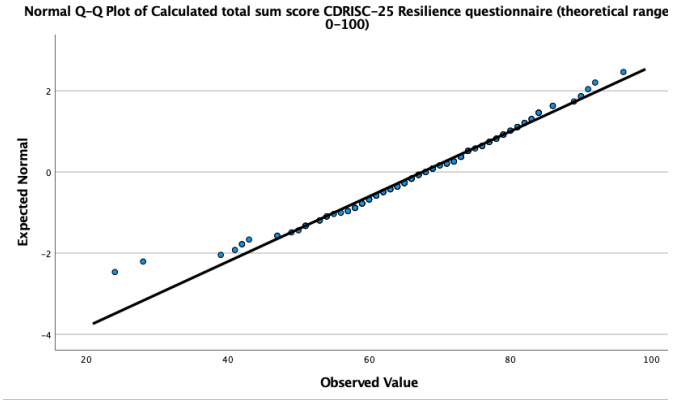


Note. Tests of normality: Kolmogorov-Smirnov test: p = <0.000 and Shapiro-Wilk test: p = <0.000.

Figure A3-a.

Evaluating normality of the Connor-Davidson Resilience scale (CD-Risk 25) sum score variable

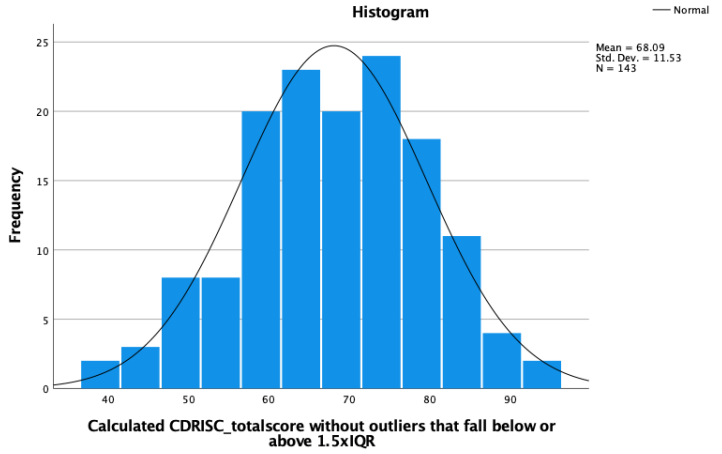


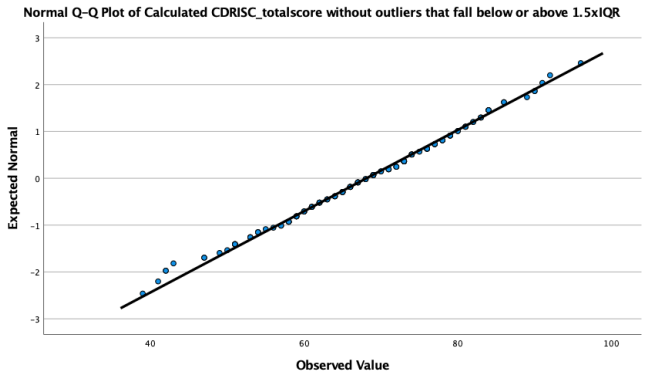


Note. Tests of normality: Kolmogorov-Smirnov test: p = 0.200 and Shapiro-Wilk test: p = 0.051.

Figure A3-b.

Evaluating normality of the Connor-Davidson Resilience scale (CD-Risk 25) sum score variable without outliers

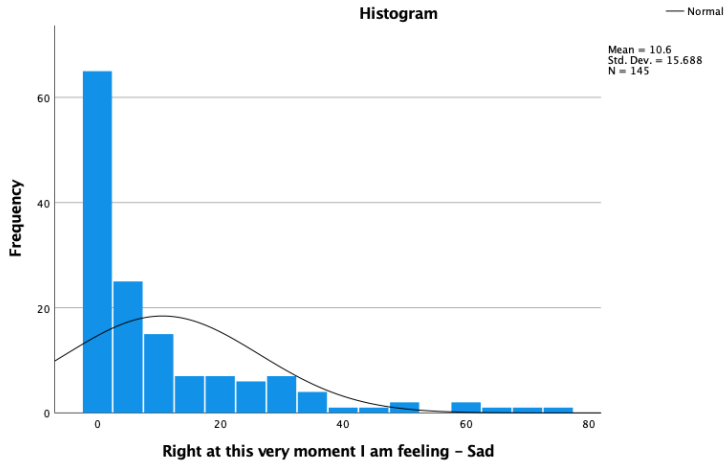


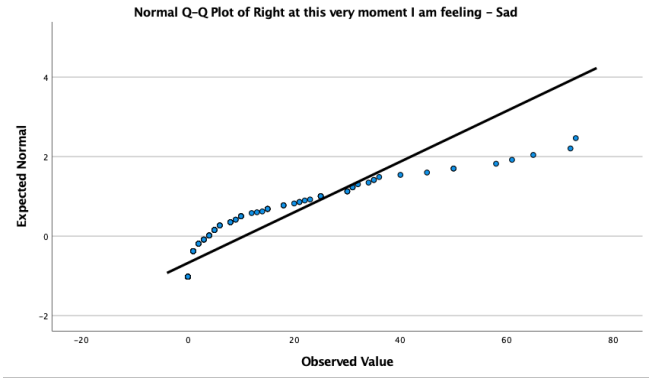


Note. Tests of normality: Kolmogorov-Smirnov test: p = 0.200; Shapiro-Wilk test: p = 0.727.

Figure A4-a.

Evaluating normality of the variable VAS pre-film emotional state 'Sad'

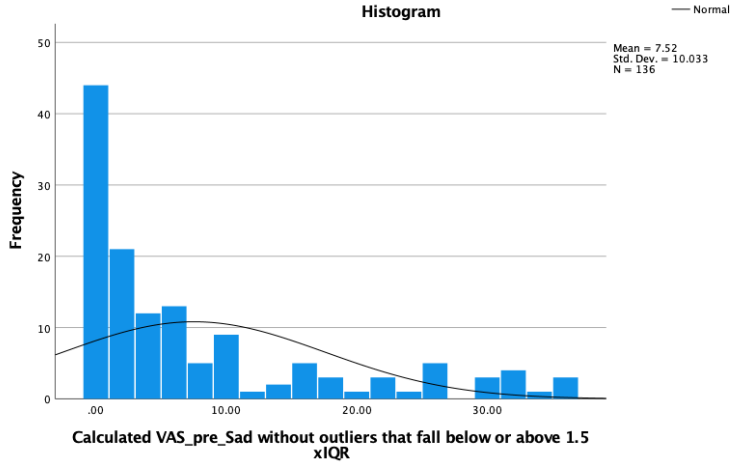


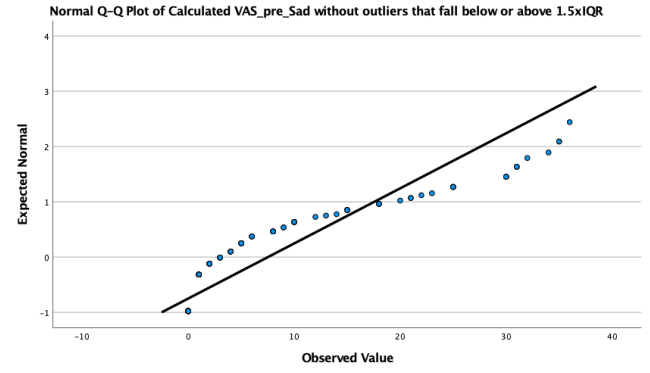


Note. Tests of normality: Kolmogorov-Smirnov test: p = <0.000 and Shapiro-Wilk test: p = <0.000.

Figure A4-b.

Evaluating normality of the variable VAS pre-film emotional state 'Sad' without outliers

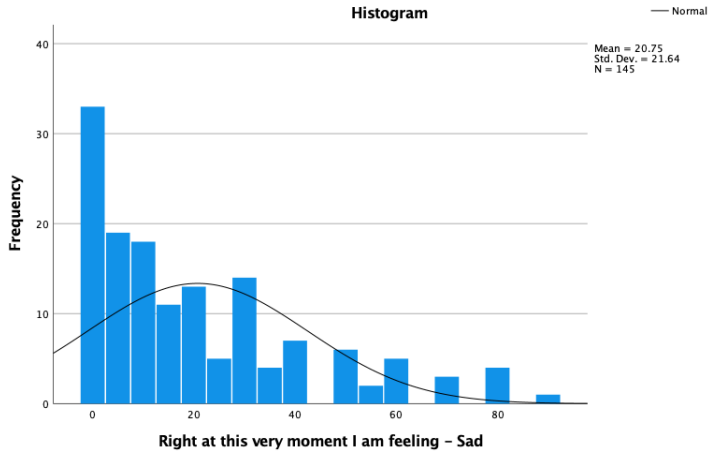


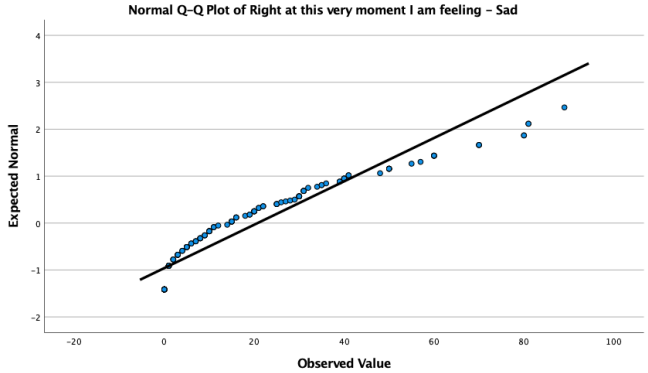


Note. Tests of normality: Kolmogorov-Smirnov test: p = <0.000 and Shapiro-Wilk test: p = <0.000.

Figure A5-a.

Evaluating normality of the variable VAS post-film emotional state 'Sad'

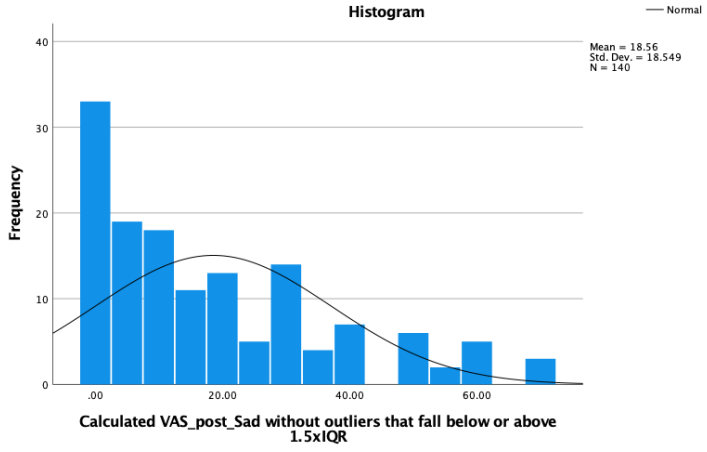


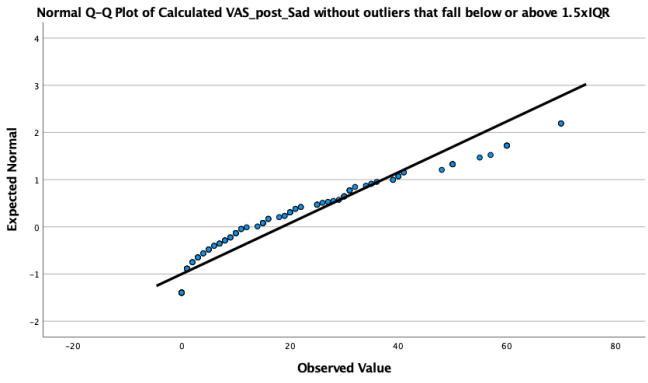


Note. Tests of normality: Kolmogorov-Smirnov test: p = <0.000 and Shapiro-Wilk test: p = <0.000.

