Practice is the best master

Shifting the interpretation bias and attention bias with an online training in borderline personality disorder.

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Master's thesis

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I wish you much joy in reading this thesis.

Carlijn van de Pas

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Abstract

Borderline Personality Disorder (BPD) is found to have two biases underlying emotional dysregulation. BPD patients are found to interpret ambiguous faces as expressing anger and to have the disability disengaging attention away from negative faces. The present study investigated whether both biases could be shifted through an online training. As the tool, developed with the aim to use it among BPD patients, is in its early stages of development the present research focused on healthy participants. With an Interpretation Bias Training (IBT) participants were trained to interpret ambiguous faces as happy by giving them tailored feedback. The Attention Bias Training (ABT) trained participants to focus attention on happy faces over angry faces. Analyses have shown that the online training tool is effective in shifting both biases into a more positive interpretation of faces and a faster attention towards happy faces over angry faces. As both biases were measured with independent assessments, results can be generalized to other facial stimuli. For the interpretation bias, this is only true for women. In addition, the tool was effective in reducing the attention towards angry faces for men high in borderline. At last, participants high in anxiety were faster in detecting angry faces in the pre- assessment compared to participants low in anxiety.
As an extension, a usability research was conducted, which uncovered aspects on which the tool can be improved in order to meet all usability needs.

Keywords: Borderline Personality Disorder, Interpretation Bias, Attention Bias, Online training tool, Usability.

Contents

Introduction

Borderline Personality Disorder (BPD) is one of the most prevalent personality disorders, affecting 15% to 20% of patients in a hospital or clinic (Skodol, et al. 2002). Of all BPD patients, 75% is found to be female (Skodol & Bender, 2003). BPD is associated with severe functional impairment and high rates of mortality by suicides (Grant, et al. 2008). In fact, 84% of BPD patients show suicidal behavior of which 4.5 % succeeds (Storebø, et al. 2018). Besides suicidality, BPD is characterized by unstable and intense emotions and an unstable sense of the self (Austin, Riniolo & Porges, 2007; Barnow, Stopsack, Grabe, et al. 2009; Gunderson, Herpertz, Skodol, Torgersen & Zanarini, 2018; Zanarini, 2005).

One of the central features of BPD is emotional dysregulation, which is theorized to be related to greater emotional vulnerability. Consequences of problems with this vulnerability can be clinical features such as impulsivity and interpersonal difficulties (Baer, Peters, Eisenlohr-Moul, Geiger & Sauer, 2012; Lynch, et al. 2006). Moreover, emotional dysregulation is suggested to be strongly associated with different maladaptive cognitive processes, including biases in interpretation and attention (Baer, et al. 2012).

Indeed, patients with BPD are found to evaluate others as more malicious and unfriendly than individuals with no mental disorders do (Barnow, et al. 2009). More specifically, it is found that due to negative formed beliefs, BPD patients have an interpretation bias leading them to interpret ambiguous faces as more threatening, and as expressing anger (Baer, et al. 2012; Thome, et al. 2016). Domes, et al. (2008), whom investigated this biased interpretation, support these findings. By conducting a mixed emotions forced-choice task using morphed faces, they found that BPD patients were biased towards the interpretation of angry facial expressions in highly ambiguous faces. Research by Penton-Voak, et al. (2013) showed that this interpretation bias can be shifted towards a more positive interpretation of ambiguous facial expressions through training, improving one's behavior and mood. Being able to correctly interpret one's internal state is seen as an important basis for social functioning and pro-social behavior. Moreover, recognizing other's mental state from facial expression cues is considered to be a cognitive cornerstone of social and emotional functioning. Therefore, shifting the interpretation bias could be helpful in improving the emotional dysregulation among BPD patients (Domes, Schulze & Herpertz, 2009; Dyck, et al. 2008). Hence, the present research focuses on shifting the interpretation bias towards a more positive interpretation of facial expressions through training.

In addition, patients with BPD lack the ability to disengage their attention away from negative stimuli, leading to stress or negative thoughts and are therefore found to have difficulties regulating their emotions (Domes, et al. 2006; Jovev, et al. 2012; von Ceumern-

Lindenstjerna, et al. 2010). Moreover, borderline patients are found to perceive anger as an indication of social threat, therefore having a heightened sensitivity towards cues of this threat. Information processing is generally done through two different stages of attention. The automatic stage happens unconsciously and is unintentional. The strategic stage depends on conscious control, is effortful and intentional. When processed automatically (unconscious), visual attention is drawn towards threatening information in all humans (Koster, Crombez, Verschuere, van Damme & Wiersema, 2006). During the next stage of processing (strategic) the attention is drawn away from threat. The idea is that patients with BPD are, however, abnormally sensitive to threatening information and have a difficulty disengaging attention away in the preconscious stage of processing information (Linehan, 1993 in Jovev, et al. 2012). This leads to a limited capacity to control this negative attention in further conscious stages of information processing (Jovev, et al. 2012). Hence, patients with BPD have a so-called attention bias towards angry faces and have a hinderance focusing attention on positive emotional information over these negative threatening stimuli (Compton, 2000; Daros, Zakzanis & Ruocco, 2013; Kaiser, et al. 2019; von Ceumern-Lindenstjerna, et al. 2010).

It is suggested that an essential factor of psychological well-being is being able to control your attention (Bardeen, Daniel, Hinnant & Orcutt, 2017). Moreover, von Ceumern-Lindenstjerna, et al. (2010) state that having this ability to direct one's attention would result in a better emotion regulation than those who lack the concerning ability. It is for this reason that the present study focuses on improving the ability to shift one's attention to a more positive level with training.

As both biases are possible causes for social problems in BPD and are strongly associated with emotional dysregulation, improving one's bias could lead to changes in behavior and to better social interactions (Baer, et al. 2012; Penton-Voak, et al. 2013). Therefore, the present research will investigate whether an online training could be effective in gaining a more positive interpretation of faces and being able to disengage attention away from negative cues in a healthy sample. It will be tested if the tool does what it needs to do and whether results are generalizable to other stimuli with the aim to shift the interpretation and attention bias in patients with BPD.

Training

The present study will investigate whether both the interpretation bias as well as the attention bias can be shifted through an online computer-based training program among healthy adult participants. Previous research has proven to shift the interpretation bias through online

training in a clinical context (Herman, 2018). With concern to the attention bias, effect of training shifting one's attention from negative to positive stimuli has been found in different studies. Waters, et al. (2013) for example, successfully trained anxious children to shift their attention bias towards happy faces with an online visual search task.

In addition, Schulpen (2019) has performed a pilot usability research of the present study. Here, positive effects of the online training shifting one's interpretation and attention bias were found. The present research will elaborate on previous findings by testing the online tool again with additions. At first, independent measurements will be added to be able to generalize results to other facial stimuli. Moreover, multiple usability obstacles, based on findings by Schulpen (2019) will be eliminated from the tool. At last, by using a questionnaire testing for BPD, it will be investigated whether results can be related to BPD and specific BPD traits. It is expected to replicate findings by Schulpen (2019), using an online training with healthy participants.[1] This means that it is hypothesized to shift one's interpretation bias into a more positive interpretation of facial stimuli with the online training. Moreover, it is hypothesized to effectively shift one's attention bias towards happy faces and away from angry faces. By doing so, the present study has the aim to prove effects of the online training tool in a non-clinical setting with the aim to create an effective training for patients with BPD. As an addition, the present research also focuses on possible effects of borderline and gender on the interpretation and attention bias.

Borderline

As mentioned earlier, patients with BPD have an interpretation bias and attention bias which are strongly related to emotional dysregulation (Baer, et al. 2012). The present research investigates the effectivity of an online training tool shifting these biases with the aim to make it available for patients with BPD. It will therefore take the first steps in investigating the effect of borderline on the biases within healthy participants. As patients with BPD are found to interpret ambiguous faces as negative (Domes, et al. 2008) it is expected to find higher rates of the interpretation bias among participants who score high on borderline. Moreover, as patients with BPD are found to have the disability disengaging attention away from negative

[1] Initially, the present study would investigate training effects for the interpretation and attention bias on patients with BPD. Unfortunately, due to the COVID-19 virus (WHO, 2020) it has become impractical to test in a lab. Recruiting clinical participants from home would be difficult and due to the fact that the training tool would need adjustments before testing, it is chosen to conduct present research on non-clinical adult participants.

faces, it is expected to find higher rates of the attention bias among participants who score high on borderline as well.

In addition, research has found BPD and anxiety to be highly correlated and even comorbid at some points. Moreover, the percentage of borderline patients meeting criteria for an anxiety disorder is 75% (Good, 2019; Zanarini, et al., 1998). More importantly, research has found both the interpretation bias as well as the attention bias to be present in anxious individuals in the same way as in individuals with BPD (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg & van Ijzendoorn, 2007; Mathews & Mackintosh, 2000). Therefore, the present research will investigate anxiety as a trait of borderline as well. As anxiety is comorbid with BPD in a lot of cases and report the existence of the interpretation and attention bias, it is expected to find the same effect of anxiety on both biases as of borderline. Therefore, it is hypothesized that participants high in anxiety will have higher rates of the interpretation bias as well as the attention bias.

Gender

The present research will, as a last addition, investigate whether gender has an effect on the interpretation bias and attention bias in differing between men and women.

Bradley, Conklin & Westen (2005) found that in BPD, female patients are more emotionally dramatic and have more internalizing expressions than men. These male patients on the other hand show more angry and disinhibited behavior and externalizing expressions. This is an important finding as people with an internalizing versus an externalizing style require different treatments, which indicates that the training might have different effects on female and on male participants (Bradley, et al. 2005). Furthermore, it is found that some symptoms of BPD differ between men and women. Men are found to have higher rates of an antisocial personality disorder, and women have more symptoms overall among which anxiousness (Silberschmidt, Lee, Zanarini & Schulz, 2015). When looking at the differences between men and women among the general population, research has found some dissimilarities when it comes to the facial expression recognition. When shown low intensity faces, meaning more neutral faces, women are more accurate in recognizing the emotion than men. With respect to emotions individually, a significant difference in the recognition of happiness was also found between genders, indicating a greater advantage for women (Hoffmann, Kessler, Eppel, Rukaniva & Traue, 2010). This finding is especially interesting for the present study, indicating women would be better in the recognition of happy facial expressions. This raises the question whether the interpretation bias would be less present for

women than for men. Therefore, the present study will investigate whether a gender difference exists on the topic of the both biases. It is expected to find higher rates of the interpretation bias among men, but no differences are expected for the attention bias (Hindash, et al. 2019).

Moreover, 75% of all BPD patients are found to be female (Skodol & Bender, 2003). As women have a considerable share in the prevalence of BPD, it is interesting to investigate whether the effects of borderline on the interpretation and attention bias will be more present for female participants. Hence, the present research will investigate a possible interaction between borderline and gender on both the interpretation bias as the attention bias. It is expected to find greater effects of borderline on both biases for female than for male participants.

In sum, the present research will test the online training tool on its effectivity shifting the interpretation and attention bias in a non-clinical sample with the aim to use it for patients with BPD. By doing so, the following hypotheses will be investigated:

H1. *The online training will be effective in shifting one's interpretation bias into a more positive interpretation of facial stimuli.*

H2. *The online training will be effective in shifting one's attention bias into an attention towards happy faces and away from angry faces.*

H3. *Results from the online training can be generalized to other facial stimuli than used in the online training itself.*

H4. *Participants scoring high on borderline will have a more negative interpretation bias and a higher attention bias towards angry faces and away from happy faces.*

H5. *Participants scoring high on anxiety will have a more negative interpretation bias and a higher attention bias towards angry faces and away from happy faces*

H6. *Male participants will have a more negative interpretation of faces than female participants.*

H7. *The effect of borderline on the interpretation bias and attention bias will be more present among female participants.*

The training tool investigated in the present research is still in its early stages of development. Therefore, the present study will perform a usability research in addition. All information regarding this usability study can be found in appendix 3.

Methods

The aim of the present research was to investigate whether the interpretation bias and attention bias could be shifted through an online training. More importantly, it was tested whether results of the training could be generalized to other facial stimuli. To investigate this, the present research consisted of an online experiment in which both biases were trained and assessed with regular and independent assessments in the online training tool.

Participants

In the present study 30 healthy subjects participated in the experiment. All were recruited through a private network via WhatsApp. All participants with a mean age of 23.3 (*SD* = 2.01) gave informed consent. 28 of them completed all elements as two participants did not complete all tasks. To test for any effects of gender an equal number of male and female participants was used for the experiment of which 15 males with a mean age of 23.2 (*SD* = 2.15) and 15 females with a mean age of 23.5 (*SD* = 2.10) were included in all analyses.[2]

Stimuli and tasks

The experiment consisted of two different parts training and assessing the interpretation and attention bias. All tasks were performed in an online training tool developed by "De Ontwikkelfabriek", commissioned by GGZCentraal. This web-based tool is made with the goal to shift both the interpretation bias as well as the attention bias among patients with BPD. Participants were able to perform all tasks on their own laptop or computer from home in a browser, with a link to the online tool.

Interpretation bias

The interpretation bias was trained and assessed with the Interpretation Bias Training, further named the IBT (Penton-Voak, et al. 2013). Within one IBT session three different parts had to be completed: a pre- assessment, a training and a post- assessment.

The training part of the IBT encourages one to interpret happiness over anger in ambiguous faces and can be seen as the manipulation within the present study. Within the

[2] Initially, present study was meant to be conducted on patients with BPD but due to the COVID-19 virus (WHO, 2020) it was not possible to work in a lab and to test patients in person. Moreover, as new adjustments were made in the tool it was necessary to test for its usability again. It was therefore decided to conduct the experiment on healthy participants before investigating the effectivity and usability of the tool on BPD patients.

assessment parts, the pre- assessment functioned as a baseline measurement and the post-assessment as a manipulation check to control whether the effect of the training was present.

Most importantly, an independent pre- and post- assessment was added to the tool during the present research, which had to be completed respectively before the first and after the last IBT session. These assessments included different stimuli than the IBT itself, with that enabling the present research to investigate whether the effect of the IBT could be generalized to other facial stimuli.