Figure A5-b.

Evaluating normality of the variable VAS post-film emotional state 'Sad' without outliers

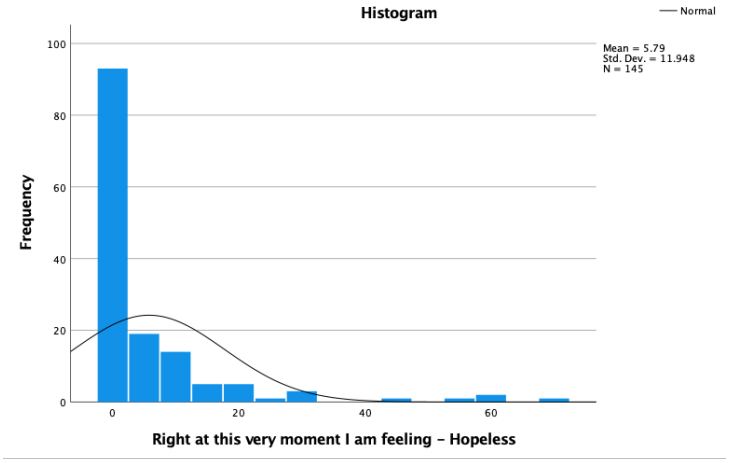


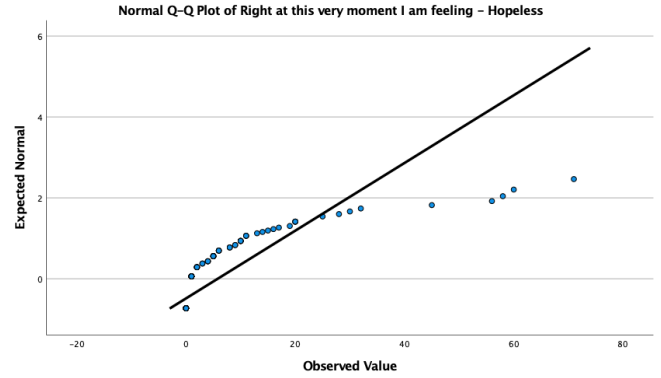


Note. Tests of normality: Kolmogorov-Smirnov test: p = <0.000 and Shapiro-Wilk test: p = <0.000.

Figure A6-a.

Evaluating normality of the variable VAS pre-film emotional state 'Hopeless'

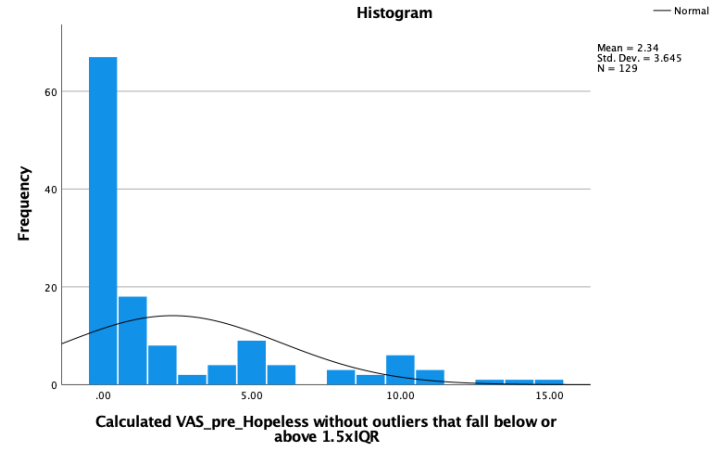


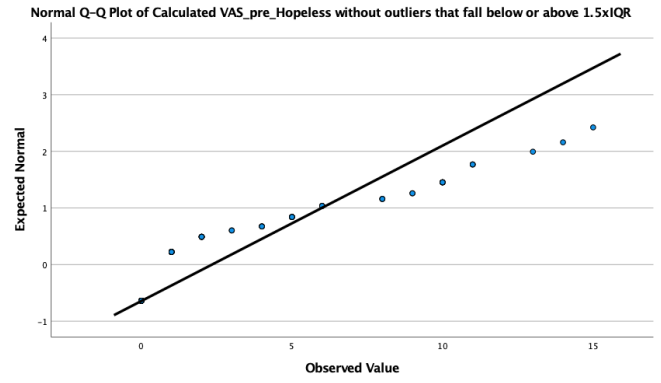


Note. Tests of normality: Kolmogorov-Smirnov test: p = <0.000 and Shapiro-Wilk test: p = <0.000.

Figure A6-b.

Evaluating normality of the variable VAS pre-film emotional state 'Hopeless' without outliers

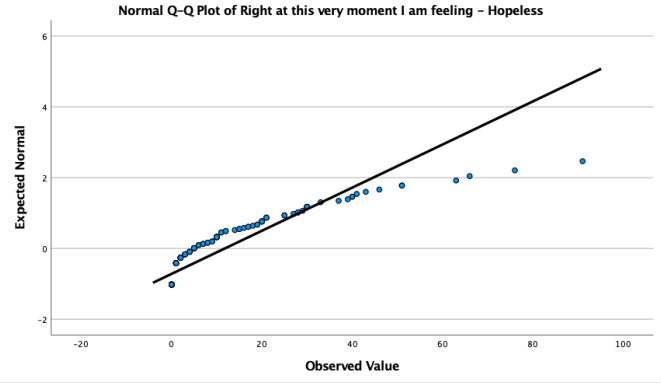




Note. Tests of normality: Kolmogorov-Smirnov test: p = <0.000 and Shapiro-Wilk test: p = <0.000.

Figure A7-a.

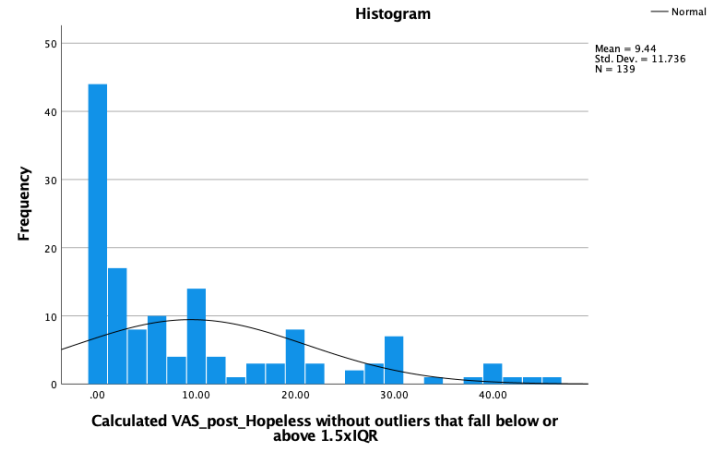
Evaluating normality of the variable VAS post-film emotional state 'Hopeless'

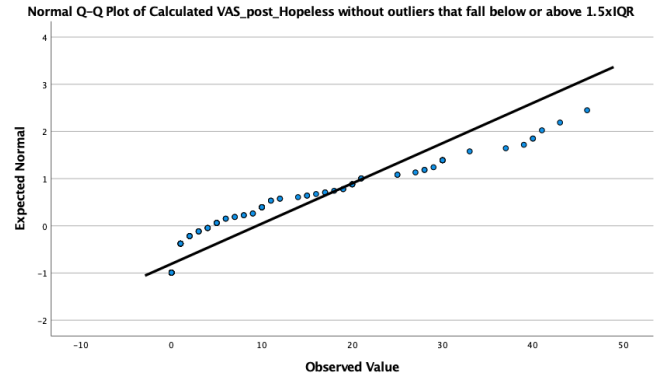


Note. Tests of normality: Kolmogorov-Smirnov test: p = <0.000 and Shapiro-Wilk test: p = <0.000.

Figure A7-b.

Evaluating normality of the variable VAS post-film emotional state 'Hopeless' without outliers

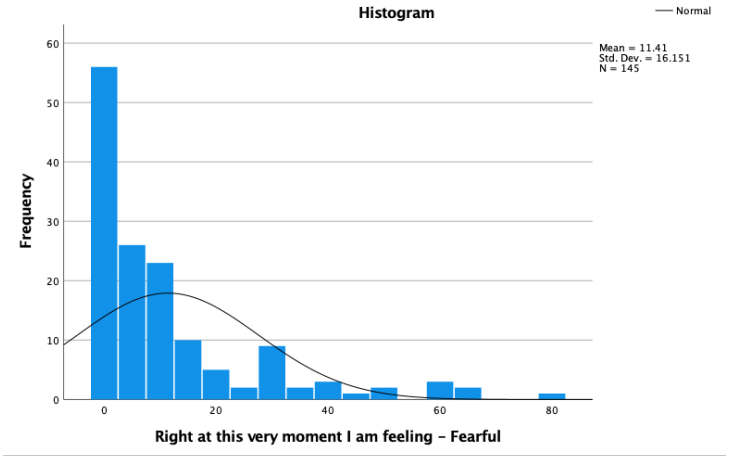


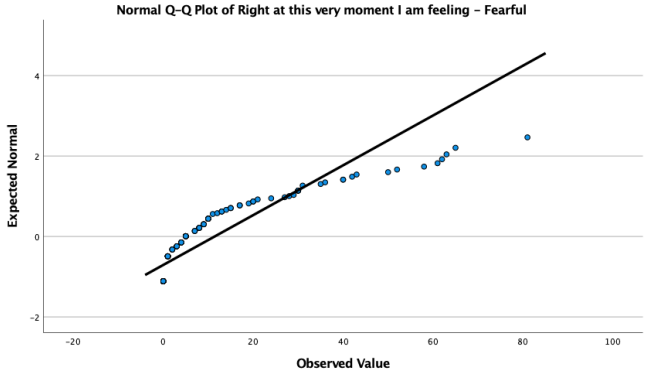


Note. Tests of normality: Kolmogorov-Smirnov test: p = <0.000 and Shapiro-Wilk test: p = <0.000.

Figure A8-a.

Evaluating normality of the variable VAS pre-film emotional state 'Fearful'

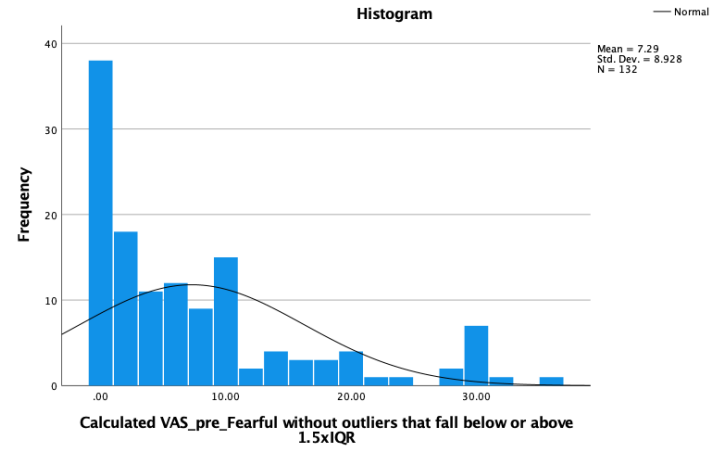


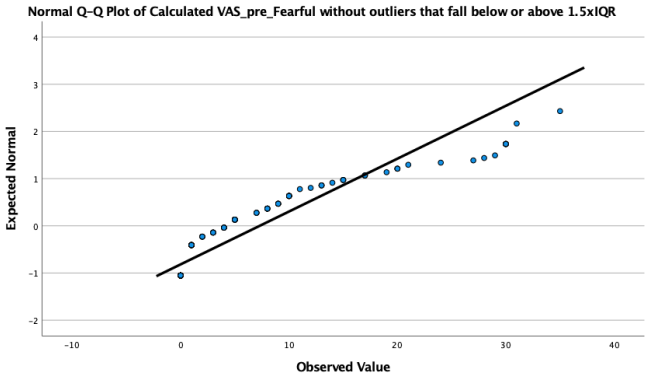


Note. Tests of normality: Kolmogorov-Smirnov test: p = <0.000 and Shapiro-Wilk test: p = <0.000.

Figure A8-b.

Evaluating normality of the variable VAS pre-film emotional state 'Fearful' without outliers

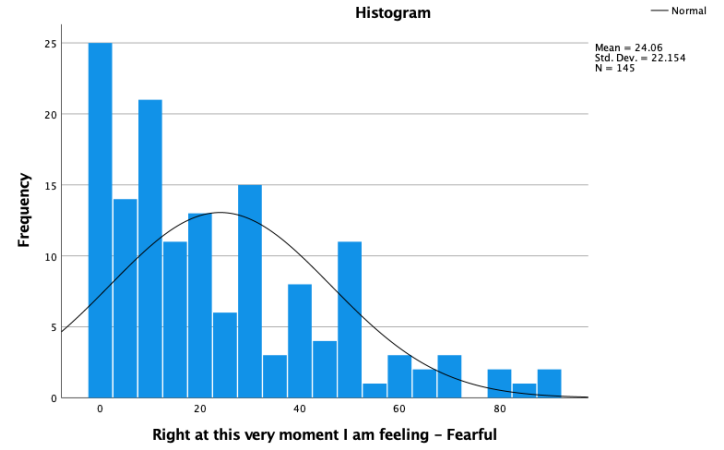


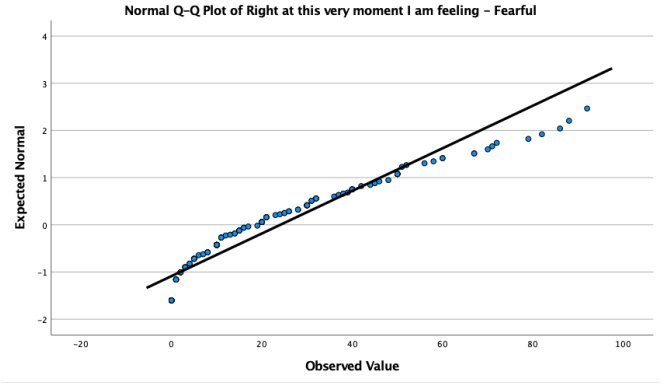


Note. Tests of normality: Kolmogorov-Smirnov test: p = <0.000 and Shapiro-Wilk test: p = <0.000.

Figure A9-a.

Evaluating normality of the variable VAS post-film emotional state 'Fearful'

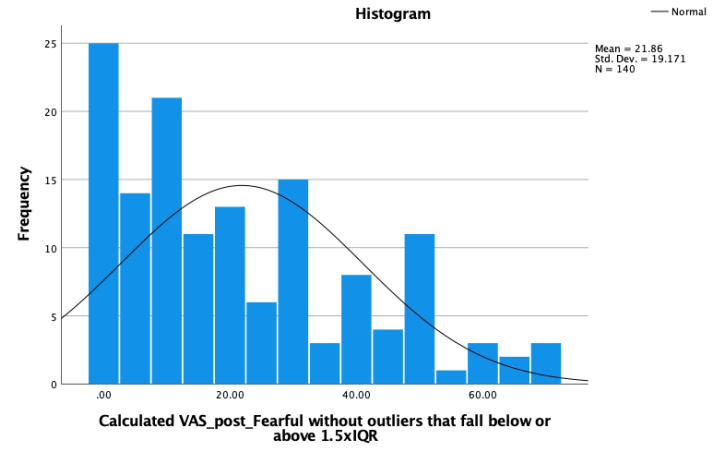


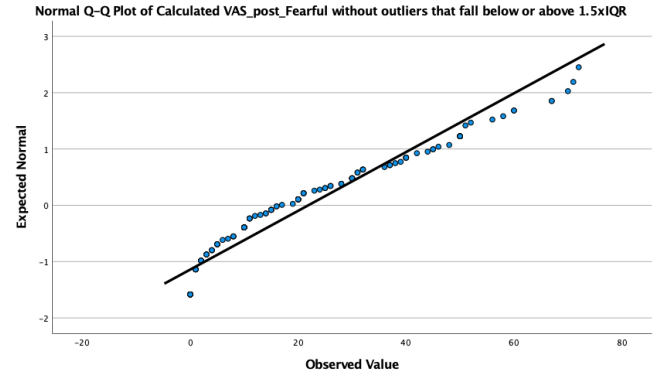


Note. Tests of normality: Kolmogorov-Smirnov test: p = <0.000 and Shapiro-Wilk test: p = <0.000.

Figure A9-b.

Evaluating normality of the variable VAS post-film emotional state 'Fearful' without outliers

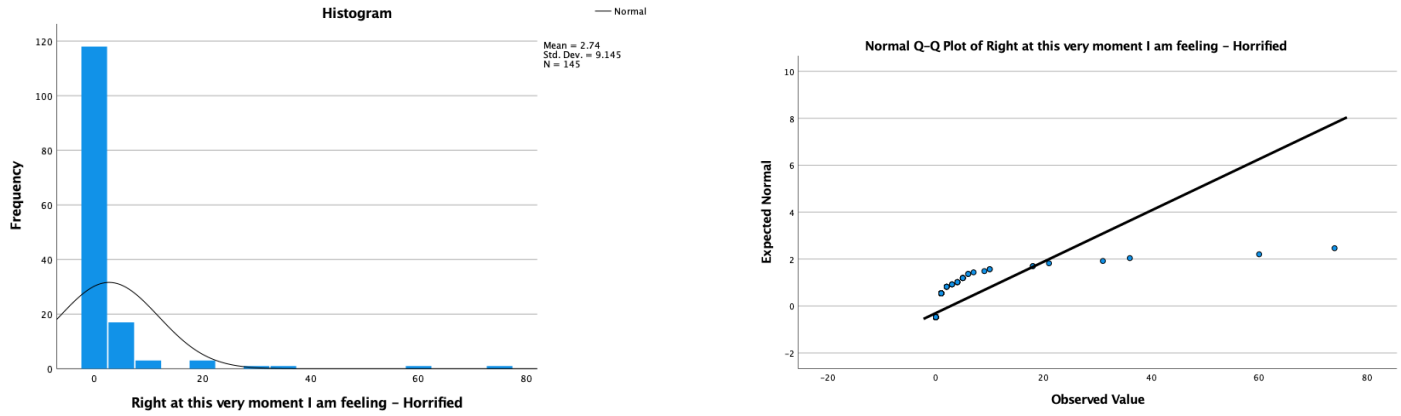




Note. Tests of normality: Kolmogorov-Smirnov test: p = <0.000 and Shapiro-Wilk test: p = <0.000.

Figure A10-a.

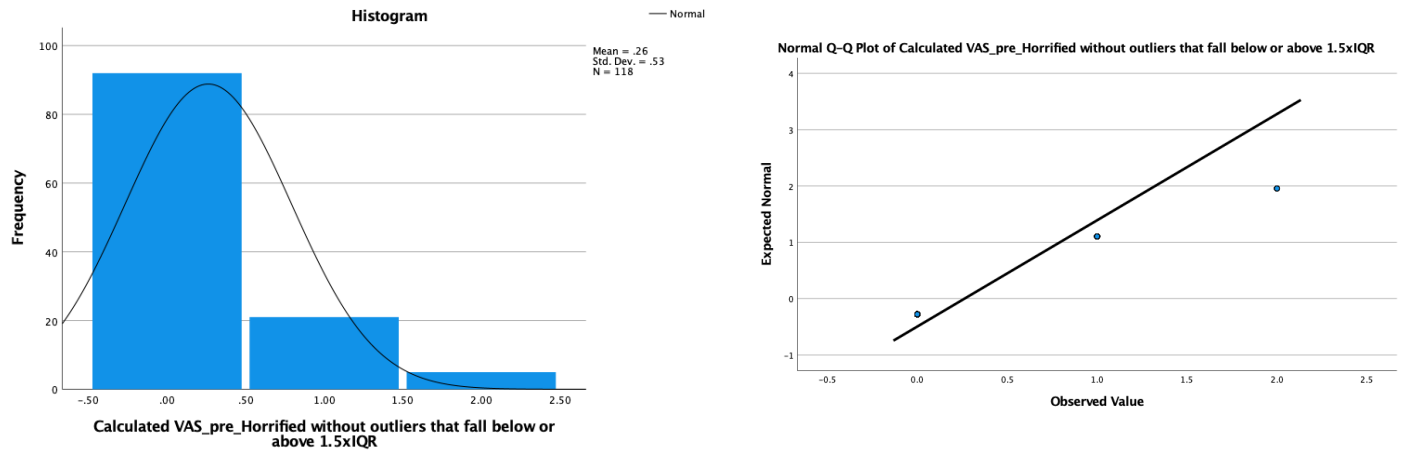
Evaluating normality of the variable VAS pre-film emotional state 'Horrified'



Note. Tests of normality: Kolmogorov-Smirnov test: p = <0.000 and Shapiro-Wilk test: p = <0.000.

Figure A10-b.

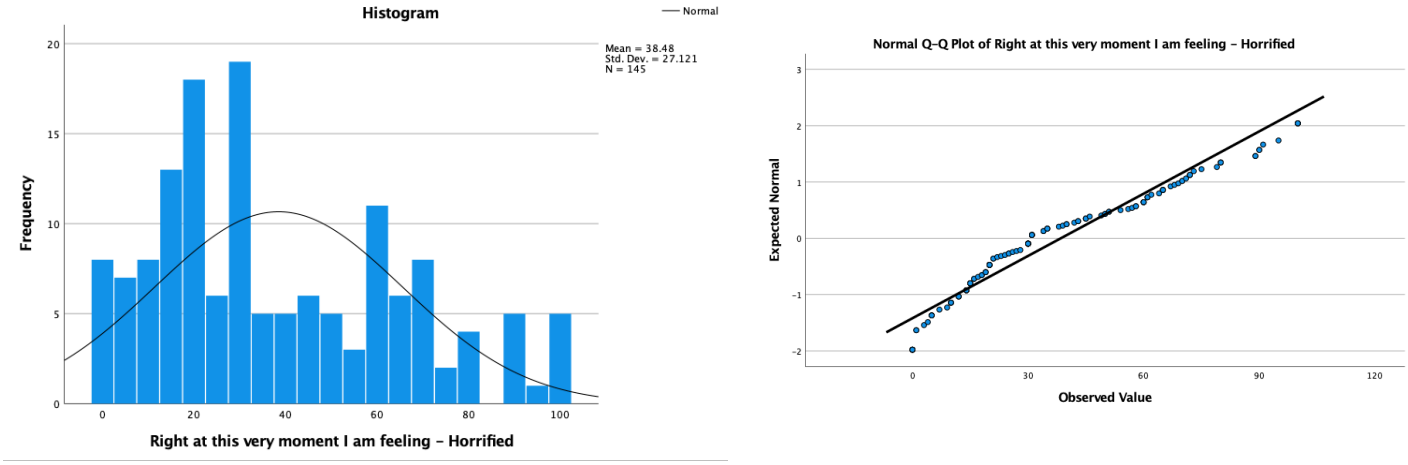
Evaluating normality of the variable VAS pre-film emotional state 'Horrified' without outliers



Note. Tests of normality: Kolmogorov-Smirnov test: p = <0.000 and Shapiro-Wilk test: p = <0.000.

Figure A11.