Interpretation Bias Training

For the pre- and post- assessment of the IBT, a linear morph sequence of fifteen faces going from happy to anger with ambiguous expressions in the middle was used to assess the interpretation bias. The first and last faces were showing respectively a happy and an angry expression and the thirteen faces in between were all ambiguous morphed faces. In each trial within the assessment, participants first saw a fixation cross for 150-250 milliseconds (ms) (randomly allocated). Subsequently, an image of a face was shown (150 ms) followed by a visual noise mask (150 ms) after which a question mark appeared on the screen. When the question mark was visible, the participant had to indicate whether the face looked happy or angry by pushing a keyboard key (respectively c or m button). By doing so, a so-called threshold could be measured. This threshold is the point at which a participant either interpret an ambiguous face as happy or as angry and was measured by dividing the number of 'happy' responses by 2. More information regarding the calculation of the threshold can be found in the analyses paragraph. This threshold, however, falls between two faces on the morph sequence where all faces below the threshold are interpreted as 'happy' and all faces above the threshold are interpreted as 'angry'. A higher threshold indicates that the participant is more likely to interpret an ambiguous face as happy as illustrated in figure 1. As the interpretation bias means that one interprets ambiguous faces as angry instead of happy, a higher threshold would indicate having a low interpretation bias.

In the pre- and post- assessment parts of the IBT, each face was shown twice which resulted in 30 trials per assessment (2 x 15). The training part of the IBT consisted of 240 trials, in which all faces were shown equally. When clicking a keyboard button when the question mark was shown, participants were automatically led to the next trial.

The trials in the IBT training part had the same design as the aforementioned assessment trials but were supplemented with tailored feedback. This means that participants received feedback after each trial on whether they classified the emotion of the target

"correct" or "incorrect". The threshold of the feedback was determined by going up two points to the right from the pre-assessment threshold in the direction of 'angriness' per participant. All faces above this point were feedbacked as expressing angriness and all faces below as expressing happiness. This has given participants relatively more feedback in the direction of expressing happiness than they interpreted in the pre-assessment (see figure 1). By doing so, it was expected to shift the participants' threshold more to the right in the post-assessment, making them interpret an ambiguous face as expressing happiness more easily. Hence, this would shift the interpretation bias towards a more positive interpretation of ambiguous faces.

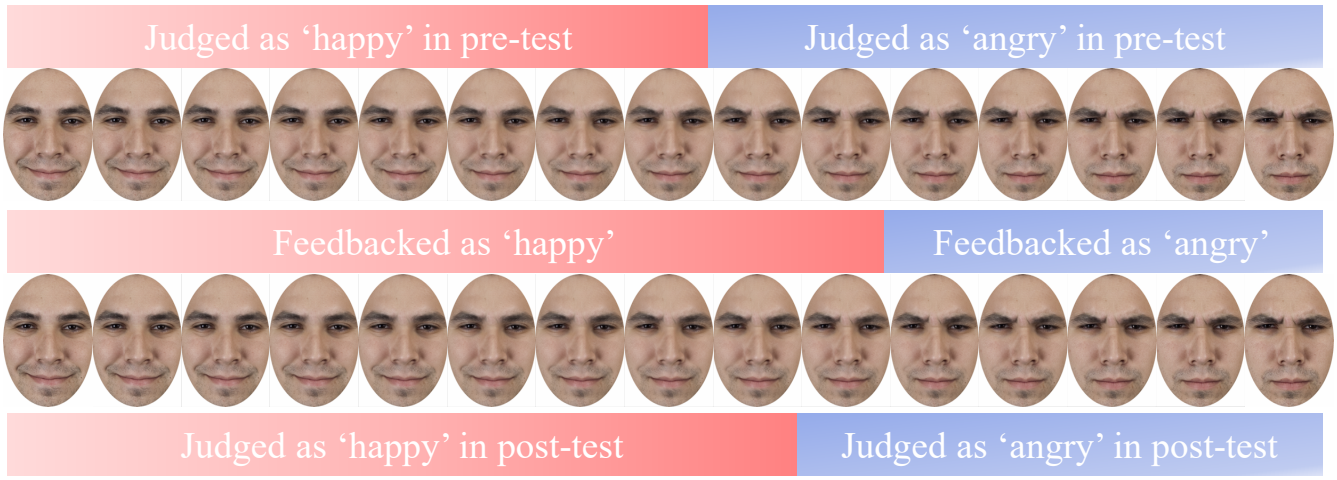

Figure 1. Illustration of the morph sequence of the Interpretation Bias Training on a continuum from happy to angry with in the middle 13 ambiguous morphed faces. Based on Penton-Voak, et al. (2013) with faces from the Chicago Faces Database (CFD version 2.0.3.) by Ma, Correll & Wittenbrink, 2015.

Independent Interpretation Bias Assessment

The independent pre- and post- assessment of the interpretation bias threshold consisted of the same tasks as the regular IBT. However, as an important aspect of the independent assessments, the stimuli differed from those used in the regular IBT. Most importantly, different faces than in the IBT were used to ward off possible recognition effects (Field, 2013). By doing so, the present research could investigate whether the online training tool would be effective in shifting one's interpretation bias in other facial stimuli than used in the IBT. Moreover, instead of using only one actor, four actors were used (2 male / 2 female) of which two black and two white actors (distributed equally over the male and female actors). This means that one black male, black female, white male and white female actor was used in the independent pre- and post- assessment. This was done to ward off any cross-race effects (Wong, Stephen & Keeble, 2020). Here, faces from the Chicago Faces Database (CFD

version 2.0.3.) were used (Ma, Correll, & Wittenbrink, 2015). Actors were chosen based on their ratings on their angry and happy expression, which are visible in table 2 in appendix 1. During each independent pre- and post- assessment every face was shown twice, resulting in 120 trials ((2 * 4) * 15) per assessment.

Attention bias

The attention bias was trained with the Attention Bias Training (ABT). This training, which served as the manipulation within the experiment, trained participants to focus more on happy faces over angry faces. The attention bias was assessed with the Attention Bias Assessment (ABA) which consisted of an independent pre- and post- assessment with different stimuli than used in the training. The pre- attention bias assessment was completed before the first ABT session and the post- attention bias assessment was completed after the last ABT session. Other than for the interpretation bias, the ABT only consisted of a training without a baseline and manipulation check assessment.

Both the ABT and ABA used faces from the Chicago Faces Database (CFD version 2.0.3.) (Ma, et al. 2015). Other faces were used than for the interpretation bias. Of all faces, 32 actors (16/16 M/F) with the highest scores on their angriness and happiness expressions were selected from the database (see table 3 & 4 in appendix 1). The faces were divided in two groups: X and Y, both consisting 16 faces with an equal number of males, females, black and white actors in both groups. The equal distribution of races was done to eliminate any possible cross-race effects (Wong, et al. 2020). The attention bias experiment consisted of two different conditions in which participants were randomly but equally divided. In condition 1, participants saw faces from group Y in the ABT and faces from group X in the ABA and in condition 2 vice versa. This randomly counterbalancing (Field, 2013) was done to preclude recognition effects, enabling the present research to generalize findings to other facial stimuli. Participants were assigned to the pre- and post- assessment on the (respectively) first and last day of the experiment. The five days in between, they were assigned to the ABT.

Attention Bias Training (ABT)

In this ABT, which consisted of multiple trials, participants were trained to focus more on happy faces over angry faces by using a 3x3 grid with faces from the CFD. In each trial, eight of the nine faces showed an angry expression and the ninth face showed a happy expression (randomly divided) as is visible in figure 2. Participants were asked to click on the ‘happy’

face as quickly as possible with their mouse. Every ‘happy’ face was shown 10 times, which resulted in 160 trials (10 x 16) per training session. Between trials, a visual noise mask was shown for 150 milliseconds. Participants received no feedback whether they were correct or not. For every trial the reaction time of clicking on the target face (the happy face) was measured in milliseconds. When clicking on the wrong face, not the target face, nothing happened. When clicking on the target face participants were led to the next trial automatically. This means that participants could only continue by clicking on the target face.

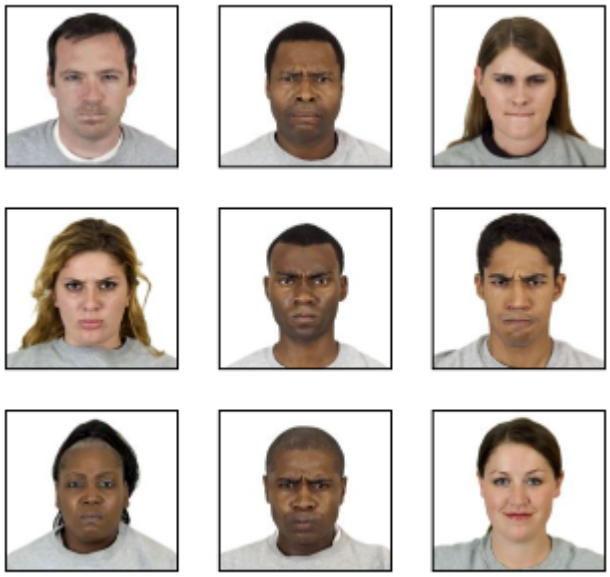

Figure 2. Example of an ABT trial. Note that eight faces look angry, while one face is looking happy.

Attention Bias Assessment (ABA)

The ABA consisted of both a pre-assessment and a post-assessment. Here, participants got to see a 3x3 grid with faces from the CFD as well as in the ABT. In each trial, eight of the nine faces showed a neutral expression and one of the faces either had an angry or a happy expression (randomly divided) as is visible in figure 3. Participants were asked to click on the face that showed an emotion (either an angry or a happy expression) as quickly as possible with their mouse. Of each actor, the angry and happy face was shown 5 times, resulting in 80 ‘angry’ and 80 ‘happy’ trials (5 x 16). This resulted in a total of 160 trials per assessment with a visual noise mask (150 ms) shown between trials. As well as in the ABT, the reaction time of clicking on the target face (either the angry or the happy face) was measured. Moreover, participants were only led to the next trial after they clicked on the target face. When clicking on a wrong face (that is not the target face) nothing happened.

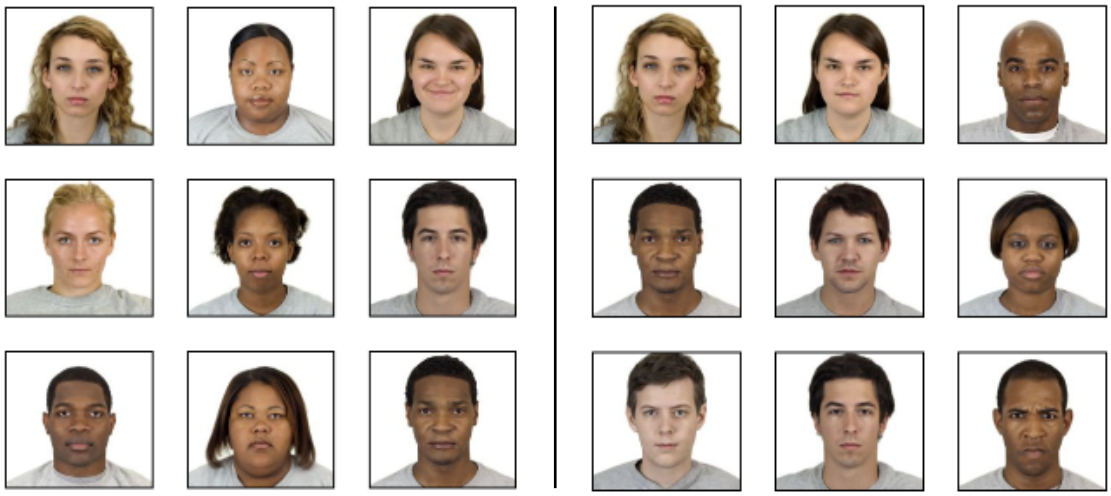

Figure 3. Example of an ABA trial. Note that on the left grid eight faces have a neutral expression, while one face is expressing happiness. On the right grid eight faces have a neutral expression, while one face is expressing angriness.

Borderline

The interpretation bias and the attention bias were both found to be present in patients with BPD (Baer, et al. 2012). It was therefore tested whether borderline had an effect on the interpretation bias as well as the attention bias in a non-clinical sample. Moreover, it was tested whether the effect of borderline on both biases would be more present for female participants. To test for these possible effects, participants were asked to complete the Borderline Personality Questionnaire (BPQ) by Poreh, et al. (2006) on the first day of the experiment. The BPQ is an 80-item (True (2) /False (1)) questionnaire divided in nine subscales: Impulsivity, Affective Instability, Abandonment, Relationships, Self-Image, Suicide/Self-Mutilation, Emptiness, Intense Anger & Quasi-Psychotic State (see table 5 in appendix 1). As people with anxiety were also found to have an interpretation bias and attention bias, this borderline trait was investigated in the present research as well by using the subscale Affective Instability of the BPQ as a measurement for anxiety (Bar-Haim, et al. 2007; Mathews & Mackintosh, 2000).

Procedure

The present study consisted of a 7-days experiment in which participants were asked to complete tasks in the online training tool. Previous research (Schulpen, 2019) tested the tool with respect to its usability in a non-clinical context. Based on recommendations from this study, some adjustments were made to the tool first. At first, the faces in ABA/ABT were replaced with new faces from the CFD, creating a diverse offer of different genders and races.

In addition, happy faces with the mouth closed were used as previous research noted that participants started looking for teeth when searching for happy versus angry faces. Moreover, the information before starting a task was updated, and practice trials were added before starting each task. By making these changes it was expected to improve the usability and with that the effectivity of the tool. At last, an independent pre- and post- assessment of the interpretation bias was added as an addition to the IBT. These assessments contained different faces than the general IBT to serve as an independent measurement with respect to the generalization of the tool (Field, 2013).