Evaluating normality of the variable VAS post-film emotional state 'Horrified'

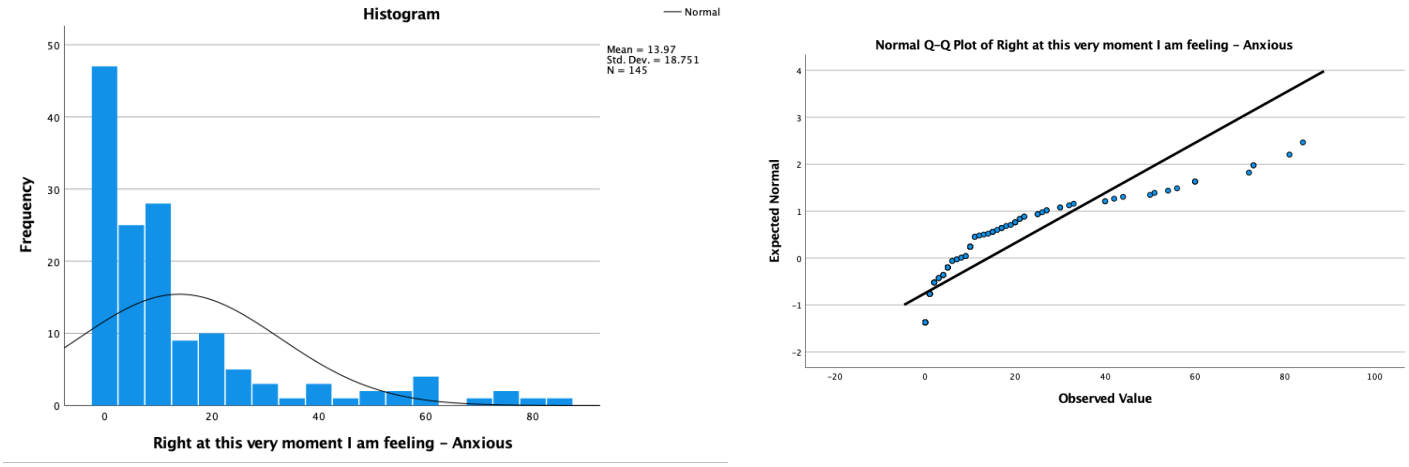


Note. Tests of normality: Kolmogorov-Smirnov test: p = <0.000 and Shapiro-Wilk test: p = <0.000. Abbreviations: p = probability (p)-value; Q-Q (Quantile-Quantile)-plot.

No variable without outliers was created as there were no outliers detected in the VAS post-film emotional state 'Horrified'.

Figure A12-a.

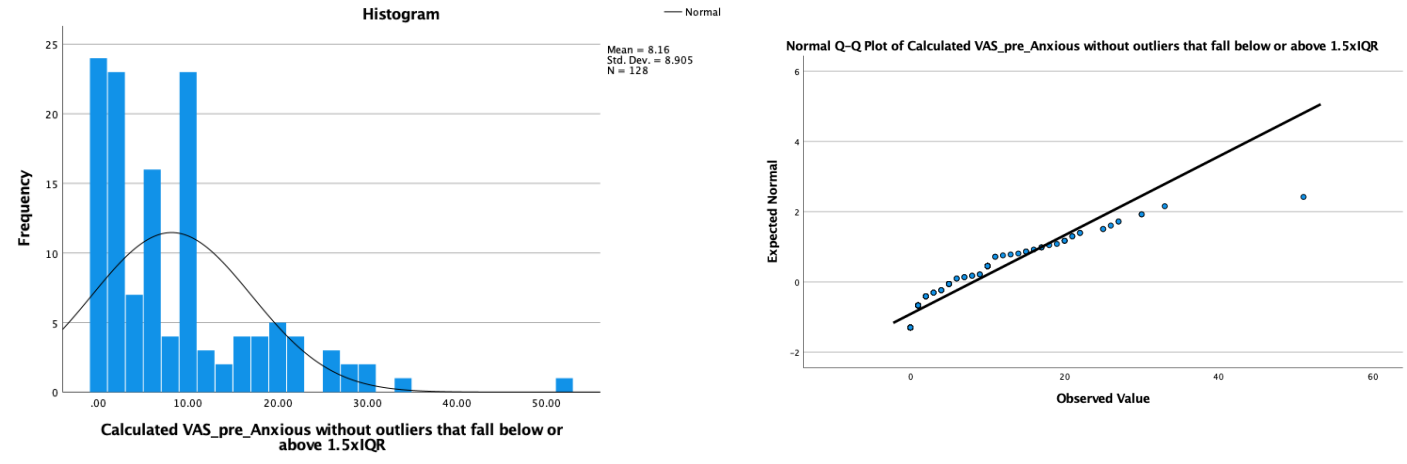
Evaluating normality of the variable VAS pre-film emotional state 'Anxious'



Note. Tests of normality: Kolmogorov-Smirnov test: p = <0.000 and Shapiro-Wilk test: p = <0.000.

Figure 12-b.

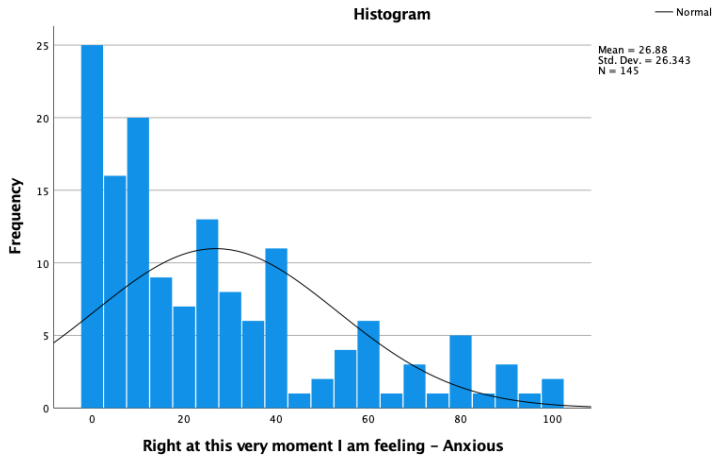
Evaluating normality of the variable VAS pre-film emotional state 'Anxious' without outliers

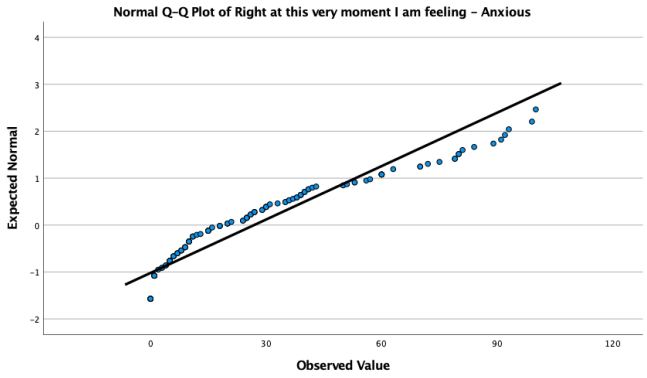


Note. Tests of normality: Kolmogorov-Smirnov test: p = <0.000 and Shapiro-Wilk test: p = <0.000.

Figure A13-a.

Evaluating normality of the variable VAS post-film emotional state 'Anxious'

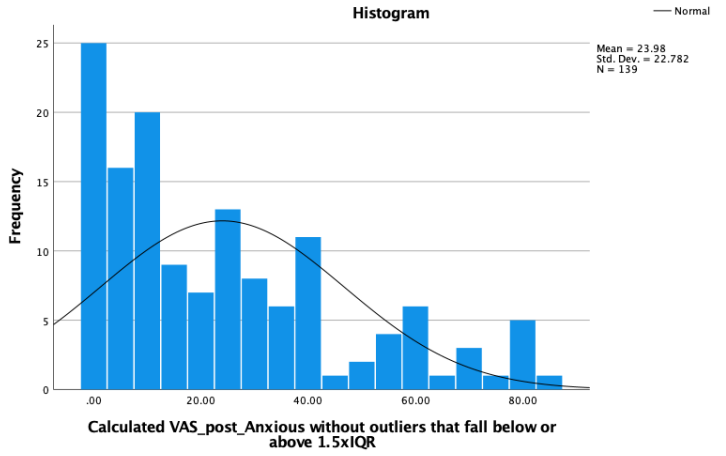


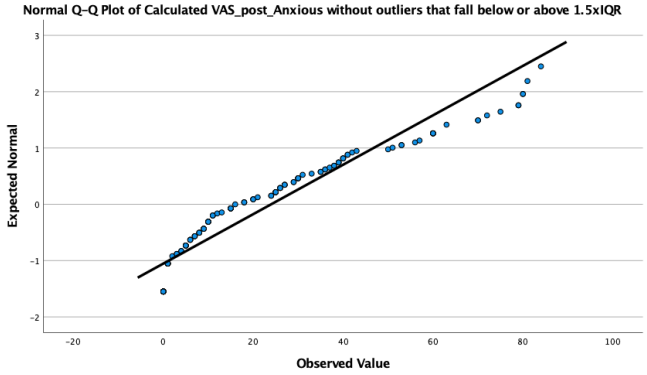


Note. Tests of normality: Kolmogorov-Smirnov test: p = <0.000 and Shapiro-Wilk test: p = <0.000.

Figure 13-b.

Evaluating normality of the variable VAS post-film emotional state 'Anxious' without outliers

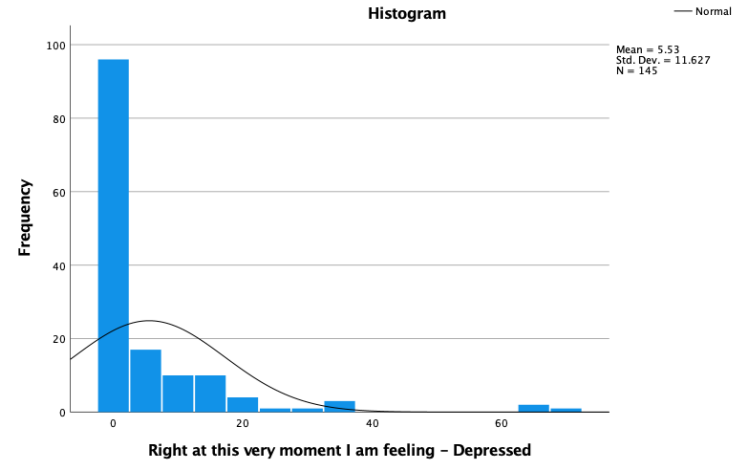


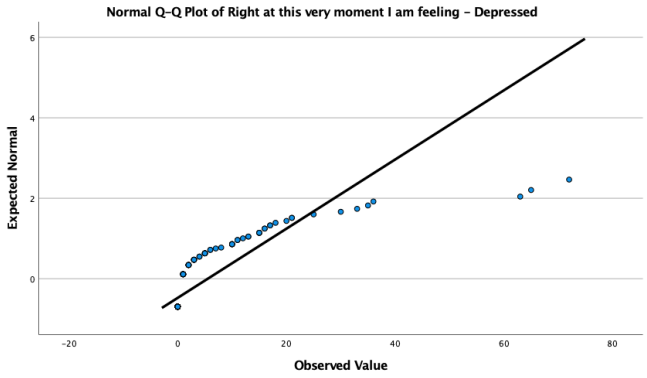


Note. Tests of normality: Kolmogorov-Smirnov test: p = <0.000 and Shapiro-Wilk test: p = <0.000.

Figure A14-a.

Evaluating normality of the variable VAS pre-film emotional state 'Depressed'

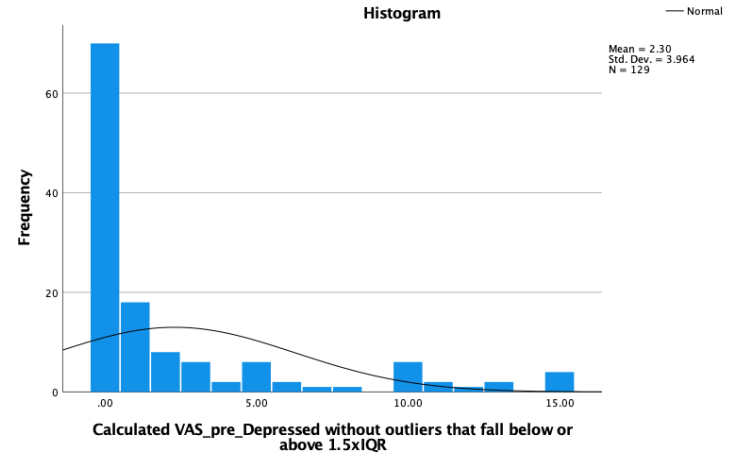


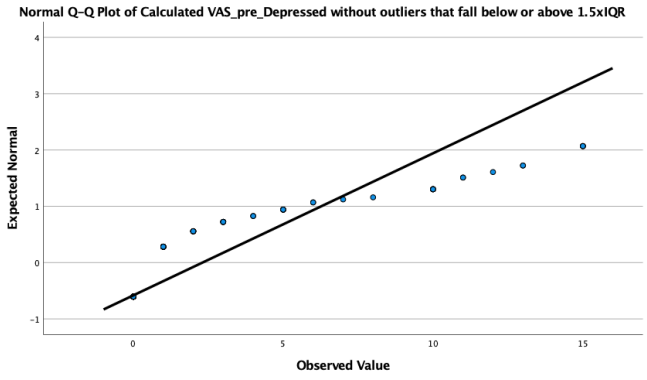


Note. Tests of normality: Kolmogorov-Smirnov test: p = <0.000 and Shapiro-Wilk test: p = <0.000.

Figure 14-b.

Evaluating normality of the variable VAS pre-film emotional state 'Depressed' without outliers

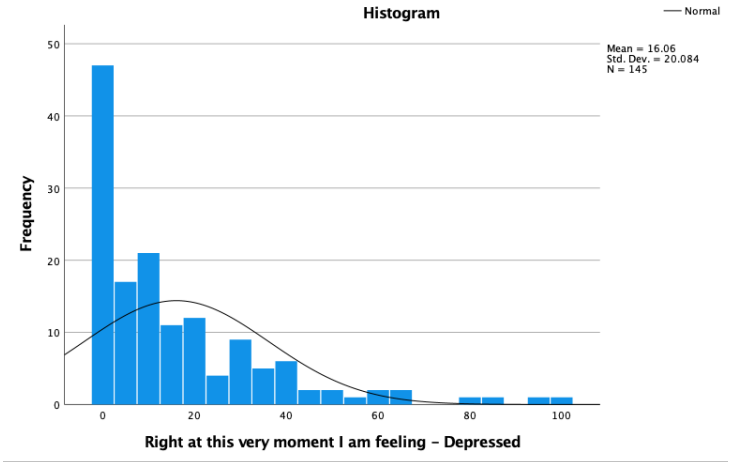


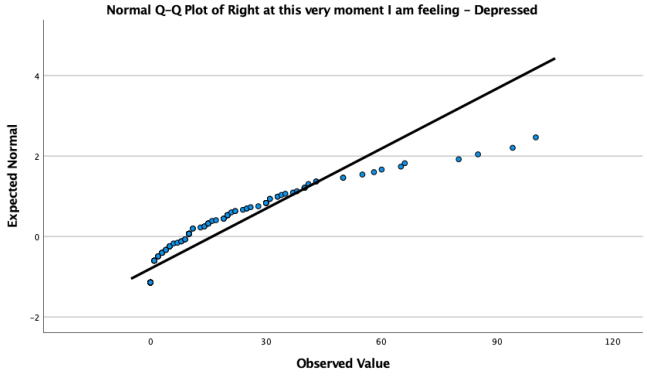


Note. Tests of normality: Kolmogorov-Smirnov test: p = <0.000 and Shapiro-Wilk test: p = <0.000.

Figure A15-a.

Evaluating normality of the variable VAS post-film emotional state 'Depressed'

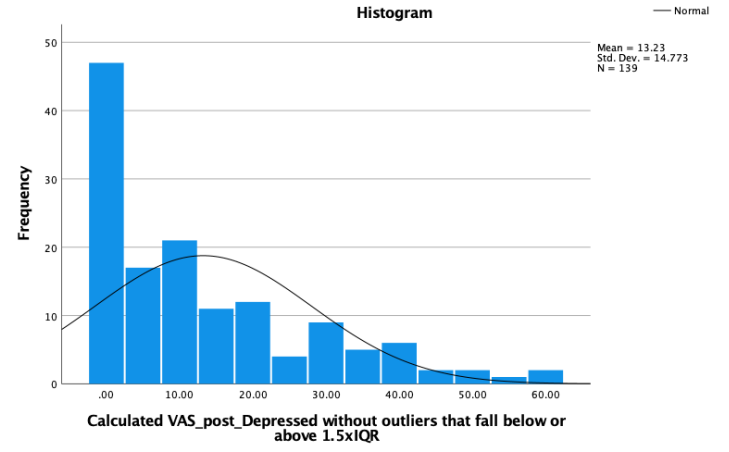


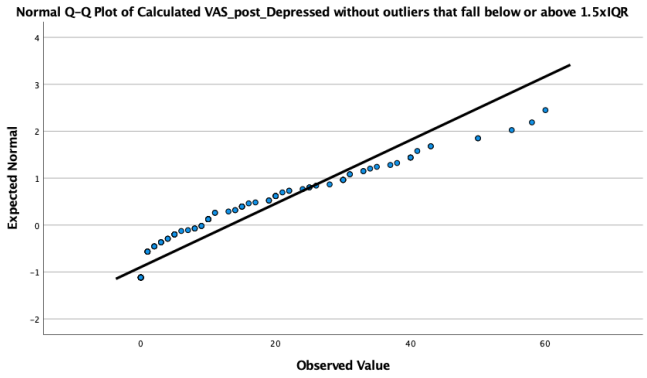


Note. Tests of normality: Kolmogorov-Smirnov test: p = <0.000 and Shapiro-Wilk test: p = <0.000.

Figure 15-b.

Evaluating normality of the variable VAS post-film emotional state 'Depressed' without outliers

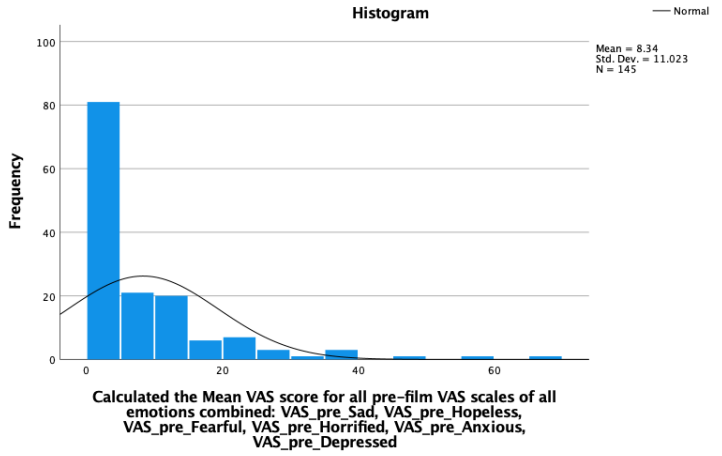


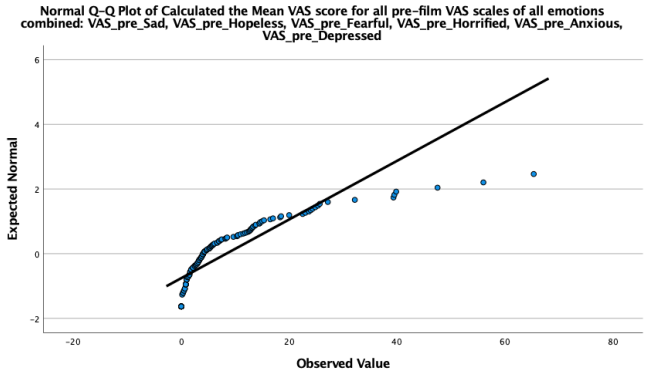


Note. Tests of normality: Kolmogorov-Smirnov test: p = <0.000 and Shapiro-Wilk test: p = <0.000.

Figure A16-a.

Evaluating normality of the variable VAS pre-film mean score of all emotional states combined (Sad, Hopeless, Fearful, Horrified, Anxious, Depressed)

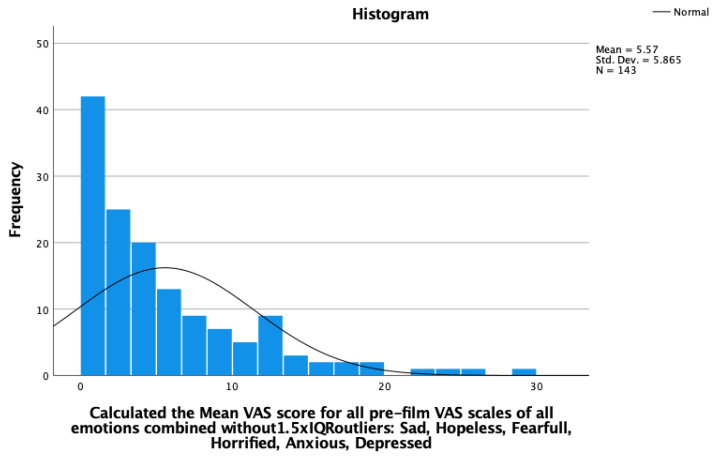


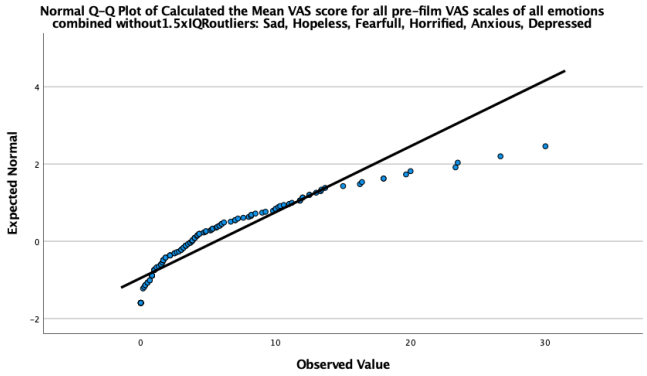


Note. Tests of normality: Kolmogorov-Smirnov test: p = <0.000 and Shapiro-Wilk test: p = <0.000.

Figure 16-b.

Evaluating normality of the variable VAS pre-film mean score of all emotional states combined (Sad, Hopeless, Fearful, Horrified, Anxious, Depressed) without outliers

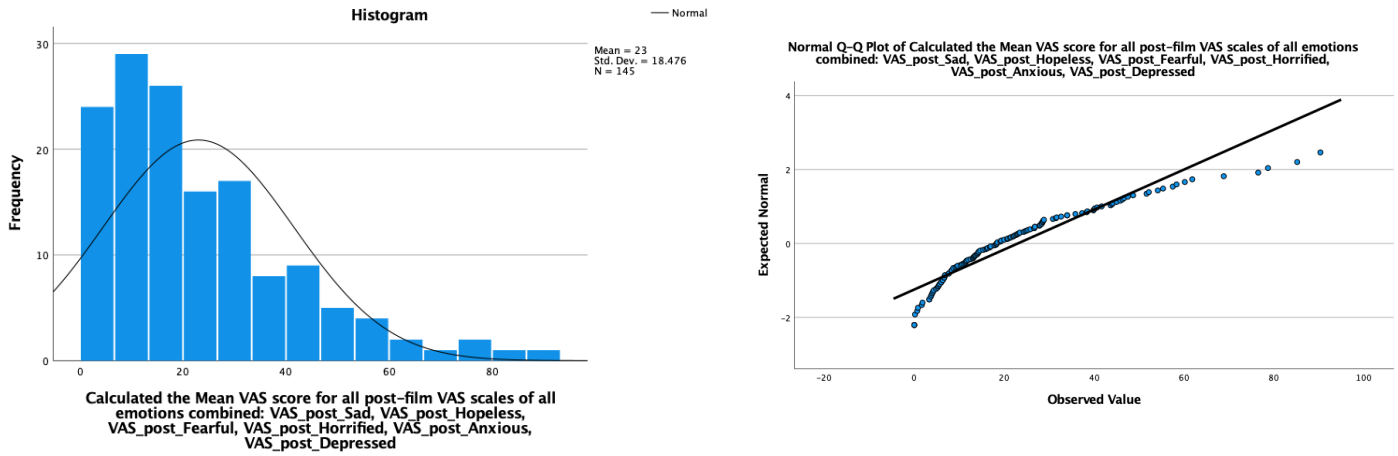




Note. Tests of normality: Kolmogorov-Smirnov test: p = <0.000 and Shapiro-Wilk test: p = <0.000.