Before starting the experiment, each participant first received a personal introduction letter giving them information about the study and what they were expected to do, along with a schedule of when to complete all the tasks and questionnaires, see figure 4. The introduction letter moreover consisted of a link to the online training tool[3] along with a personal login code for the IBT and a different personal login code for the ABA/ABT. Each participant was able to enter the tool with the link in a Google Chrome browser[4] from their own laptop or computer. All questionnaires were conducted with Qualtrics, which was available via a link in the letter as well. At last, the introduction letter included an informed consent, stating that participation was voluntary and withdraw from the experiment was possible at any moment without a given reason. Moreover, it stated the participants' willingness to participate and guaranteed the anonymity of the data. The anonymity of the data was guaranteed by deleting the overview of which personal login code belonged to each participant after the experiment. This means that when analyzing the data, only the personal login codes were visible, which made it not possible to trace this back to an individual. The informed consent had to be signed in Qualtrics before entering the first questionnaire.

The entire experiment could be done from home and participants were able to contact the researcher in case of problems or questions.

[3] http://ggz.deontwikkelfabriek.nl
[4] A Google Chrome browser was necessary as the tool showed some deficits when used in other browsers.

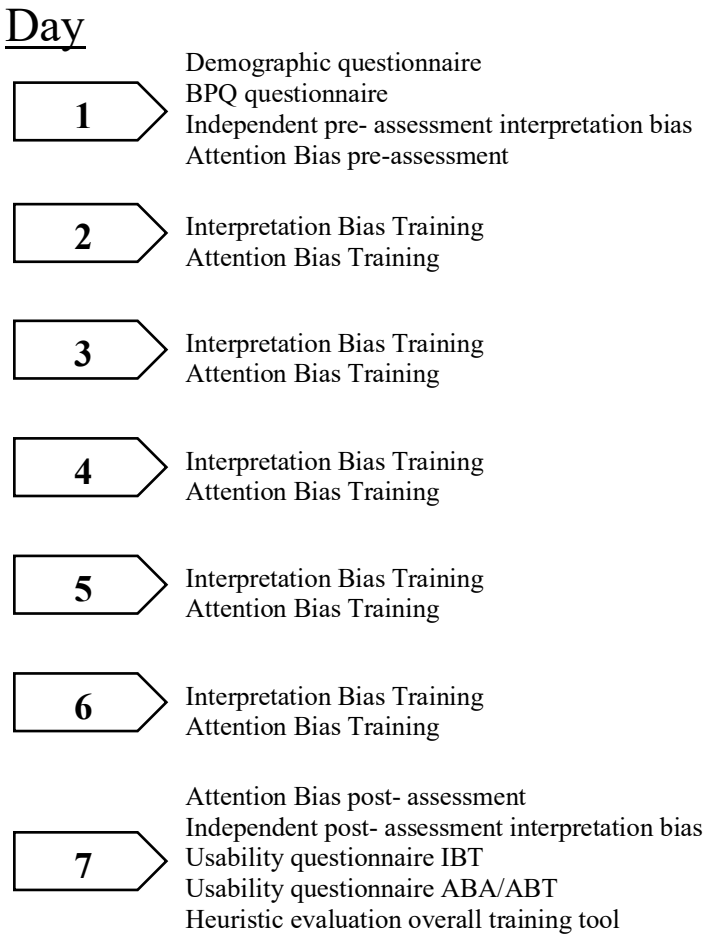

Figure 4. Visualization of the planning of the 7-days experiment.

At the start of the experiment, participants received one link to Qualtrics including a demographic questionnaire and the BPQ. On the last day of the experiment, after finishing all the tasks, participants received two questionnaires to test for any usability problems in de tool. All questionnaires were in English, but the information given at the start of the experiment, and all tasks were in Dutch. Reason for this was that all questionnaires were originally English and translating them would require a time-consuming validation process (Tsang, Royse & Terkawi, 2017). Moreover, the tool was already made in Dutch and not using the participants' native language could result in confusions about the tasks.

At the start of the demographic questionnaire and the BPQ, participants had to sign the informed consent first. Moreover, participants were asked to enter their personal login code for the IBT as well as for the ABA/ABT. This was necessary to be able to link the answers from the questionnaires to data from the online training tool.

Each day the participants received a reminder for completing the tasks they were assigned to that day. After completing the tasks in the tool on the first day (independent pre-

assessment of the interpretation bias and the attention bias pre- assessment) participants could use their same personal login code on the next days for the IBT and the ABT. The tool automatically recognized whether the first task was done and then continued to the following tasks. The IBT and the ABT could be completed an infinite number of times. Therefore, participants received a different personal login code for the independent post- assessment of the interpretation bias and for the attention bias post- assessment on the last day of the experiment. Moreover, they received a link to the usability questionnaire on the 7th day.

Analyses

With the data from the experiment, multiple analyses were conducted to test whether the online training would have effect on the interpretation bias and the attention bias.

Interpretation bias

For the interpretation bias it was expected that a higher threshold would be found in the post-assessment compared to the pre- assessment as an indication that the interpretation bias had shifted towards a more positive interpretation of stimuli.

At first, the threshold for the pre- and post- assessment in the IBT was calculated by the online tool itself, dividing the number of 'happy' responses (amount of times a participant pressed 'c') by 2. This was done per participant per test phase (pre- assessment and post-assessment). For example, as the pre-assessment consisted of 30 trials the highest possible threshold would be 15 (30/2). If a participant would click on 'c' for 20 times for example, his threshold would be 10 (20/2), meaning that the threshold would lie between the 10th and 11th face on the morph sequence. This means that this participant would interpret the 10th face from the left as happy, but the 11th face as angry (see figure 1 for visualizations). Having an increase in the threshold through the training would therefore mean that the balance point for interpreting an ambiguous face had shifted to a more positive interpretation. It was expected that this threshold value would be higher in the post- assessment compared to the pre-assessment as an effect of the training.

To test for this expectation, multiple analyses were performed in IBM SPSS Statistics 26. At first, a repeated measures ANOVA was conducted for the interpretation bias threshold in the pre- and post- assessment per IBT session (5 in total). In addition, gender was added to the analysis as a between-subjects factor, testing for any possible effects of gender. After that, borderline was added as a covariate to the same analysis testing for possible interaction and main effects of borderline, gender and the pre- and post- assessment per training session. At

last, anxiety replaced borderline as a covariate in the repeated measures ANOVA model to test for any possible interaction and main effects between anxiety, gender and the pre- and post- assessment per training as well.

For the independent measurements of the interpretation bias, it was necessary to calculate the threshold per actor per test phase first. This was done in Microsoft Excel by dividing the number of happy responses per actor per test phase by 2 for each participant (the same as for the IBT). Of each actor, all faces were shown twice, therefore having 30 trials per actor per assessment. This means that per actor a maximum threshold of 15 was achievable.

It was expected to find a significant higher threshold in the independent post-assessment compared to the independent pre- assessment. When finding such results, it would be assumed that effects of the IBT are generalizable to more stimuli than only the faces used in the general IBT. This was tested by performing multiple analyses in SPSS.

At first, a repeated measures ANOVA was conducted with the independent pre- and post- threshold measurement per actor. After doing so, gender was added as a between-subjects factor to the model to test whether the interpretation bias threshold would differ between male and female participants. To test for any effects of borderline, this variable was added as a covariate to the analysis. Here, an interaction effect and main effects of borderline, gender and the pre- and post- assessment per actor was investigated. Finally, borderline was removed, and anxiety was added as a covariate to the model. Besides investigating a main effect of anxiety on the threshold, it was also tested whether an interaction effect between anxiety, gender and the pre- and post- measurements per actor was present for the interpretation bias.

Attention bias

For the attention bias the reaction time in clicking on the target was measured in milliseconds (ms) per trial. This reaction time was used as the dependent variable, with the expectations it would be lower for happy trials and higher for angry trials in the post- assessment compared to the pre- assessment.

All analyses for the attention bias were performed in Jamovi 1.2.22 with multilevel modeling. By performing multilevel modeling, all trials were used as cases with that making the model more sensitive and creating a greater power. To start with, all trials with a reaction time less than 200 ms or more than two standard deviations from the personal average reaction time were excluded from the dataset. Moreover, all trials where the participant clicked on the wrong face (not the target face) were excluded as well.

A mixed model analysis was conducted to test whether the reaction time differed between the pre- and post- assessment (later mentioned as the test phase) and between happy and angry trials (later mentioned as the trial emotion). In addition, multiple variables were added to the mixed model analysis. At first, gender was added as a factor to test whether the attention bias would differ between male and female participants. After that, borderline was added to the analysis. An interaction effect between borderline, gender, the test phase and the emotion trial was investigated as well as a main effect of borderline. Finally, anxiety replaced borderline as a covariate in the mixed model analysis, investigating for a possible interaction effect between anxiety, gender, test phase and the trial emotion on the reaction time. A main effect of anxiety was investigated as well.

Borderline and anxiety

The BPQ was used to generate a total score on BPD for every participant. Before starting the analyses, some scores had to be recoded as they were reverse scored, see table 5 in appendix 1. A high score on the BPQ meant being high in borderline. Moreover, scores on the subscale Affective Instability were used as a measure for anxiety. A high score on this subscale meant having a high score on anxiety as well. Both the borderline scores as the anxiety scores were added as covariates to multiple analyses for the interpretation bias and the attention bias. Both were used as a continuous variable in the analyses, but for possible visualizations they were transformed into categories. For borderline this means that participants were seen as low borderline when they scored minus one standard deviation (7.15) below the mean (M = 14.33). For high borderline this was plus one standard deviation above the mean. The same was done for anxiety with a standard deviation of 2.14 below or above the mean (M = 3.70).

Results

Interpretation bias

The interpretation bias was tested and trained with the IBT. It was expected that with the online training the threshold of participants would increase. This means that the training would shift one's bias into a more positive interpretation of facial stimuli. To test whether the expected training effects could be generalized to other facial stimuli, an independent pre- and post- assessment was performed. It was expected to find a higher threshold in the independent post- assessment compared to the independent pre- assessment.

IBT.

A repeated measures ANOVA with the ten measuring points (five pre- assessments and five post- assessments) showed, as expected, a significant effect of training on the interpretation bias threshold with $F(1,27) = 11.77$, $p < .01$, $\eta_p^2 = .30$. In line with the hypothesis the interpretation bias threshold increased per training session, as visible in figure 5. Between the first and last training session the average pre- and post- assessment threshold increased with 2.11, which means that the threshold has shifted two faces to the right on the morph sequence (see figure 1).

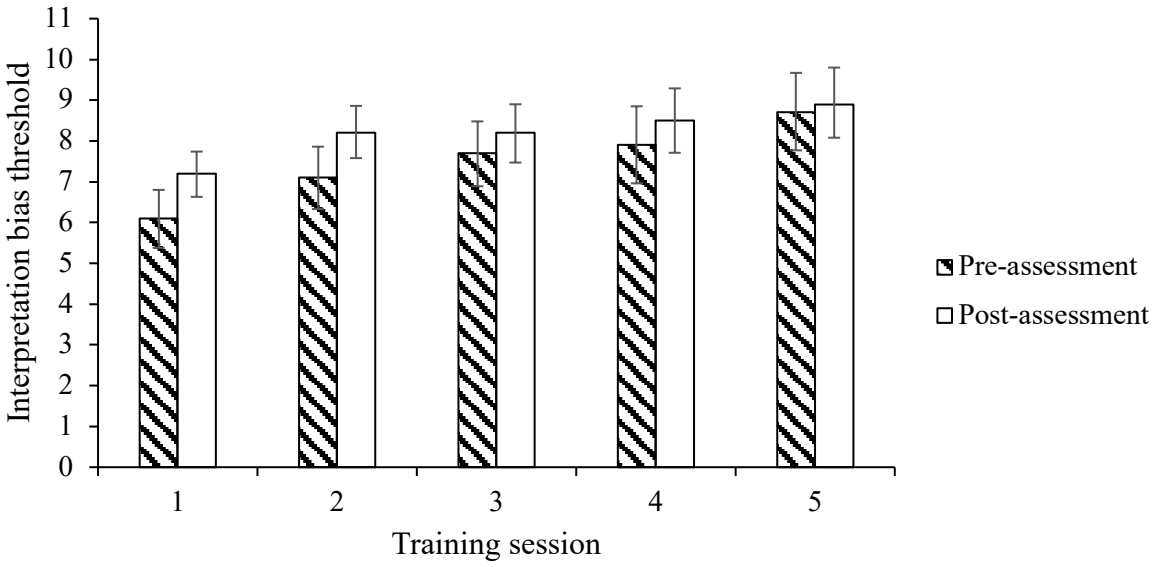

Figure 5. Results of the mean threshold measurement per training session. The error bars indicate the 95% confidence interval.

Only between training two and three and training three and four no significant differences were found, see table 1.

As additional analyses gender, borderline and anxiety were added to the repeated measures ANOVA model. At first, when gender was added to the analysis as a between-subjects factor, no interaction effect was found, F (1,26) = .29, p = .593. Moreover, no main effect of gender on the threshold was found, F (1,26) = .348, p = .560, with that rejecting the hypothesis that male participants would have a lower threshold than female participants.

Table 1.
Differences in the average interpretation bias threshold between the five IBT sessions.

Training	1	2	3	4	5
1	-				
2	.982**	-			
3	1.304**	.321	-		
4	1.536**	.554*	.232	-	
5	2.107**	1.125**	.804**	.571*	-

Note. * $p < .05$, ** $p < .01$.

When borderline was added as a covariate to this analysis, no interaction effect was found between borderline, gender and the pre- and post- interpretation bias threshold per training, F (1,24) = .16, p = .692. This finding is in contrast with the expectation that the effect of borderline on the interpretation bias would be more present for female participants. The interaction effect between the pre- and post- interpretation bias threshold per training and gender was, again, not significant, F (1,24) = .404, p = .531. Moreover, the interaction effect between the pre- and post- threshold and the training did not remain significant, F (1,24) = 3.43, p = .077. The effect of borderline itself was, unexpectedly, not found to be significant as well, F (1,25) = .92, p = .348.