Figure A17-a.

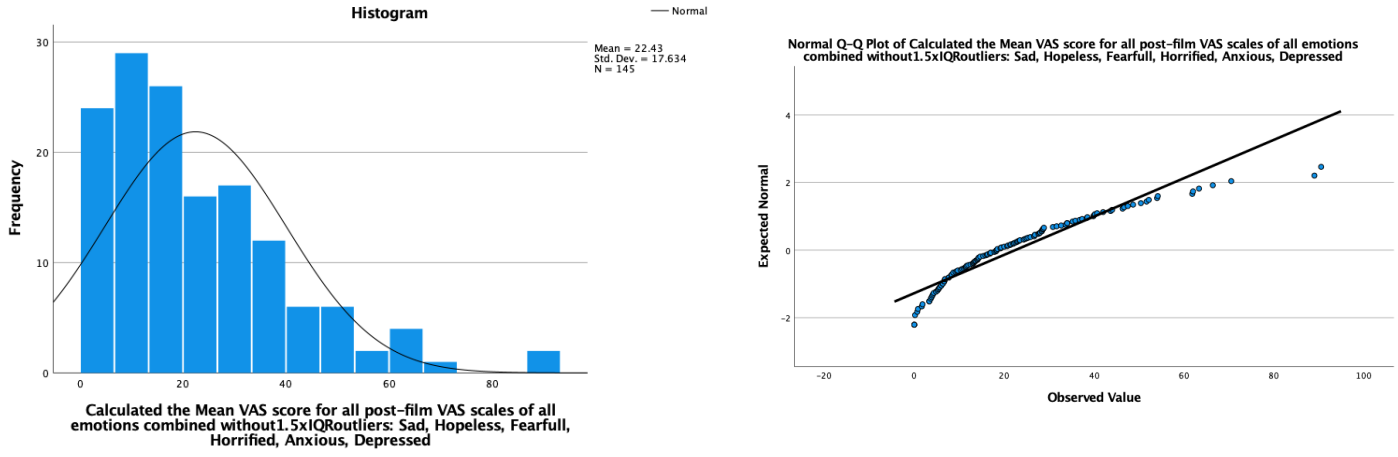
Evaluating normality of the variable VAS post-film mean score of all emotional states combined (Sad, Hopeless, Fearful, Horrified, Anxious, Depressed)



Note. Tests of normality: Kolmogorov-Smirnov test: p = <0.000 and Shapiro-Wilk test: p = <0.000.

Figure 17-b.

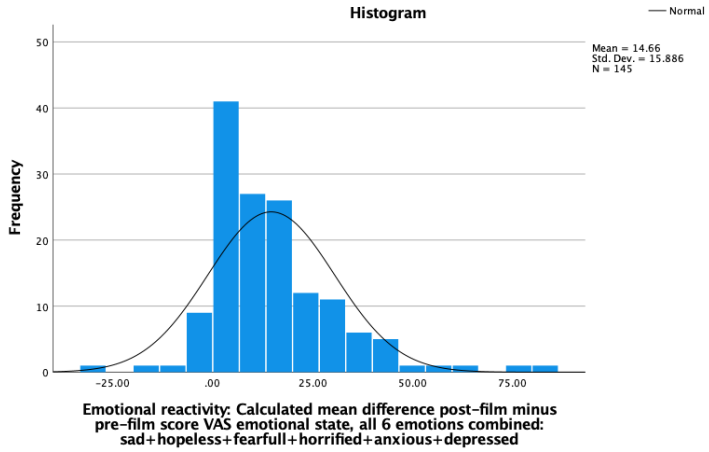
Evaluating normality of the variable VAS post-film mean score of all emotional states combined (Sad, Hopeless, Fearful, Horrified, Anxious, Depressed) without outliers

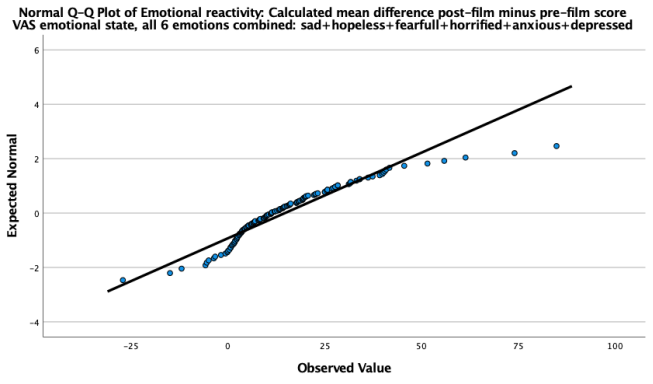


Note. Tests of normality: Kolmogorov-Smirnov test: p = <0.000 and Shapiro-Wilk test: p = <0.000.

Figure A18-a.

*Evaluating normality of the variable emotional reaction**

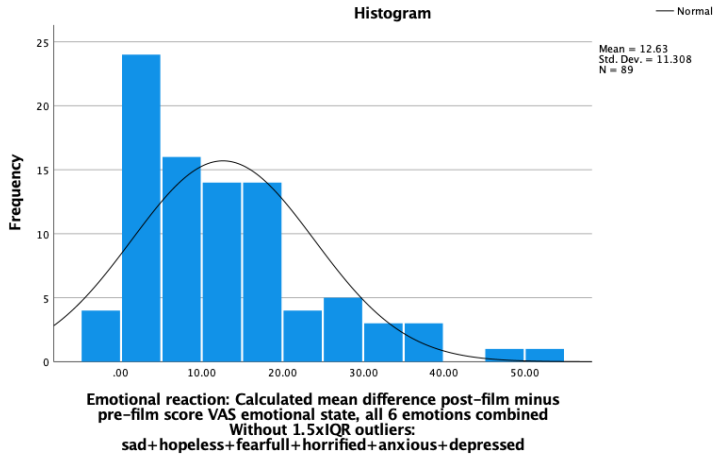


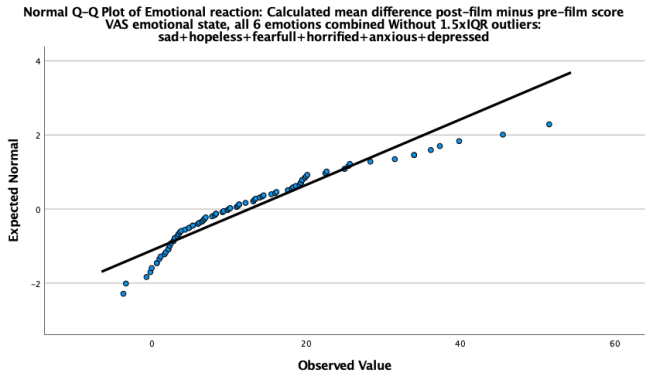


Note. Tests of normality: Kolmogorov-Smirnov test: p = <0.000 and Shapiro-Wilk test: p = <0.000. Abbreviations: p = probability (p)-value; Q-Q (Quantile-Quantile)-plot. *Emotional reaction = average of all emotional state delta scores pre- and post-film.

Figure A18-b.

Evaluating normality of the variable emotional reaction without outliers*





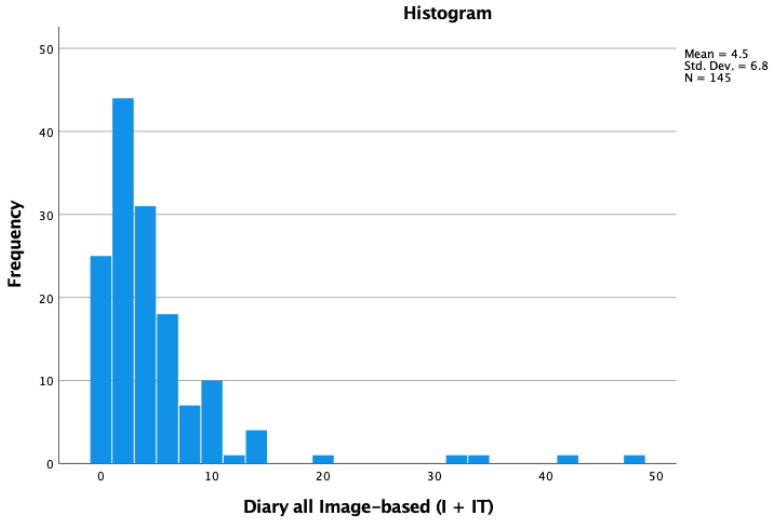
Note. Tests of normality: Kolmogorov-Smirnov test: p = <0.011 and Shapiro-Wilk test: p = <0.000. Abbreviations: p = probability (p)-value; Q-Q (Quantile-Quantile)-plot. *Emotional reaction = average of all emotional state delta scores pre- and post-film.

Appendix B

Visual representation of Negative Binomial Regression assumptions for variable image-based intrusions

Figure B1.

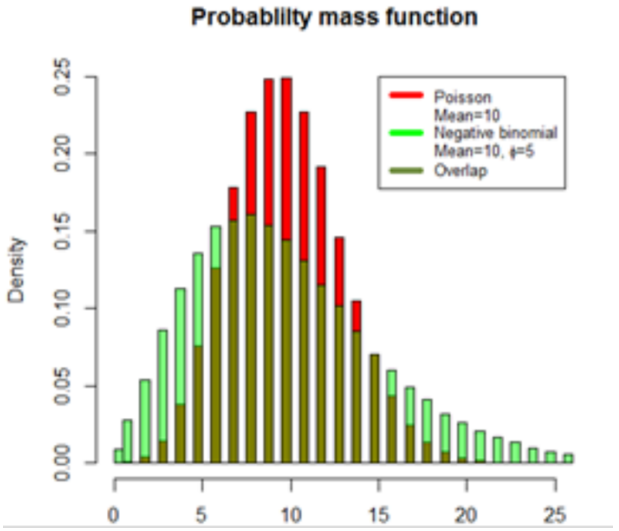
Assumption Negative Binomial Regression analysis: The dependent variable consists of count data.



Note. Histogram with distribution of image-based intrusions assessed in the intrusive memory dairy. Required Assumption of Negative Binomial Regression analysis relevant to the figure presented: The dependent variable consists of count data. Counts must be positive integers (i.e. whole numbers) 0 or greater (0,1,2,3…k).

Figure B2.

Assumption Negative Binomial Regression analysis: The distribution of counts follows a Negative Binomial distribution.



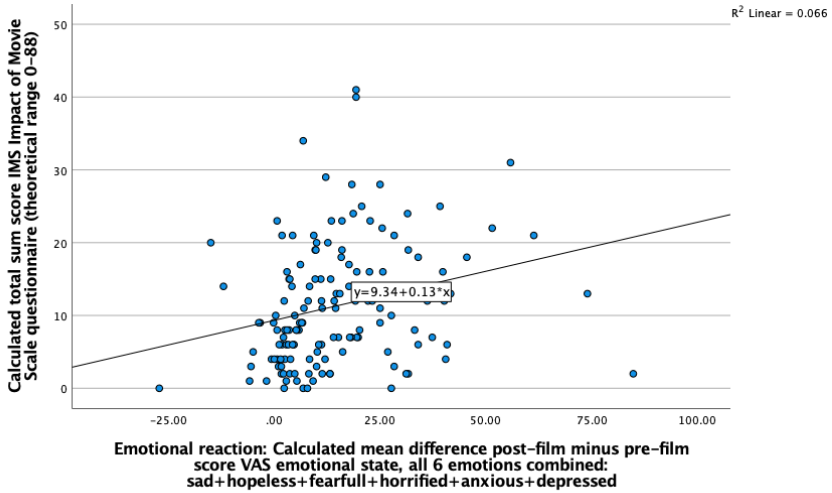
Note. Image copied for comparative purposes of a Negative Binomial Distribution (Figure 1: Yang & Berdine, 2015). "A negative binomial distribution is more spread than a Poisson distribution with the same mean" (Yang & Berdine, 2015). Required Assumption of Negative Binomial Regression Ananlysis relevant to the figure presented: The distribution of counts follows a Negative Binomial distribution, with an unequal mean and variance. The mean of the variable image-based intrusions, assessed in the intrusive memory dairy, is 4.74 and the variance is 45.65.

Appendix C

Linear regression assumptions Impact of Movie Scale (IMS)

Figure C1.

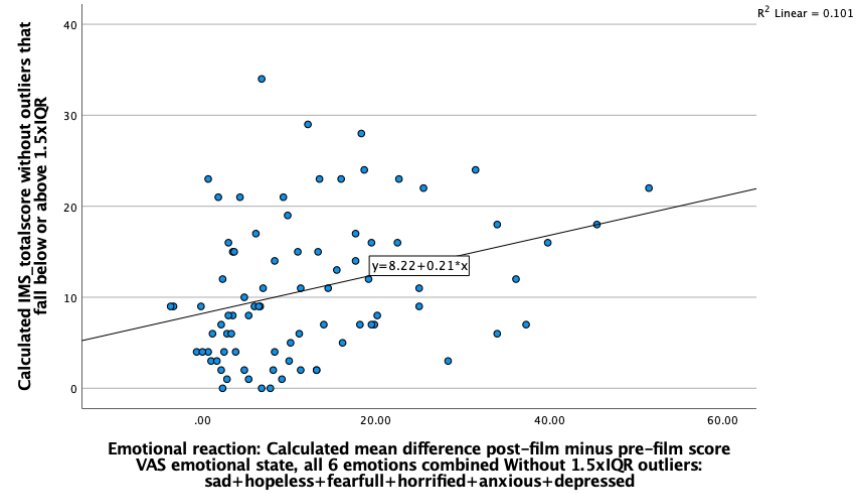
Graph of linear relationship retrospectively reported intrusions (IMS) (dependent variable) and emotional reaction (independent variable)



Note. The graph indicates a small positive linear relationship between the dependent and independent variable. The Pearson correlation coefficient (0.257) indicates a statistically significant linear relationship (p 0.002).

Figure C2.

Graph of linear relationship retrospectively reported intrusions (IMS) without outliers (dependent variable) and emotional reaction (independent variable) without outliers



Note. The graph indicates a small positive linear relationship between the dependent and independent variable. The Pearson correlation coefficient (0.318) indicates a statistically significant linear relationship (p 0.003).

Multicollinearity assumption

Pearson correlation coefficient between retrospectively reported intrusions (IMS) and emotional reaction should not be >0.800 (cut-off). Pearson correlation is 0.257 (for IMS variable without outliers Pearson correlation = 0.318). Furthermore, the Variance Inflation Factor (VIF) in the collinearity statistics should be well below 10, this score is 1.000. The tolerance score in the collinearity statistics should be above 0.2, this score is 1.000. The VIF and tolerance scores are the same for the IMS variable without outliers. Conclusion: No multicollinearity present, both in the original IMS variable and the variable without outliers.

Independence of residuals assumption

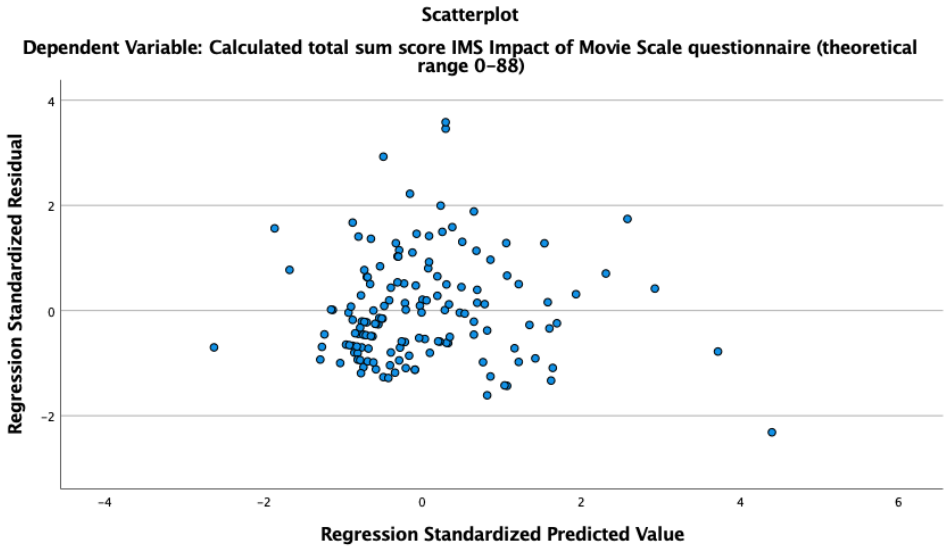
The value of the Durbin-Watson statistic is close to 2, values below 1 and above 3 are causes for concern. Value Durbin-Watson is 2.017. With regard to the IMS variable without outliers the Durbin-Watson value is 2.162. Conclusion: residuals are independent in both variables.

Assumption: No influential cases biasing your model

No values within the Cook's statistic should be close to 1. Conclusion: no values within the dataset of both IMS variables (with and without outliers) are close to 1, no influential cases bias the model.

Figure C3.

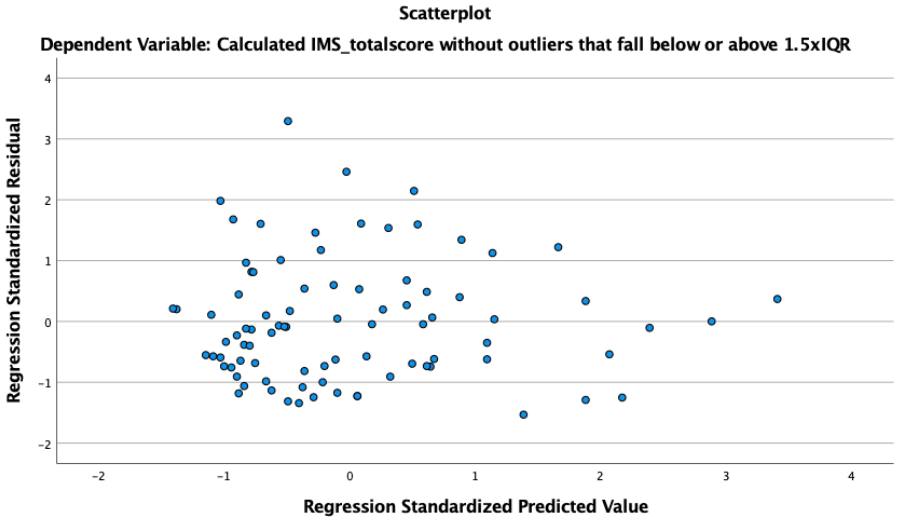
Scatterplot of retrospectively reported intrusions (IMS) to test the assumption of homoscedasticity



Note. Scatterplot shows the Regression Standardized Residuals and Standardized Predicted value to see of the variation in the residuals (or amount of error in the model) is similar at each point of the model. The variation in the residuals should be roughly similar and the plot (area of dots) should appear more random than funnelled. Conclusion: The plot (area of dots) appears more random than funnelled.

Figure C4.

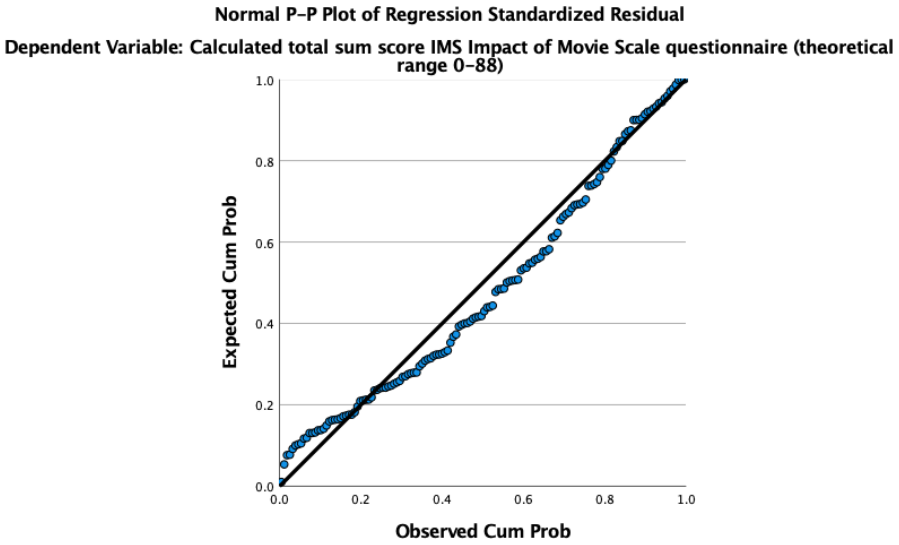
Scatterplot of retrospectively reported intrusions (IMS) without outliers to test the assumption of homoscedasticity



Note. Scatterplot shows the Regression Standardized Residuals and Standardized Predicted value to see of the variation in the residuals (or amount of error in the model) is similar at each point of the model. The variation in the residuals should be roughly similar and the plot (area of dots) should appear more random than funnelled. Conclusion: The plot (area of dots) appears more random than funnelled.

Figure C5.

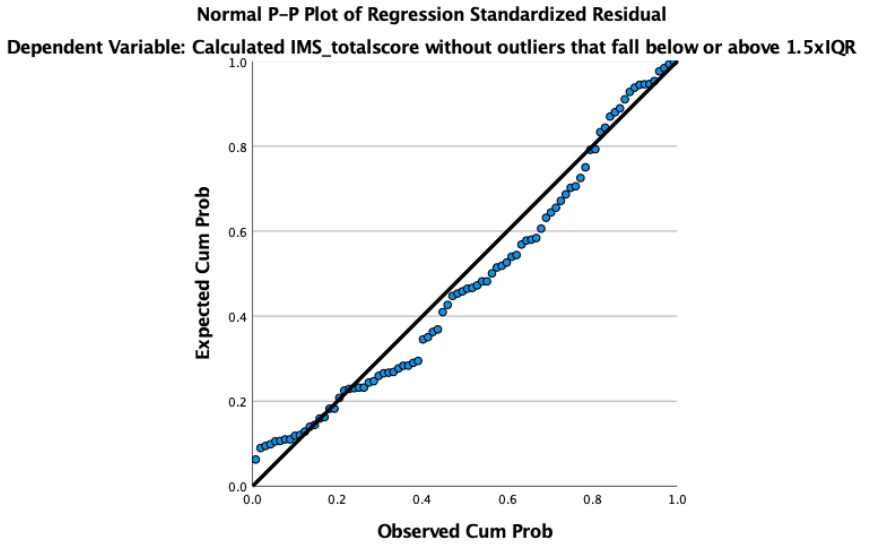
Normal P-P-plot of retrospectively reported intrusions (IMS)



Note. The Normal Probability-Probability (P-P) plot is a graphical tool used to evaluate the assumption that the values of the residuals in a dataset are normally distributed. The plot compares the observed cumulative distribution of the residuals to the expected cumulative distribution of a normal distribution. The closer the plot points are to the diagonal line, the better the fit between the observed and expected distributions, indicating normality of the residuals. Conclusion: The dots appear to deviate from the line, mainly at the centre, which indicates residuals are not normally distributed.

Figure C6.