When anxiety was added as a covariate instead of borderline, results showed no interaction effect with anxiety, gender, and the pre- and post- interpretation bias threshold per training, F (1,24) = 1.78, p = .195. Results also showed no significant interaction effect between the pre- and post- interpretation bias threshold per training and gender, F (1,24) = 1.78, p = .195. Moreover, the interaction effect of the training on the pre- and post-interpretation bias threshold did not remain significant again, F (1,24) = 4.20, p = .052. No significant main effect of anxiety was found as well, F (1,24) = 1.29, p = .268, with that rejecting the expectation that anxiety would have a negative effect on the interpretation bias threshold.

In sum, results showed that the interpretation bias threshold has increased through the five training sessions. However, no effects of gender, borderline and anxiety were found.

Independent interpretation bias.

Within the independent interpretation bias assessments, faces of four different actors were used. Therefore, the threshold per actor per independent test phase was measured and used in the following analyses.

At first, a repeated measures ANOVA with the threshold per actor per test phase was conducted. Results showed no significant interaction effect for the actors on the independent pre- and post- interpretation bias threshold, F (1,29) = 1.81, $p = .189$.

In line with the hypothesis, a significant main effect of the independent pre- and post-interpretation bias threshold was found, F (1,29) = 11.83, $p < .01$, $\eta_p^2 = .29$. Moreover, a main effect of actor on the interpretation bias threshold was found as well, F (1,29) = 65.96, $p < .001$, $\eta_p^2 = .70$. Pairwise comparison showed a significant increase of 1.16 in the average threshold from the independent pre- assessment to the independent post- assessment. This confirms the expectation that the average interpretation bias threshold of the four actors would be significantly higher in the independent post- assessment ($M = 8.84$, $SD = 2.18$) compared to the independent pre- assessment ($M = 7.68$, $SD = 1.59$).

At last, pairwise comparison revealed that the interpretation bias threshold for all four actors significantly differed from each other as is visualized in figure 6. For the white female actor ($M = 11.63$, $SD = 3.25$) the highest threshold was measured, where for the black male actor ($M = 5.10$, $SD = 1.99$) the lowest threshold was found.

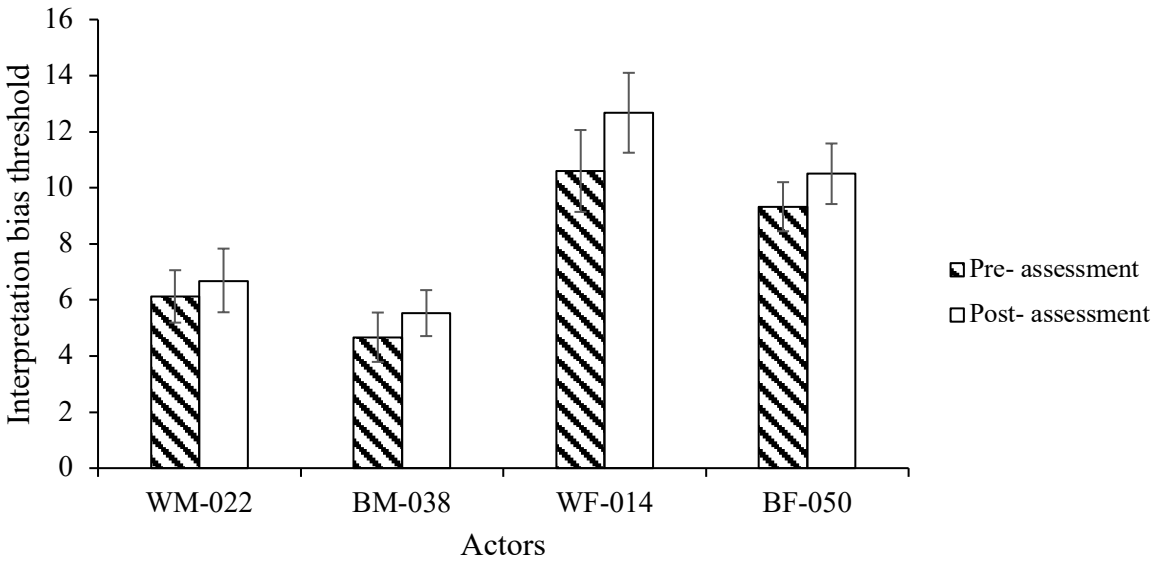

Figure 6. Results of the independent threshold measurement per actor for the pre- and post- assessment. The error bars indicate the 95% confidence interval.
Note. B stands for Black, W stands for White, M stands for Male and F stands for Female.

As an addition to the main analysis, gender was added as a between-subjects factor. Results showed a significant interaction effect between gender and the independent pre- and post- assessment per actor, $F(1,28) = 4.69$, $p < .05$, $\eta_p^2 = .143$. Female participants were found to have a higher threshold in the post- assessment than male participants, as visible in figure 7. This finding is in line with the expectation that male participants would have a more negative interpretation of the faces.

A complementary analysis on the independent pre- and post- assessment per actor was performed per gender, thus for male and female participants separately. This showed that the main effect of the independent pre- and post- assessment on the threshold was only significant for female participants, $F(1,14) = 37.56$, $p < .001$.

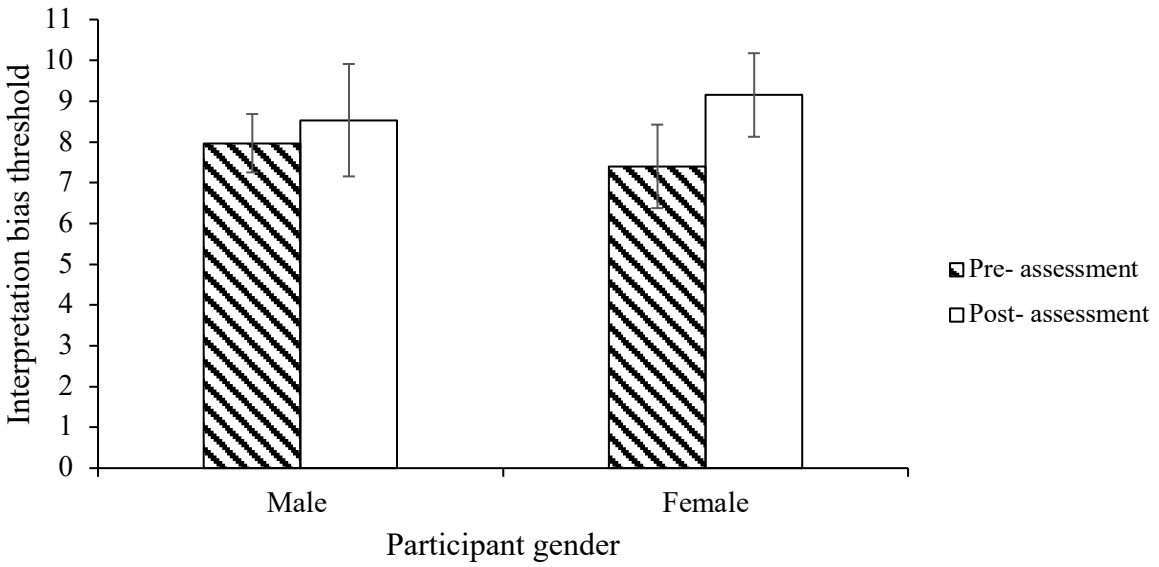

Figure 7. Results of the independent pre- and post- assessment of the interpretation bias threshold for male and female participants. The error bars indicate the 95% confidence interval.

To dive deeper in previous findings, borderline was added as a covariate to the analysis model. Unexpectedly, no interaction effect between borderline, gender and the independent pre- and post- threshold per actor was found, F (1,26) = 3.04, p = .093. However, the interaction between gender and the independent pre- and post- assessment per actor remained significant, F (1,26) = 7.01, $p < .05$. With borderline as a covariate, an interaction effect between the pre- and post- assessment and the actors was found, F (1,26) = 7.36, $p <$ .05. At last, no main effect of borderline was found on the independent pre- and post- assessment (F (1,28) = .03, p = .855), and on the threshold per actor (F (1,28) = .55, p = .463). This finding was in contrast with the expectations that participants high on borderline would have a more negative interpretation of facial stimuli.

For the last analysis, borderline was removed from the model and anxiety was added as a covariate. Results showed no interaction effect between anxiety, gender and the independent pre- and post- assessment per actor, F (1,26) = .348, p = .560. The interaction between gender and the independent pre- and post- assessment per actor was not significant as well, F (1,26) = 3.77, p = .063. An interaction between the pre- and post- assessment and the four actors was found, F (1,26) = 8.81, $p < .01$. Moreover, in contrast with the expectations, no main effect of anxiety was found on the independent pre- and post- assessment (F (1,26) = .312, p = .581.) and on the threshold per actor (F (1,26) = 1.15, p = .294.

In sum, results showed that the interpretation bias threshold in the post- assessment was significantly higher than in the pre- assessment. This effect was found to be only true for female participants. In addition, the threshold differed between all four actors and between male and female participants. No effects were found for borderline and anxiety.

Attention bias.

The attention bias was trained with the ABT and assessed with the ABA. It was tested whether training with the ABT would have effect on the reaction time in the post- assessment compared to the pre- assessment (test phase) and in angry trials versus happy trials (trial emotion). Moreover, by using two conditions with different faces in the ABA than in the ABT it was investigated whether results could be generalized to other facial stimuli. Multilevel analyses in Jamovi were used to test for all hypotheses.

At first, a mixed model analysis was performed to test for effects of training on the reaction time in the post- versus the pre- assessment and in happy versus angry trials. The analysis showed that the interaction between the test phase and trial emotion had a significant effect on the reaction time, F (1,8018) = 236, $p < .001$. Both the test phase (F (1,8023) = 252, $p < .001$) and trial emotion (F (1,8022) = 140, $p < .001$) showed a significant main effect on the reaction time as well. Post hoc comparisons showed that, in line with the expectations, participants were significantly 1097.8 milliseconds (ms) faster on happy trials in the post-assessment compared to the pre- assessment, t (8023) = 22.02, $p < .001$. On the other hand, no significant effects were found for the angry trials. All results are visualized in figure 8.

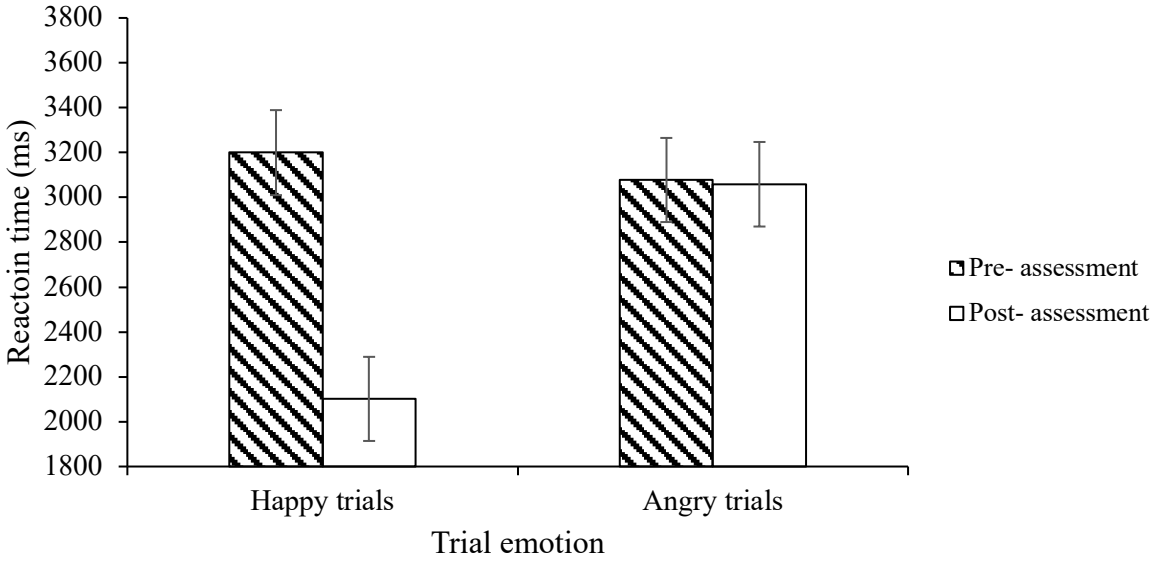

Figure 8. Results of the reaction time (in milliseconds) for the trial emotion per measurement. The error bars indicate the 95% confidence interval.

In addition to the main analysis, effects of gender, borderline and anxiety on the attention bias were investigated as well.

Though no effect of gender on the attention bias was expected, results showed that in fact there was a significant interaction effect between gender, the test phase and the trial emotion on the reaction time, F (1,8014) = 8.13, $p < .01$. Gender interacted significantly with both the test phase, F (1,8020) = 7.38, $p < .05$, and with the trial emotion, F (1,8019) = 32.79, $p < .001$. Post hoc comparisons showed that, unexpectedly, female participants were significantly 535.3 ms faster in detecting an angry face in the post- assessment than male participants were, t (35) = -2.838, $p < .05$. All results on the reaction time for the trial emotion and gender per test phase were visualized in figure 9.