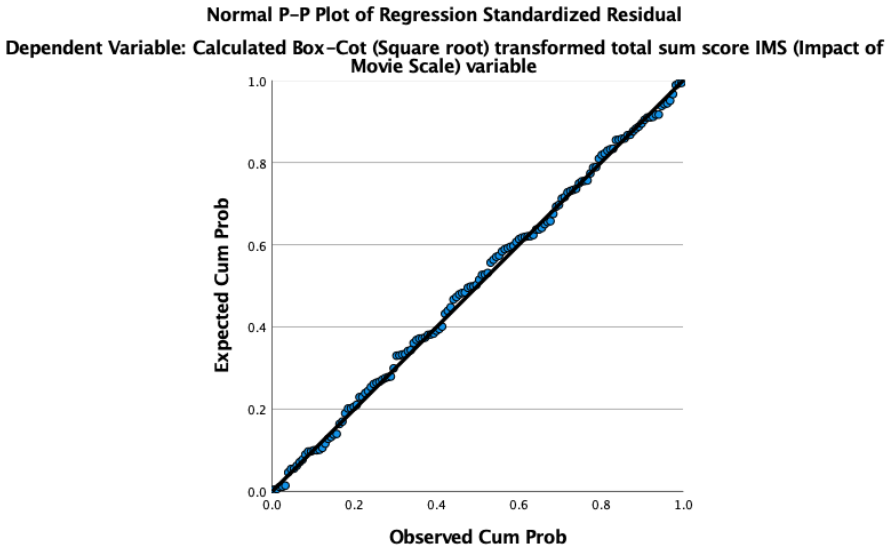
Normal P-P-plot of retrospectively reported intrusions (IMS) without outliers



Note. The Normal Probability-Probability (P-P) plot is a graphical tool used to evaluate the assumption that the values of the residuals in a dataset are normally distributed. The plot compares the observed cumulative distribution of the residuals of the IMS data to the expected cumulative distribution of a normal distribution. The closer the plot points are to the diagonal line, the better the fit between the observed and expected distributions, indicating normality of the residuals. Conclusion: The dots appear to deviate from the line, mainly at the centre, which indicates residuals are not normally distributed.

Figure C7.

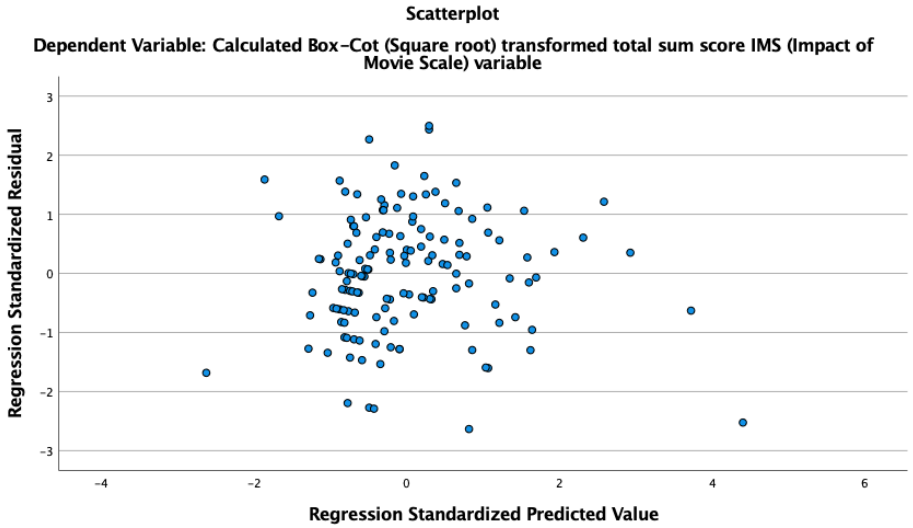
Normal P-P-plot of Box-Cox transformed retrospectively reported intrusions (IMS)



Note. The Normal Probability-Probability (P-P) plot is a graphical tool used to evaluate the assumption that the values of the residuals in a dataset are normally distributed. The plot compares the observed cumulative distribution of the residuals to the expected cumulative distribution of a normal distribution. The closer the plot points are to the diagonal line, the better the fit between the observed and expected distributions, indicating normality of the residuals. Conclusion: The dots appear close to the line.

Figure C8.

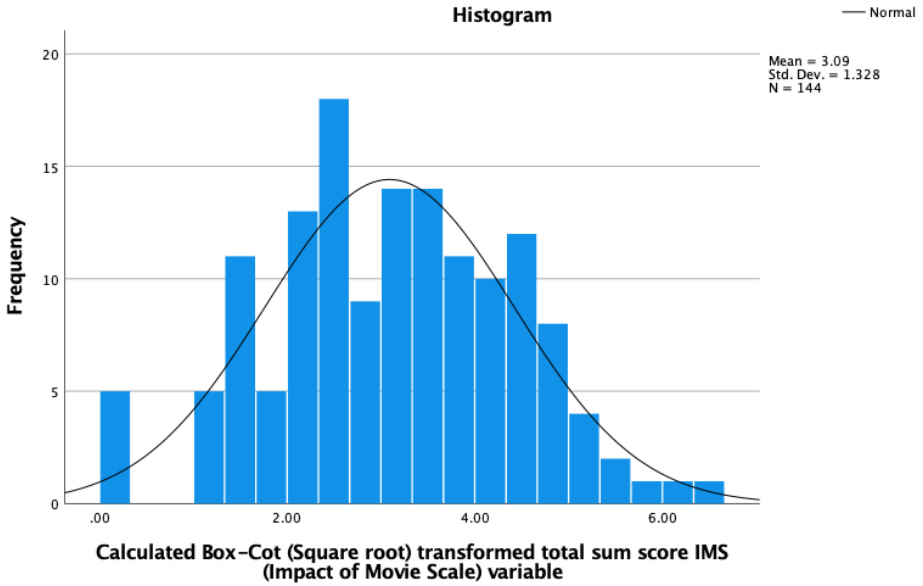
Scatterplot of Box-Cox transformed retrospectively reported intrusions (IMS) to test the assumption of homoscedasticity

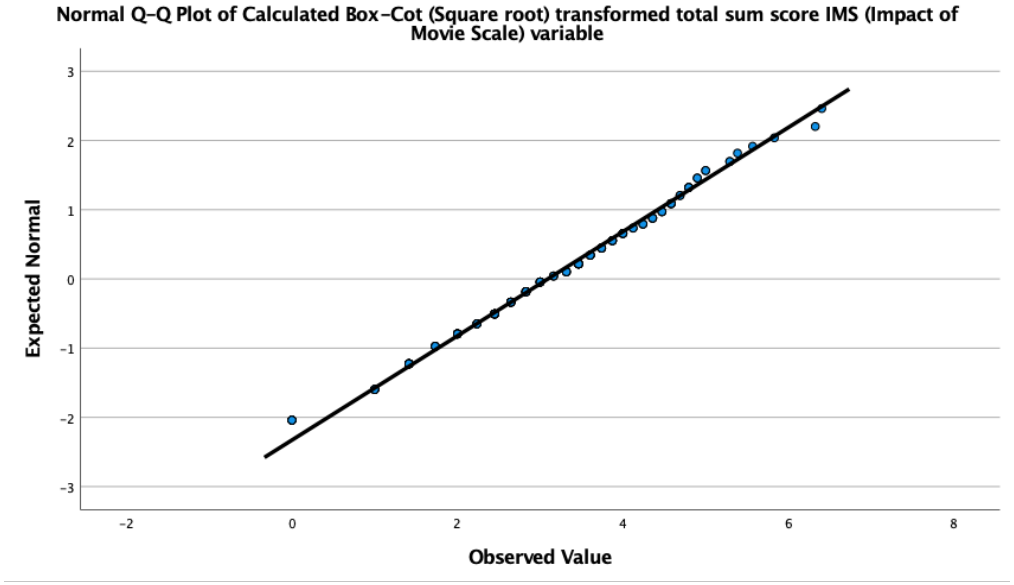


Note. Scatterplot shows the Regression Standardized Residuals and Standardized Predicted value to see of the variation in the residuals (or amount of error in the model) is similar at each point of the model. The variation in the residuals should be roughly similar and the plot (area of dots) should appear more random than funnelled. Conclusion: The plot (area of dots) appears more random than funnelled.

Figure C9.

Evaluating normality of the Box-Cox transformed retrospectively reported intrusions (IMS) variable





Note. Tests of normality: Kolmogorov-Smirnov test: p = <0.200 and Shapiro-Wilk test: p = <0.356. Abbreviations: p = probability (p)-value; Q-Q (Quantile-Quantile)-plot.

Appendix D

Results negative binomial regression analyses image-based intrusions reported in the intrusive memory diary excluding outliers

Table D1.

Results image-based intrusions in the involuntary memory diary, emotional reaction, resilience, and the moderating effect of resilience without outliers

Model	Variable	*b*	SE	Wald χ^2	Exp(β) (Wald 95% CI)	*p*
4.	Intercept	1.165	.1089	114.474	3.206 (2.590– 3.968)	<.000
	Emotional reaction [a]	0.010	.0101	0.928	1.010 (0.990 – 1.030)	.335
5.	Intercept	1.128	.0814	192.276	3.090 (2.635 – 3.624)	<.000
	Resilience [b]	- 0.06	.0067	0.782	0.994 (0.981 – 1.007)	.377
6.	Intercept	1.168	.1100	122.777	3.216 (2.592 – 3.989)	<.000
	Emotional reaction	0.009	.0103	0.763	1.009 (0.989 – 1.030)	.382
	Resilience	- 0.009	.0084	1.246	0.991 (0.975 – 1.007)	.246
7.	Intercept	1.175	.1107	112.676	3.238 (2.606 – 4.022)	<.000
	Emotional reaction	0.010	.0106	0.960	1.010 (0.990 – 1.032)	.327
	Resilience	- 0.009	.0085	1.015	0.991 (0.975 – 1.008)	.305
	Interaction Emotional reaction x Resilience	0.000	.0009	0.275	1.000 (0.999 – 1.002)	.600

Note. Models were analysed with negative binomial regression, including all variables without outliers.
[a] Emotional reaction: mean difference between post- and pre-film emotional states assessed by Visual Analogue Scales (VAS) asking: 'Right at the moment I am feeling': 'sad', 'hopeless', 'fearful', 'horrified', 'anxious', and 'depressed' (0 = *not at all* to 100 = *extremely*) (adapted from James et al., 2015),
[b] Resilience: sum score of 25-item Connor-Davidson Resilience scale (CD-Risk 25) (Connor & Davidson, 2003).
* Indicates a significant p-value < 0.05 level.

Appendix E

Results linear regression analyses retrospective intrusion ratings (IMS) excluding outliers

Table E1.

Results retrospective intrusion ratings (IMS), emotional reaction and the moderating effect of resilience without outliers

Model	Variable	B	SE	*t*	95% CI	*p*
8.	Intercept	3.121	.139	22.447	2.844 – 3.397	<.000
	Emotional reaction [a]	0.041	.012	3.323	0.016 – 0.065	.001*
9.	Intercept	3.127	.141	22.231	2.8847 – 3.407	<.000
	Emotional reaction	0.040	.012	3.219	0.015 – 0.065	.002*
	Resilience	- 0.005	.012	- 0.380	- 0.028 – 0.019	.705
10.	Intercept	3.138	.143	21.965	2.854 – 3.422	<.000
	Emotional reaction	0.042	.013	3.241	0.016 – 0.067	.002*
	Resilience	- 0.004	.012	- 0.374	- 0.028 – 0.019	.709
	Interaction Emotional reaction x Resilience	0.001	.001	0.517	- 0.002 – 0.003	.606

Note. Models were analysed with hierarchical multiple linear regression; emotional reaction, resilience and the interaction term were added to the model as centered variables without outliers.

[a] Emotional reaction: mean difference between post- and pre-film emotional states assessed by Visual Analogue Scales (VAS) asking: 'Right at the moment I am feeling': 'sad', 'hopeless', 'fearful', 'horrified', 'anxious', and 'depressed' (0 = *not at all* to 100 = *extremely*) (adapted from James et al., 2015),

[b] Resilience: sum score of 25-item Connor-Davidson Resilience scale (CD-Risk 25) (Connor & Davidson, 2003).

* Indicates a significant p-value < 0.05 level.