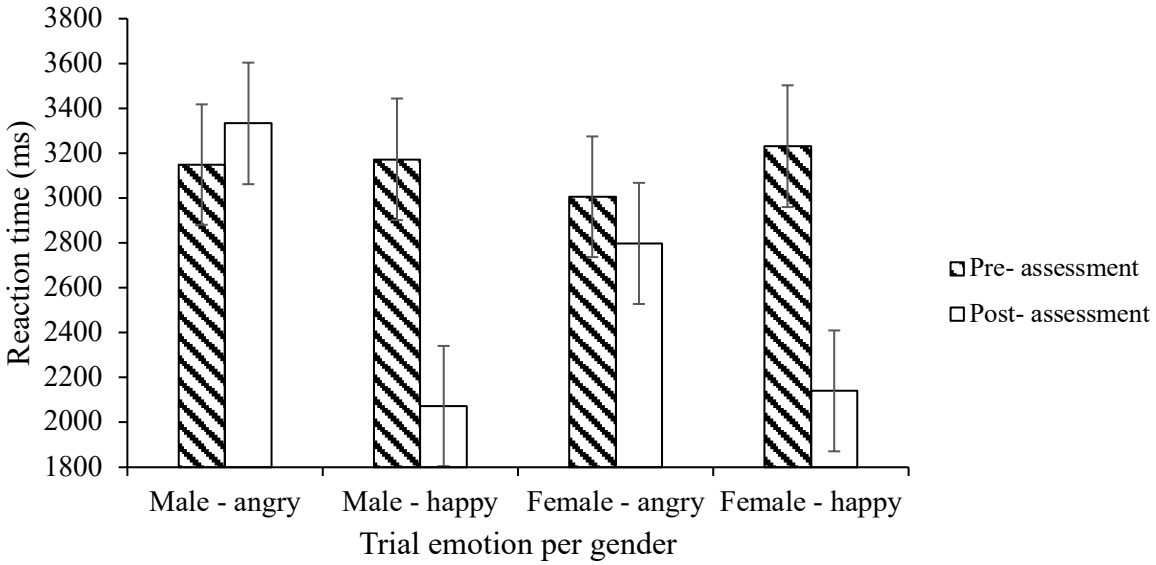

Figure 9. Results of the reaction time (in milliseconds) for the trial emotion and gender per assessment. The error bars indicate the 95% confidence interval.

Secondly, borderline was added to the model with gender still present as an additional factor. This analysis showed, in line with the expectations, a significant interaction effect between borderline, gender, the test phase and trial emotion on the reaction time, F (1,8011) = 10.49, $p < .01$.

Another result that is in line with the expectations is the significant interaction effect between borderline, the test phase and the trial emotion on the reaction time, F (1,8011) = 26.49, $p < .001$. Moreover, borderline showed a significant interaction effect with the test phase, F (1,8017) = 14.9, $p < .001$, but no significant interaction effect with the trial emotion on the reaction time was found, F (1,8015) = .003, $p = .960$. The interaction effect between the test phase and trial emotion on the reaction time remained significant, F (1,8007) =

260.05, $p < .001$. Finally, no significant main effect of borderline on the reaction time was found, F (1,26) = .37, $p = .550$.

Post hoc comparisons showed that borderline was significantly positively correlated with finding angry faces in the post- assessment, t (33) = 2.23, $p < .05$, as visualized in figure 10. This effect was found to be only present for male participants. No effects of borderline were found on the reaction time for angry trials in the pre- assessment or for happy trials in both assessments. Nonetheless, a main effect of finding a happy face between the pre-assessment and post- assessment remained significant, t (8019) = 22.05, $p < .001$.

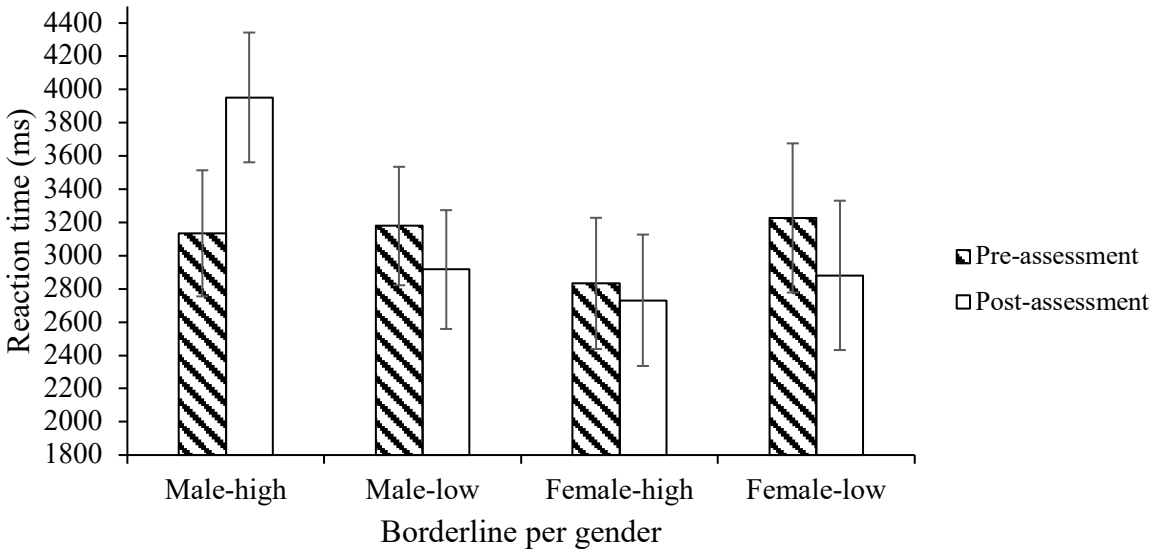

Figure 10. Results of the Attention Bias Assessment on the reaction time (in milliseconds) in angry trials for high and low borderline participants. The error bars indicate the 95% confidence interval.
Note. For visualizations a distinction between high and low borderline was made. This was based on the mean ($M = 14.33$) minus one standard deviation (7.15), meaning low borderline, or plus one standard deviation, meaning high borderline.

A final analysis was performed with gender still added as a factor and anxiety as a covariate. This analysis showed no significant interaction effect between anxiety, gender, the test phase and the trial emotion, F (1,8009) = 2.15, $p = .142$. In contrast with the expectation, also no interaction effect between anxiety, the test phase and the trial emotion on the reaction time was found, F (1,8009) = 1.85, $p = .174$. When looking at the freestanding effects, no significant interaction between anxiety and the test phase was found, F (1,8017) = 1.01, $p = .315$. Results showed that the effect between anxiety and the trial emotion on the reaction

time was significant, F (1,8014) = 18.03, $p < .001$. At last, no main effect of anxiety on the reaction time was found, F (1,26) = 1.54, $p = .225$.

When diving deeper into the interaction effect between anxiety and the trial emotion, it was found that anxiety was slightly negatively correlated with finding angry faces in the pre-assessment, t (32) = -2.05, $p < .05$, which is visualized in figure 11. On the other hand, no effects of anxiety were found for the reaction time on angry trials in the post- assessment or on happy trials in both assessments. With anxiety as a covariate, the effect between the test phase and trial emotion on the reaction time remained significant, F (1,8007) = 241.82, $p < .001$.

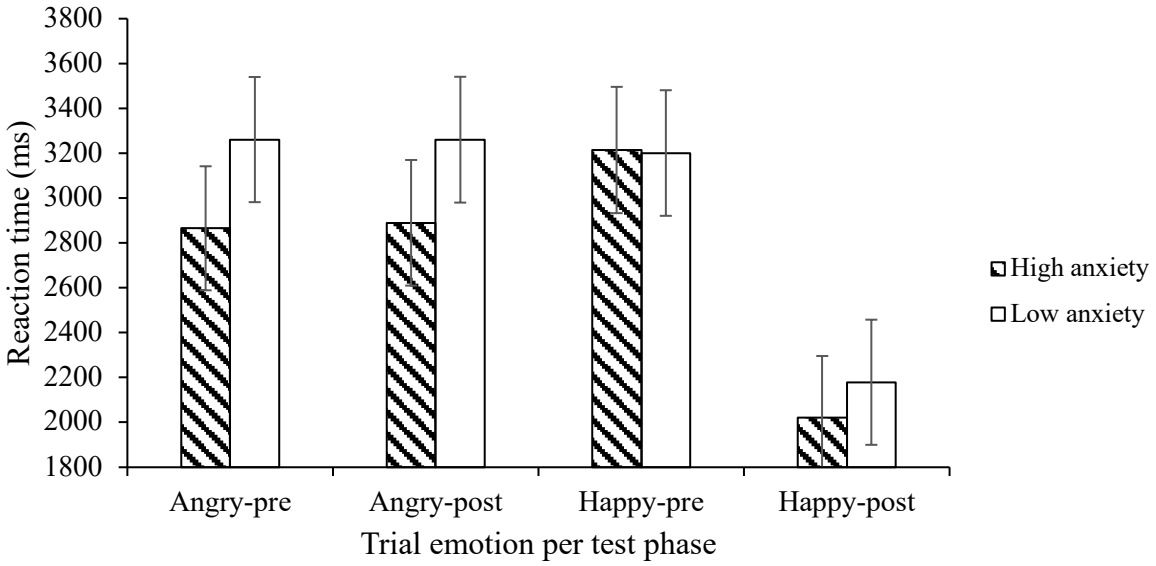

Figure 11. Results of the Attention Bias Assessment of the reaction time (in milliseconds) in the pre- and post-assessment for high and low anxiety. The error bars indicate the 95% confidence interval.
Note. For visualizations a distinction between high and low anxiety was made. This was based on the mean (M = 3.70) minus one standard deviation (2.14), meaning low anxiety, or plus one standard deviation, meaning high anxiety.

In sum, results showed that the interaction between the pre- and post- assessment and the happy and angry trials on the reaction time was significant. Participants were found to be faster on happy trials in the post- assessment compared to the pre- assessment. Moreover, results showed gender and borderline to have effects on searching for angry faces in the post-assessment, where anxiety was found to influence the reaction time on angry trials in the pre-assessment.

A more profound model with possible effects of the target was investigated to test for any effects on the reaction time. More specifically, it was investigated whether the location of

the target in the 3x3 grid, the race and the gender of the target had effect on the reaction time. Moreover, it was analyzed whether interactions between the target race and participant gender and the target gender and participant gender were present. Results of these supplementary analyses are visible in appendix 2.

Discussion

The aim of the present research was to investigate the effectivity of an online training tool in shifting the interpretation bias and attention bias. The goal is to use the online training tool among patients with BPD, but the present study first focused on testing it among healthy participants.

It was hypothesized that using the online training tool would have effect on both biases. For the interpretation bias it was expected that participants would show a more positive interpretation after training. For the attention bias it was expected that training would result in participants having a lower reaction time searching for happy faces in the post-assessment. Another important expectation was to find these results on the independent assessments, enabling the present research to generalize findings to other facial stimuli.

Moreover, it was expected to find higher rates of the interpretation bias among male participants compared to female participant, but no gender differences were expected for the attention bias. At last it was hypothesized that borderline and anxiety would have an effect on the interpretation bias and attention bias. These effects for borderline were expected to be more present for female participants than for male participants.

Interpretation bias

Results of the present research showed that the online training is effective in shifting the interpretation towards a more positive interpretation of faces. It was shown that between all training sessions the interpretation became more positive, but no statistical improvements were found between the second and third and between the third and fourth training. This implies that one training could already be enough in shifting one's interpretation, but more training sessions would result in an even more positive shift.

Moreover, results of the present research have proven that the training was effective in shifting one's interpretation in other facial stimuli than only the faces used in the IBT. As the independent measurements of the interpretation bias used different faces than in the general IBT, recognition effects were excluded and results can, carefully, be generalized to other faces (Field, 2013). However, this effect was only found to be present among female participants. This indicates that results can only be generalized to other facial stimuli for women.

Another interesting finding is that the interpretation differed for the four actors used in the independent measurements. All actors used in the assessments were rated on their angry

and happy expressions and were, as mentioned earlier, selected based on these ratings (see table 3 in appendix 1). An important finding is that the order in which the actors were rated on their happy expression is in line with the order of the positivity of the interpretation. This means that the white female actor, who received the highest rating on her happy expression of the four actors, was the actor who was interpreted as expression happy the most in the independent measurements. This is an important finding, because it emphasizes that the score of the target's face on his/her expression, could influence the performance of a user on interpreting that face. For further development, the actors should therefore be chosen carefully with these findings kept in mind.

Besides the main effect of training on one's interpretation, other possible factors influencing the effect of training were investigated in the present research. At first, women were found to have a more positive interpretation of faces than men did in the independent post- assessment. This does not entirely confirm the hypothesis than men would have a more negative interpretation as this effect was not found in the pre- assessment. Also taking into account the finding that results are only generalizable to other facial stimuli for women, it could be possible that the training is mostly effective for women and that for men mostly recognition effects were present. As most patients with BPD are women (Skodol & Bender, 2003) this finding is still promising and should be explored further in future research.

As the training has proven to be effective in shifting one's interpretation, however, no indications were found for borderline and anxiety to have an effect on this interpretation. This could be explained by the sample being healthy subjects without any reporting borderline (highest score of 33 on a scale from 1 -160) and anxiety (highest score of 8 on a scale from 1 - 20). However, this does not change anything in the effectiveness of the training tool in shifting one's interpretation and could be investigated further in a research among BPD patients.

Strong parts of the assessment of the interpretation within the present research is having an independent pre- and post- assessment to control for any recognition effects and to control for having different genders and ethnicities as faces providing a more valid effect (Field, 2013). Moreover, a strong part of the present research was adding three practice trials before starting the real task. Participants did report forgetting which buttons they had to use, but by adding practice trials hopefully less mistakes were made than participants would have without the practice trials. Limitations of this part of the present research are at first not being able to see the participants in the lab and therefore not being able to control for any setting influences. As with COVID-19 (WHO, 2020) all participants had to stay home, it could be

possible they got distracted by external factors such as roommates getting in the room. Furthermore, the small sample size might have contributed to not finding effects of gender and borderline on the threshold for the five training sessions.

Attention bias

Results have shown that, in line with the expectations, the online training tool is effective in shifting one's attention. Despite the results not showing longer reaction times when searching for angry faces, the results are still promising as the tool proved to be effective in shifting one's attention more towards happy faces through training. As the attention assessments used different faces than the training, results can be carefully generalized to other facial stimuli (Field, 2013).

The present research investigated the effectiveness of an online training in shifting one's attention, with concern to other possible effects such as gender, borderline and anxiety. At first, results have, unexpectedly, shown that women are faster in detecting angry faces than men in the post- assessment. This finding is in contrast with previous research stating that men would have a lower reaction time since women were found to have a small threat avoidance compared to men (Carr, Scully, Webb & Felmingham, 2016). Regardless of this finding, both men and women showed a heightened sensitivity towards happy faces, indicating that the training is effective in shifting one's attention more towards happy faces.

Moreover, borderline was found to be positively correlated with the reaction time in finding angry faces in the post- assessment for men. This means that men with borderline, whom are known to have a heightened sensitivity towards anger (Daros, et al. 2013), would benefit from this tool as it improves their ability to disengage attention away from negative stimuli. However, an important annotation is that the lowest score on the BPQ was 33 on a scale from 1 to 160. This indicates that further research could be done with participants who would score higher on the BPQ, indicating a higher score on borderline.

At last, as expected, a negative moderating effect of anxiety was found for searching angry faces in the pre- assessment. This means that participants scoring high on anxiety were faster in detecting angry faces over happy faces, which could be explained by anxious individuals having difficulty disengaging attention away from negative stimuli (Bar-Haim, et al. 2007). As these findings were only found in the pre- assessment, it could be assumed that the training has helped to flatten out the effect of anxiety on searching for angry faces in the post- assessment.

Strong aspects of the attention bias part of the present research is the addition of a new set of faces with more diversity in race and gender, excluding possible cross-race effects (Wong, et al. 2020). Also, happy faces with the mouth closed were used so that participants would not only look for teeth when searching for happy faces.

Limitations of the present research are at first that after each trial the mouse was positioned where the participant left, that is where the previous target was placed. This resulted in distracting the participant towards the mouse or leading them to have some kind of search strategy. It is therefore recommended to let participants click on a central point before continuing to the next trial, so that they always start from the middle with searching. This finding is also part of the usability research within the present study. A discussion of these results can be found in appendix 3. Moreover, as participants had to complete all tasks at home due to COVID-19 (WHO,2020), possible external factors such as distraction by roommates could have influenced the performance on the tasks. Especially for the attention assessments this is an important note, as the reaction time here was measured as the dependent variable. Further research should therefore control for these external factors. By doing so, the present findings could be confirmed and might even be found to have greater effects.

Future implications

The present study has shown the online training tool to be effective in shifting one's interpretation towards a more positive interpretation of faces and shifting one's attention more in the direction of happy faces. These findings are promising as the main goal of the present research was to proof the effectiveness of the tool, building a foundation for implications of the tool in patients with borderline personality disorder.

Before this tool can be used among patients with BPD, it is important to test for its effectivity among a BPD sample, as results can be different in a clinical sample than with non-clinical participants. Before doing so, a complementary study with a non-clinical sample could be performed first. Indeed, the present study consisted of a non- placebo-controlled experiment, as all participants received the treatment. It could therefore be interesting to set up an experiment with a control group and even more interesting would be a reversed manipulation group. In the present study participants were manipulated in shifting their interpretation and attention towards a more positive bias. Future research, testing whether those two biases could be shifted into a more negative bias, could give even more insights in

the effect of the training tool. Ethically, this should only be performed on healthy participants as it could have negative side-effects for clinical participants.

In addition, no relations between the interpretation bias and attention bias were investigated. Everaert, Tierens, Uzieblo, and Koster (2013) found that a shift in the attentional bias through training could influence the interpretation bias. For future research, it could be interesting to test whether the training for both biases influence each other. With that it can be investigated whether a specific order or following the training for both biases together would influence any performance on one another. Moreover, as 75% of the BPD patients are women, future research could focus more on women as the target group (Skodol & Bender, 2003). The present research used an equal number of men and women, with that finding some gender differences. To dive deeper in the effects of training on women, future research should use a larger sample with men and women divided as is within clinical settings.

Finally, the usability research, as visible in appendix 3, showed that the tool has some important, if not fatal, issues. These problems need to be fixed before testing the tool on patients with BPD, as it could influence the clinical effectiveness of the tool (Petersen, et al. 2019). These then made changes in the usability of the tool should be tested again to guarantee an optimal usability.

Conclusion

The present research has proven the online training tool to be effective in training healthy subjects to interpret ambiguous faces as more positive and to shift attention towards happy faces more easily. Results can be generalized to other facial stimuli than used in the training sessions. However, for the interpretation bias this is only true for women.

Moreover, borderline was found to be positively correlated with finding angry faces in the post- assessment of the attention bias for men. This means that men high in borderline would benefit from the tool, as it improves their ability to disengage attention away from negative faces. Contradicting to the hypothesis, no effects of borderline were found for women. Additionally, anxiety was found to be negatively correlated with the reaction time in finding angry faces in the pre- assessment, but not in the post- assessment. This means that before the training anxious individuals showed a higher sensitivity towards angry faces than non-anxious individuals, but after training this effect disappeared.

The usability of the IBT was found to have most issues on a functional and usable level. With that it can be concluded that the tool not yet does what it needs to do and that the

tasks are difficult to perform. For the ABA/ABT most found problems indicate that the tool does not yet convince the users in using the training. It can be concluded that for the ABA/ABT the tool does what it needs to do, but the tasks are not pleasant enough for users to like using the tool.

Next steps would be to further investigate the found results and to test effectivity of the tool within a sample of which 75% are females to match the prevalence of gender in BPD. Moreover, the usability problems in the tool should be tackled to guarantee a fulfillment of the persuasive needs. Once this is done, the tool can be tested on its effectivity in a clinical population. Hopefully, in the future the training tool can successfully be used by patients with Borderline Personality Disorder shifting their interpretation bias and attention bias.

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Appendixes

Appendix 1

Table 2.
Overview of the faces used in the independent pre- and post-assessment of the IBT with scores per emotional expression. Sorted by average score. Based on the Chicago Face Database (Ma, Correll, & Wittenbrink, 2015.) All faces were rated on a 7-point Likert scale going from 1 (not at all) to 7 (extremely) with the question to consider the face on the concerning trait (here angry and happy).

Image code	*Gender*	*Angry score*	*Happy score*	*Avg. Score*
BF-050	Female	3.43	2.39	2.91
WF-014	Female	2.33	3.29	2.81
BM-038	Male	3.03	2.20	2.61
WM-022	Male	3.07	2.00	2.53

Note. B stands for Black, W stands for White, M stands for Male and F stands for Female. Thus, for example, BF is a black female actor and WM is a white male actor.

Table 3.
Overview of the male images used in de ABT/ABA with scores per emotional expression. Sorted by average score. Based on the Chicago Face Database (Ma, Correll, & Wittenbrink, 2015.)
All faces were rated on a 7-point Likert scale going from 1 (not at all) to 7 (extremely) with the question to consider the face on the concerning trait (here angry and happy).

Image code	*Angry score*	*Happy score*	*Avg. Score*	*Image set ABT*
WM-014	2.33	3.29	2.81	Y
BM-011	3.19	2.33	2.76	Y
BM-026	2.67	2.77	2.72	X
BM-032	2.40	3.02	2.71	X
BM-017	3.08	2.24	2.66	X
WM-016	3.17	2.12	2.65	Y
BM-031	2.74	2.53	2.64	Y
BM-033	2.74	2.51	2.62	Y
BM-002	2.03	3.16	2.60	X
WM-006	2.44	2.75	2.60	X
WM-028	2.56	2.64	2.60	Y
WM-031	2.71	2.47	2.59	X
BM-034	2.37	2.76	2.56	Y
WM-017	2.75	2.34	2.55	Y
WM-009	2.78	2.26	2.52	X
BM-039	2.32	2.68	2.50	X

Note. B stands for Black, W stands for White, M stands for Male and F stands for Female. Thus, for example, BF is a black female actor and WM is a white male actor.

Table 4.
Overview of the female images used in de ABT/ABA with scores per emotional expression. Sorted by average score. Based on the Chicago Face Database (Ma, Correll, & Wittenbrink, 2015.)
All faces were rated on a 7-point Likert scale going from 1 (not at all) to 7 (extremely) with the question to consider the face on the concerning trait (here angry and happy).

Image code	*Angry score*	*Happy score*	*Avg. Score*	*Image set ABT*
WF-016	3.43	2.63	3.03	Y
WF-021	3.29	2.21	2.75	Y
BF-025	2.16	3.28	2.72	X
WF-007	2.17	3.24	2.71	X
BF-016	3.29	2.06	2.67	X
WF-001	3.20	2.07	2.64	X
BF-034	3.10	2.19	2.64	Y
WF-012	2.79	2.47	2.63	X
BF-032	2.73	2.54	2.63	Y
BF-044	3.10	2.16	2.63	Y
WF-015	2.54	2.69	2.61	X
WF-023	2.07	3.05	2.56	Y
BF-027	2.02	3.09	2.55	Y
BF-019	2.45	2.63	2.54	X
WF-017	2.29	2.79	2.54	Y
BF-021	2.77	2.23	2.50	X

Note. B stands for Black, W stands for White, M stands for Male and F stands for Female. Thus, for example, BF is a black female actor and WM is a white male actor.

Table 5.
Borderline Personality Questionnaire (BPQ) by Poreh, et al. (2006).

Item	*Question*	*Subscale*
1	I often do things without thinking them through.	Impulsivity
2	I often become depressed or anxious 'out of the blue.'	Affective Instability
3	People often leave me.	Abandonment
4	I am rarely disappointed by my friends. *	Relationships
5	I feel inferior to other people.	Self-Image
6	I have threatened to hurt myself in the past.	Suicide/Self-Mutilation
7	I do not believe that I have the skills to do anything with my life.	Emptiness
8	I rarely get angry at other people. *	Intense Anger
9	Sometimes I feel like I am not real.	Quasi-Psychotic State
10	I will not have sex with someone unless I have known them for quite some time. *	Impulsivity
11	I sometimes feel anxious or irritable and become sad a few hours later.	Affective Instability
12	When people close to me die or leave me, I feel abandoned.	Abandonment
13	I often exaggerate the potential of friendships only to find out later that they don't work.	Relationships
14	If I were more like other people, I would feel better about myself.	Self-Image
15	I have deliberately tried to hurt myself without trying to kill myself.	Suicide/Self-Mutilation
16	In general, my life is pretty boring.	Emptiness
17	I frequently get into physical fights.	Intense Anger
18	People are sometimes out to get me.	Quasi-Psychotic State
19	My friends have told me that my mood changes very quickly.	Affective Instability
20	I am afraid to spend time alone.	Abandonment
21	People who seem trustworthy often disappoint me.	Relationships
22	I have made a suicide attempt in the past.	Suicide/Self-Mutilation
23	I often feel like I have nothing to offer others.	Emptiness
24	I have trouble controlling my temper.	Intense Anger
25	I can read other people's minds.	Quasi-Psychotic State
26	I have tried 'hard' street drugs (e.g., cocaine, heroin).	Impulsivity
27	My mood frequently alternates throughout the day between happiness, anger, anxiety, and depression.	Affective Instability
28	When my friends leave, I am confident I will see them again. *	Abandonment
29	My friends often disappoint me.	Relationships
30	I have cut myself on purpose.	Suicide/Self-Mutilation
31	I often feel lonely and deserted.	Emptiness
32	I have no difficulty controlling my temper. *	Intense Anger
33	I sometimes see or hear things that other people cannot see or hear.	Quasi-Psychotic State
34	It is not unusual for me to have sex on the first date.	Impulsivity
35	I sometimes feel very sad, but this feeling can change quickly	Affective Instability
36	People often let me down.	Relationships
37	I wish I could be more like some of my friends.	Self-Image
38	I used to try to hurt myself to get attention.	Suicide/Self-Mutilation

39	I am often different with different people in different situations so that sometimes I am not sure who I am.	Emptiness
40	I easily become irritated by others.	Intense Anger
41	Sometimes I can actually hear what other people are thinking.	Quasi-Psychotic State
42	I get high on drugs whenever I feel like it.	Impulsivity
43	I rarely feel sad or anxious. *	Affective Instability
44	No one loves me.	Abandonment
45	When I trust people, they rarely disappoint me. *	Relationships
46	I feel that people would not like me if they really knew me well.	Self-Image
47	I get angry easily.	Intense Anger
48	It is impossible to read others' minds. *	Quasi-Psychotic State
49	I sometimes feel very happy, but this feeling can change quickly.	Affective Instability
50	I find it difficult to depend on others because they will not be there.	Abandonment
51	The relationships with people I care about have lots of ups and downs.	Relationships
52	I feel comfortable acting like myself. *	Self-Image
53	I have never made an attempt to hurt myself. *	Suicide/Self-Mutilation
54	I rarely feel lonely. *	Emptiness
55	I often find that the littlest things make me angry.	Intense Anger
56	Sometimes I can't tell between what is real and what I have imagined.	Quasi-Psychotic State
57	When I drink, I drink too much.	Impulsivity
58	I consider myself to be a moody person.	Affective Instability
59	I have difficulty developing close relationships because people often abandon me.	Abandonment
60	My friends are always there when I need them. *	Relationships
61	I wish I were someone else.	Self-Image
62	I feel like my life is not interesting.	Emptiness
63	When I am angry, I often hit objects and break things.	Intense Anger
64	I often receive speeding tickets.	Impulsivity
65	I often feel like I am on an emotional 'roller-coaster.'	Affective Instability
66	I feel like my family has deserted me.	Abandonment
67	I am very comfortable with who I am.*	Self-Image
68	I often do things impulsively.	Impulsivity
69	My life is without purpose.	Emptiness
70	I am not sure what I want to do in the future.	Self-Image
71	At times I eat so much food that I am in pain or have to force myself.	Impulsivity
72	People tell me that I am a moody person.	Affective Instability
73	The people I love often leave me.	Abandonment
74	In social situations, I often feel that others will see through me and realize that I don't have much to offer.	Self-Image
75	I have been in the hospital for trying to harm myself.	Suicide/Self-Mutilation
76	I often feel empty inside.	Emptiness
77	Others often make me angry.	Intense Anger
78	I often become frantic when I think that someone, I care about will leave me.	Abandonment
79	I am often confused about my long-term goals.	Emptiness
80	Others say I'm quick tempered.	Intense Anger

Note.
Items marked with an asterisk (*) are reverse scored.
Items on the 'affective instability' were used as a measurement for anxiety.

Appendix 2

Supplementary analyses attention bias

Within the attention bias assessment, the targets differed in location on the 3x3 grid, in race and in gender. Within trials, the location, race and gender of the target was randomly allocated and equally divided between trials. This means that these factors did not have any influence on the effects of training and emotions in the main attention bias analyses. However, it is interesting to investigate whether these variables did have influence on the reaction time itself or in combination with the participant gender. Therefore, additional analyses were performed to test for the effects of the target position in the 3x3 grid, the race and the gender of the target on the reaction time.

At first, a mixed model analysis with the target location, the test phase and trial emotion showed no significant interaction effect between the target, test phase and trial emotion on the reaction time, F (8,7982) = 1.39, p = .193. However, a significant interaction effect between the target position and the effect of trial emotion on the reaction time was found, F (8,7982) = 2.866, p < .01. All significant effects are visible in table 6.

Table 6.
Results of the significant differences in reaction time (in milliseconds) between 'angry' and 'happy' trials per target location.

Target place	M angry	M happy	Mean difference	t	df
0,0	3155	2555	599.57**	5.59	7984
0,2	3196	2592	604.00**	5,79	7982
1,2	3148	2677	470.91**	4.65	7983
1,1	2754	2353	401.64**	3.82	7984
2,0	3294	2733	560.56**	5.29	7982
2,2	3297	3031	266.35*	2.59	7983
2,1	3174	2726	448.39**	4.30	7985

Note. * p < .05, ** p < .001. Note that the first number for the target place stands for the vertical location and the second means the horizontal location. For example, target 0,0 is the upper left corner, 1,1 means the overall middle and 2,2 means the bottom right corner.

Moreover, a main effect of the target location on the reaction time was found, F (8,7983) = 13.50, p < .001. When the target was placed on the top row in the middle, participants showed the shortest reaction time (M= 2604), but when the target was placed on the bottom row in the right corner participants showed the longest reaction time (M= 3164), see figure 12.

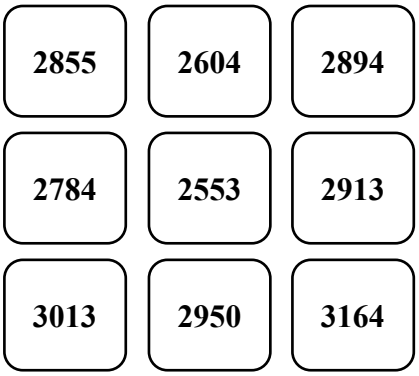

Figure 12. Mean reaction time per target position.
Note. Note that the upper left corner is target 0,0, the middle target is 1,1 and the bottom right corner is target 2,2. The first number for the target place stands for the vertical location and the second means the horizontal location

To test for any effects of the race of the target, a mixed model design was used with target race added as a factor to the main model. No significant interaction effect between the target race, test phase, and trial emotion was found, F (1,8008) = .861, p = .354. A main effect of target race on the reaction time however was found, F (1,8010) = 64.85, p < .001. When seeing a black actor, participants were 281 ms faster compared to the target being a white actor. This difference was statistically significant, t (8010) = 8.05, p < .001.

In addition, when conducting a mixed model analysis with target gender added as factor to the main mixed model analysis, no interaction effect between the target gender, test phase and trial emotion on the reaction time was found, F (1,8008) = 1.96, p = .162. However, a significant interaction effect between the target gender was found with the trial emotion on the reaction time, F (1,8008) = 26.71, p < .001. Moreover, a significant main effect of target gender on the reaction time was found, F (1,8008) = 14.01, p < .001. When the target was a female, participants were faster in detecting the target (M= 2795) than when the target was a male (M= 2926).

When both the participant gender and target gender were taken into account in the mixed model analysis, no significant interaction effect between target gender, participant gender, test phase and trial emotion on the reaction time was found, F (1,8001) = .65, p = .419. However, an interaction effect between the target gender and the participants gender on the reaction time was found, F (1,8001) = 12.75, p < .001. Female participants were 253.75 ms faster when the target was a female than when the target was a male. This difference was found to be statistically significant, t (8001) = -5.14, p < .001.

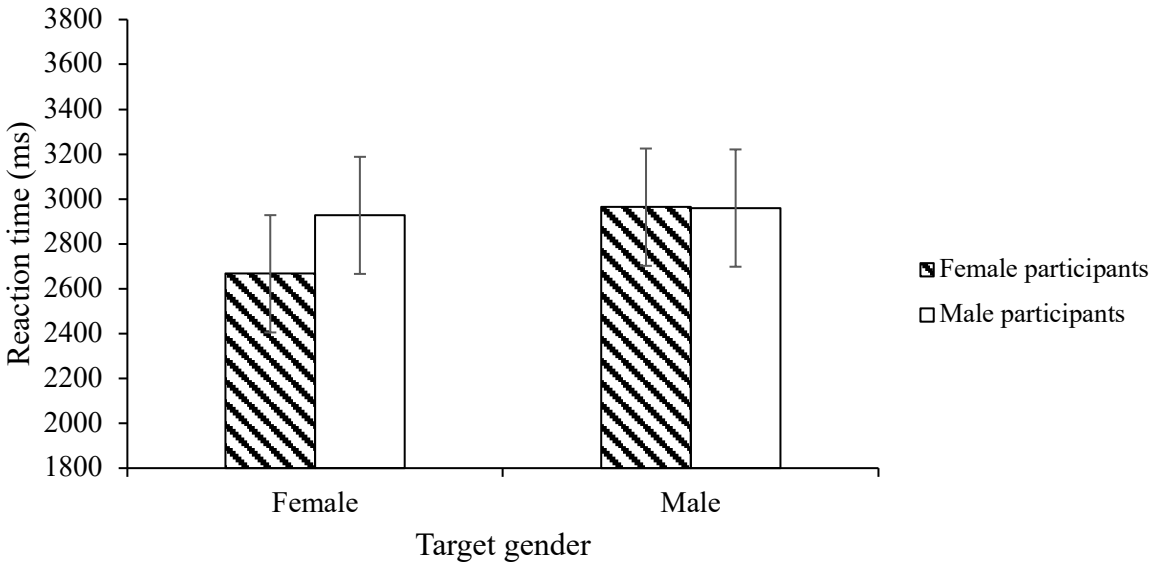

Figure 13. Results of the reaction time (in milliseconds) for female and male participants per target gender (female/male). The error bars indicate the 95% confidence interval.

Finally, when adding participant gender and target race as factors in the mixed model analysis no interaction between the participant gender, target race, test phase and trial emotion on the reaction time was found, $F(1,8001) = .535$, $p = .465$. An interaction effect between the participant gender and target race on the reaction time, however, was found to be significant, $F(1,800) = 4.87$, $p < .05$. Post hoc comparisons showed that female participants were 360.4 ms faster when the target was a black actor than when the target was a white actor. This difference was statistically significant, $t(8003) = 7.28$, $p < .001$. Male participants were 206.6 ms faster when the target was a black actor than when the target was a white actor. This difference was statistically significant as well, $t(8003) = 4.21$, $p < .001$.

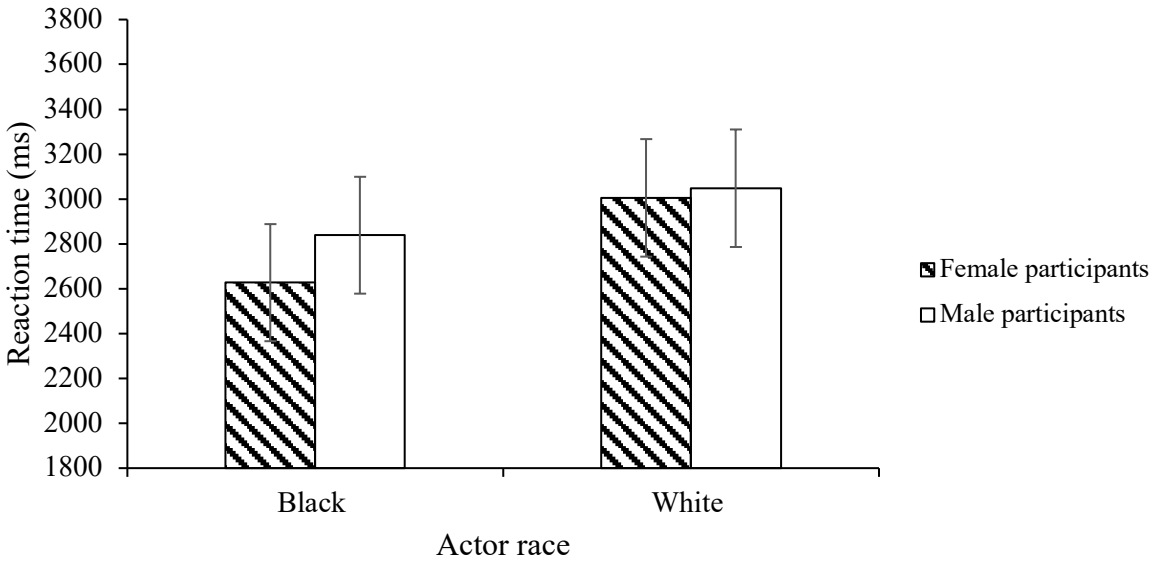

Figure 14. Results of the reaction time (in milliseconds) for female and male participants per target race (black/white). The error bars indicate a 95% confidence interval.

Appendix 3

Usability research

Introduction

Barak, Klein and Proudfoot (2009) define web-based interventions as an online intervention program which helps consumers seeking (mental -) health related support. These programs, which are initially self-guided, are to create positive changes among users. With this definition, the training tool investigated in the present research can be seen as a web-based intervention as well. Though web-based interventions have been shown to be effective in many different health care areas, other research reports the interventions to have either no or only limited positive effects (Kelders, Kok, Ossebaard & van Gemert-Pijnen, 2012). This could be caused by problems in its usefulness, as clinical effectiveness of web-based interventions is found to depend on its usability (Petersen, Nielsen, Olsen & Kok, 2019). Usability is defined as "The extent to which a product can be used by specified users to achieve specific goals with effectiveness, efficiency and satisfaction in a specified context of use." (Barnum, 2010). As it is more likely that users will use an intervention when it is adequate to use, sufficient usability will most likely result in the wanted social, personal and economic benefits for the users (Petersen, et al. 2019; van Genugten, Dusseldorp, Webb & van Empelen, 2016). The software used in the present study is new and has only been tested once on its usability. Hence, the present research will focus on the effectivity of the training tool among healthy subjects with respect to its usability.

Methods

Previous research (Schulpen, 2019) investigated the online training tool with respect to its usability. The present research focused on testing the effectiveness of the online training tool. As the tool is still in development and the main goal is to use the tool for patients with borderline, the tool still needed improvements in its usability. It was therefore chosen to implement a usability research in the present study to look for possible usability problems that still needed to be addressed. To validate improvements in the usability of the tool it was chosen to use the same research method as Schulpen (2019), enabling the present research to compare results (Barnum, 2010).[5]

When participants completed the lasts tasks in the training tool on the final day, they were asked to complete a usability questionnaire. This questionnaire, which is visible in table 7, by de Haas (2019) was used to assess the usability of the IBT as well as the ABA/ABT.

Table 7.
Usability Questionnaire by de Haas (2019).

Nr.	*Question*
1.	What is your overall impression of this online training?
2.	If you had to rate the training, from 1 to 10 (1 being the worst and 10 being the best) how would you rate this training and why?
3.	Could you describe the training for me in three words?
4.	Can you name three things that you liked about the training?
5.	Can you name three things that you did not liked about the training?
6.	If you could change three things about the training, what would you change?
7.	Would you participate in the training? Why (not)?
8.	Would you recommend the training to a friend or family member?

Next to the usability questionnaire a heuristic evaluation based on Nielsen & Molich (1990) was used at the end of the experiment (see table 8). With heuristic evaluation some major usability problems could be identified by asking participants to independently examine the training tool on some principles (Khajouei, Ameri & Jahani, 2018).

[5] To test the usability of the training tool, initial plan was to ask participants to complete some tasks in a thinking out loud method. Working this way requires the participant to perform a task while sharing thoughts about the product and especially when a problem occurs or when something is not clear (Barnum, 2010). When doing this in a lab and sitting behind the participant it would provide insight in what users think of the process and whether some things go wrong or happen in an unexpected way. Due to the COVID-19 virus (WHO,2020), it was not possible to test in a lab and therefore this way of usability testing was not used in the present research.

Table 8.
Used heuristic evaluations questionnaire based on Nielsen & Molich (1990).

Nr.	*Category*	*Question*
1	Visibility	Is it visible what functions are available and what the system currently is doing?
2	Consistency	Is the system consistent in use of designs, comparable designs and in use?
3	Familiarity	Is the use of language and are the used symbols familiar with the target group?
4	Affordance	Is the purpose of every part of the website clear?
5	Navigation	Is there signage and is there support for the user to find his way through the system?
7	Feedback	Is there quick feedback available for the user's action?
8	Recovery	Are mistakes quickly and easily erasable?
9	Limits	Are there limits to prevent users from doing unwanted actions?
11	Style	Is the design stylish and pleasant?
12	Conviviality	Is the use of language polite, friendly, warm and fitting?

All findings from the usability questionnaire and the heuristic evaluation were categorized based on the hierarchy of optimization by Eisenberg (2007), visible in figure 15. This way of categorization assumes that first some basic needs need to be met before getting to the top of the pyramid where users are persuaded to use the interface. It all starts with the *functional needs,* meaning that an interface needs to work and should be able to do what is what made for. When these needs are fulfilled, all users should be able to access the tool, preferably from home to accomplish the *accessible needs.* The *usable needs* are maybe one of the most important ones, since they give information about whether the tool is usable for everyone. Questions as whether users know how to use the interface, whether it does add up to the expectations or if there are any user problems, are questions one could ask to check the *usable needs.* Climbing up the pyramid, the *intuitive needs* tell if the tool is natural in its use and whether the process going through the tool feels intuitive. At last, users should feel convinced using the interface and should believe in the training tool helping them accomplish results in order to meet the *persuasive needs*. All needs can only be met when the preceding need is met first. Approaching the usability problems with the hierarchy of optimization provided a way of deciding which problems had priority and needed to be addressed first.

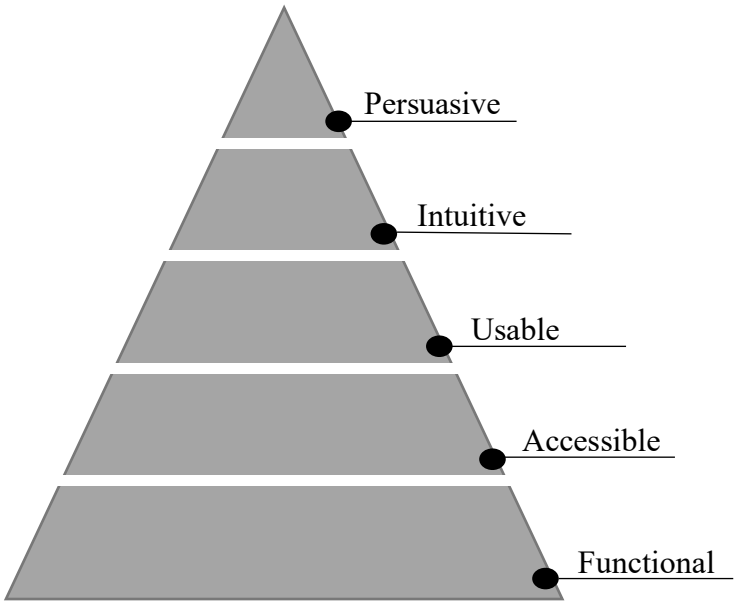

Figure 15. Visualization of the Hierarchy of Optimization based on Eisenberg (2007).

Results

IBT.

With the usability questionnaire and heuristic evaluation multiple usability problems were found. For the IBT, all feedback has been categorized based on the usability needs of the hierarchy of optimization and double problems were filtered. This resulted in 28 unique usability obstacles for the IBT of which the full list can be found in table 9.

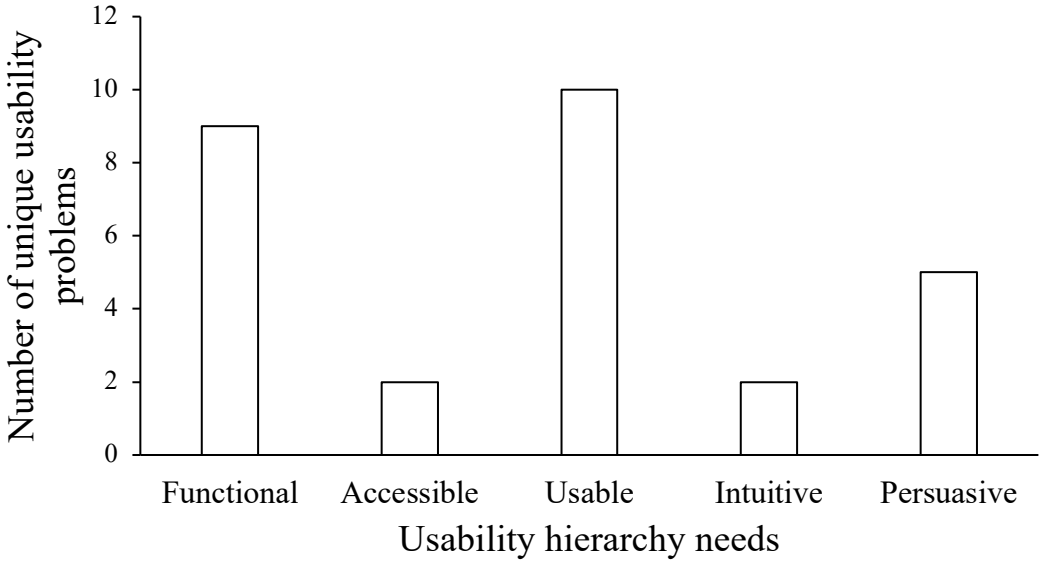

Figure 16. The found usability obstacles for the Interpretation Bias Training, sorted by the usability hierarchy of optimization needs.

Most usability obstacles of the IBT belonged to the usable needs and the functional needs. Examples of the usable problems were that the test was stressful for the eyes as the faces disappeared quickly and that some of the faces seemed fake. Examples of found functional problems were that sometimes participants did only see a grey square and no face being visible during the task.

ABA/ABT.

For the ABA/ABT all feedback was categorized as well based on the hierarchy of optimization and uniqueness of the problems. This has resulted in 25 unique usability problems for the ABA/ABT of which the full list can be found in the table 10.

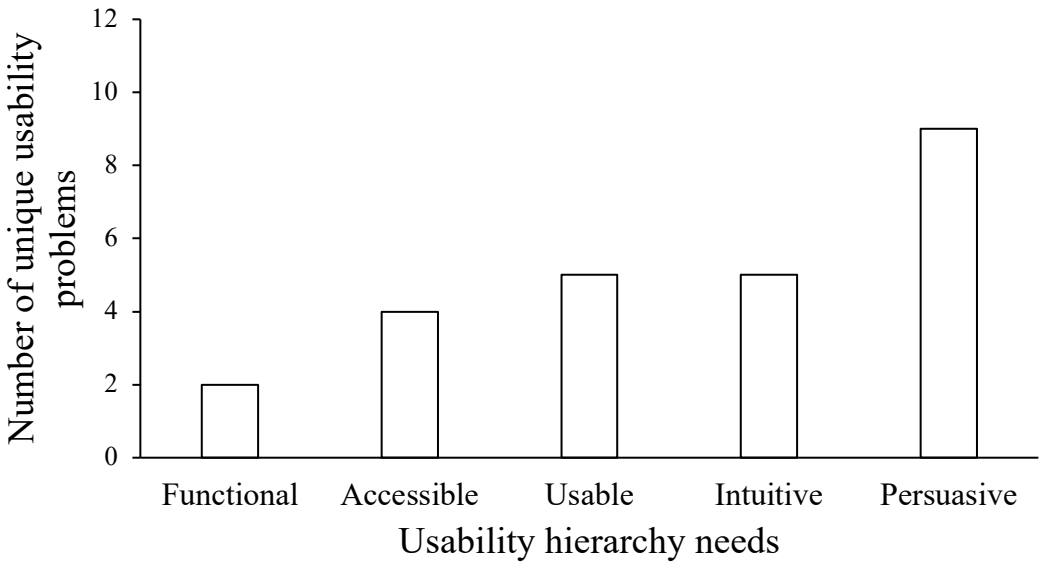

Figure 17. The found usability obstacles for the Attention Bias Training and Assessment, sorted by the usability hierarchy of optimization needs.

Within the ABA/ABT most usability problems were found within the persuasive needs. Some of these problems were that the tasks were monotonous and boring and the need for more challenging or fun components.

Discussion

The goal of testing the usability of the training tool was to uncover any user issues in the tool in order for it to work optimal and realize effectiveness. All unique issues in the tool were categorized based on the hierarchy of optimization (Eisenberg, 2007).

IBT.

For the interpretation bias task 28 unique usability problems were found. Most of these obstacles prevented the tool from meeting the functional and usable needs of the optimization hierarchy (Eisenberg, 2007). Not meeting the functional needs could be an indication of the tool not doing exactly what it needs to do. Most obstacles in the functional category were not seeing a stimulus or the tool being jammed. These problems could have a great if not fatal impact in the results and use of the tool, therefore they need to be corrected. Moreover, the usable problems are divergent from the short period in which the face is visible to the tool being repetitive in its tasks. Once the functional and accessible needs are met, it is important to resolve the usable problems as they have the biggest share in the usability problems.

Compared to previous research (Schulpen, 2019) less accessible and intuitive obstacles were found in the IBT. This means that users had no problems accessing and using the tool from home. This is an important finding as the future goal is to let patients with BPD access the tool from home. Moreover, the decline in intuitive usability problems means that users were led through the tool in a natural way. An important annotation here is that the sample of the present research consisted of non-clinical participants, so the usability might be different for BPD patients.

ABA/ABT.

For the attention bias assessment and training 25 unique usability obstacles were reported by participants. Of these problems, most were found within the persuasive level of the optimization hierarchy (Eisenberg, 2007). Most persuasive problems were related to the tool being boring and repetitive. Within a web-based intervention, the willingness to use the tool is important for its clinical effectiveness (Petersen, et al. 2019). This willingness could be seen as a requirement for the persuasive needs of the usability hierarchy. This means that when the persuasive needs are not fully met, one would not be willing or convinced to use the tool. As the ABA/ABT has the most usability problems on a persuasive level it is important to improve these in order to be fully effective in a clinical setting. Implications for further development of the tool could be to add a break with a totally different task or to give users a

pause option. This implication however should be tested as it could affect the effect of the training tool.

Related to the intuitive and usable levels of the hierarchy, participants indicated they would like to see the progress and personal performance within the task. Moreover, not all faces were thought to be as obvious, making the task confusing. Research has found intuitive aspects of a web-based interventions to be important for the clinical effectiveness as well, therefore making it an important subject of improvements (Petersen, et al. 2019).

When looking at the previous research (Schulpen, 2019) less functional and usable obstacles were found. More persuasive needs were found, which could indicate that the tool has become more complicated and less natural in its use.

Most of the overall usability problems were related to the test being difficult, stressful and requiring attention for a long consecutive period. These problems indicate the tool to be cognitive demanding. Research has found a high cognitive load to be at the expense of a learning experience, therefore making it important to keep the tool quick and easy (van Genugten, et al. 2016). Recommendations could be to minimize the number of trials or to add some breaks within a task. When diminishing the number of trials, new research is important to test whether the effects found in the present research will still be present.

Strong aspects of the usability research within present study is at first the number of participants. It is recommended to at least use a sample size of 5 participants in usability research as with this number most usability problems will be found (Nielsen, 2012). With a larger sample size even more usability issues could be found. Moreover, the present research has given a clear indication whether the tool has improved compared to previous version (Schulpen, 2019). By using the hierarchy of optimization (Eisenberg, 2007) an overview is provided of which problems should be addressed first and which problems have less priority. A limitation of conducting the usability questionnaires online is that the participants had to recall all usability obstacles and thoughts about the tool in hindsight. Initial plan was to use the thinking out loud method (Barnum, 2010) to gain more insights in why users do what they do. This would also enable the researcher to ask questions helping the participant to express itself verbally, presumable leading to discovering even more usability obstacles. Due to the COVID-19 virus (WHO, 2020) it was not possible to test in a lab and make use of this thinking out loud method, but for further research it is recommended to do so.

Table 9.
Overview of all 28 unique usability problems in the IBT, categorized by the levels of the Hierarchy of Optimization (Eisenberg, 2007).

Usability problems IBT	**Category**
It looks little bit old fashioned.	Persuasive
More diversity in the faces.	Persuasive
I would like to know my progress in some way.	Persuasive
Maybe give the participant at the end a look at the faces they got wrong most.	Persuasive
Very intense training which asks a lot of focus. It is very monotonous and boring to execute.	Persuasive
During the test, you can't see the meaning of the buttons.	Intuitive
I don't really know if it did anything.	Intuitive
The time that the faces were on the screen was short, which made it hard sometimes to decide.	Usable
You don't know if you click the correct button, and sometimes I knew it was a happy face but automatically I pushed the wrong button.	Usable
It took longer than was expected (maybe twice as long or longer).	Usable
Stressful for the eyes because the pictures disappeared so quickly.	Usable
Give people a progress line so that they can see how much longer the test is (if that is possible).	Usable
Option to choose what key means 'blij' and which 'boos'.	Usable
Include a larger part of the face in the photo flashes.	Usable
Some of the faces seemed a bit fake (as in: they frowned but their eyes were not angry.	Usable
Make the exercises different every day.	Usable
Maybe use colors that is easier for your eyes.	Usable
It was quite hard and sometimes hard to concentrate. If you're distracted for a split second you miss the face.	Accessible
The first day it wasn't explained that you would see a face for a split second, so I was surprised by that.	Accessible
Sometimes I only saw (grey and black) squares without being able to identify the faces or their emotion.	Functional
Sometimes I already pressed c or m during the image, in which case it wouldn't register.	Functional
Sometimes it jammed.	Functional
No controls shown (clicked through too fast on day two and had to guess what c and m were for, luckily correctly).	Functional
No pause options.	Functional
Hide the mouse when you are doing it (or making it smaller) so it can't block the faces.	Functional
Make a next button for the information, so you can't accidentally skip it.	Functional
You can still receive notifications which can interfere with the test.	Functional
Occasionally press the wrong button.	Functional

Table 10.
Overview of all 25 unique usability problems in the ABA/ABT, categorized by the levels of the Hierarchy of Optimization by Eisenberg (2007).

Usability problems ABA/ABT	**Category**
A bit boring to do the same every day, not really challenging.	Persuasive
Lot of angry faces staring at me.	Persuasive
The purpose was unclear.	Persuasive
Show your score. Did I improve? Add achievements?	Persuasive
More diversity within the faces.	Persuasive
Maybe a personal approach in the texts before and after.	Persuasive
Maybe add a fun component to it.	Persuasive
The design is very monotonous and very boring.	Persuasive
Did not enjoy doing it at all, it was very monotonous.	Persuasive
I wanted to know whether I answered correctly.	Intuitive
You don’t get any indication where you are, what your score is, etc.	Intuitive
No progress shown.	Intuitive
Make a button to advance in the introduction.	Intuitive
You can’t go back through the introduction, so you can’t look back on what you were supposed to do.	Intuitive
The faces weren’t that obvious all the time, sometimes they were very hard or confusing.	Usable
The fact that nothing happened when you'd click on the incorrect face (this distracted me in the beginning).	Usable
Very dependent on having the next odd face to be in the same area as the one before.	Usable
More variation. For example, other faces every day.	Usable
The ability to see a change in your performance so that you can see improvement.	Usable
Just some faces could have been a bit more expressive. Some "happy" faces were in my view just a bit too neutral.	Accessible
You need a long attention span.	Accessible
Most of the time the first thing I did was search for my cursor.	Accessible
Add breaks or something.	Accessible
Sometimes when you click on a point, it was not calibrated correctly.	Functional
When "press any button to continue" please include the mouse buttons.	Functional