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Targeting thinking bias regarding fatigue with Cognitive Bias Modification in renal patients

Master Thesis

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Abstract

Background: Renal patients with fatigue frequently show attentional bias and self-identity bias which affect individuals' focus of attention and self-representation. No comprehensive treatment for fatigue is available, however the CB model suggests that addressing cognitive bias and the main perpetuating behaviors, avoidance behavior and all-or-nothing behavior, is most relevant. Attentional bias and self-identity bias have been successfully targeted using CBM in several psychological disorders. The present pilot study explores the effectiveness of CBM in reducing attentional bias and self-identity bias regarding fatigue and related behavioral outcomes. **Methods:** The design of the present study was a single case ABA series design (N=22). After a 7 or 14 days baseline phase, there was a 2-week treatment and 3-weeks follow-up phase with the IAT, VPT and CBSQ as outcome measures. **Results:** CBM reduced attentional bias (d=0.56) and self-identity bias (d=0.81) from baseline to post-test. Individuals did not report lower avoidance behavior and all-or-nothing behavior after the intervention. Higher bias at baseline increased the CBM treatment effect. Only for self-identity bias, effects were maintained for three weeks follow-up. CBM responders showed similar levels of avoidance behavior and all-or-nothing behavior as non-responders. **Conclusion:** The present study provides the first preliminary evidence suggesting the effectiveness of CBM targeting attentional bias and self-identity bias related to fatigue. Although this study presents a valuable starting point regarding a novel CBM intervention targeting fatigue, due to insufficient statistical power, future research with an adequate powered sample is needed.

Keywords: Cognitive Bias Modification, fatigue, attentional bias, self-identity bias

Introduction

Fatigue is a prevalent symptom in kidney patients with 60% to 97% of individuals who receive hemodialysis suffering from fatigue (Jacobson et al., 2019). It is defined as a condition where individuals experience "extreme and persistent tiredness, weakness or exhaustion – mental, physical or both" (Artom et al., 2014, p.497). For kidney patients, fatigue restricts many areas of life, for example, it hinders patients to fulfill their daily duties, to participate in family life and social interactions. Furthermore, it negatively affects individuals' identity and self-esteem and is associated with decreased quality of life. Hence, fatigue is frequently considered as a vital clinical outcome by kidney patients, above pain and survival (Jacobson et al., 2019).

Until today, the origins of fatigue in patients with kidney disease remain unclear (Artom et al., 2014). Based on research about the Chronic Fatigue Syndrome (CFS), a multifactorial model appears to account best for the development of fatigue (Moss-Morris et al., 2013). The multifactorial cognitive behavioral (CB) model incorporates predisposing, precipitating and perpetuating factors and takes genetic, behavioral, emotional and cognitive processes into account (Harvey & Wessely, 2009). The CB model proposes that an individual predisposition together with a precipitating event marks the onset of fatigue and subsequently, perpetuating factors maintain the fatigue (Harvey & Wessely, 2009). Moss-Morris and colleagues (2013) specify that some individuals are more likely to develop fatigue due to particular predisposing factors, such as personality characteristics (e.g., emotional instability) or prior psychological problems. Specific events, for instance, viral infections or stress may elicit the beginning of fatigue in predisposed individuals and hence, represent the precipitating factors. Followingly, perpetuating factors, such as illness-related cognitions and behaviors and environmental factors, interact and maintain the fatigue (Moss-Morris et al., 2013).

Two main behavior patterns of fatigued kidney patients which represent perpetuating factors and hence contribute to the maintenance of fatigue, are all-or-nothing behavior and avoidance-behavior. Individuals with a certain predisposition who encounter a precipitating event that triggers fatigue, usually activate their coping mechanisms and continue their daily routines. Due to this behavior, they experience an increased level of fatigue but attribute the symptoms to physical causes. They continue to cope instead of resting since inactivity disagrees with their ambition of being able to handle their responsibilities (Moss-Morris et al., 2013). This ‘all-or-nothing behavior’ causes outbreaks of activity which in turn worsens the fatigue and misleads individuals to evaluate their symptoms as severe. Over time, individuals omit their usual routines and focus entirely on the fatigue which sustains the conviction that they suffer from an uncontrollable physical illness (Moss-Morris et al., 2013).

The avoidance of physical activity is another relevant perpetuating behavior that contributes to the maintenance of fatigue symptoms. Many patients who suffer from CFS experience a worsening of symptoms after engaging in physical activity. Because of the intensified symptoms, they frequently develop a fear of physical activity and finally avoid it altogether (Nijs et al., 2013). A recent review by Nijs and colleagues (2013) showed that the fatigue expectations that individuals hold towards physical activity play a major role in this avoidance behavior. Individuals who expect that they will suffer from increased fatigue after a physical activity, tend to perform the movement less energetically or avoid it entirely. Hence, for many CFS patients, avoiding physical strategy constitutes an approach to prevent the worsening of fatigue symptoms (Nijs et al., 2013).

The CB model described above, proposes that addressing the perpetuating factors, such as cognitive processes, is more relevant for treatment than the initial cause (Harvey & Wessely, 2009). Still, no regular treatment model for fatigue in renal patients is available since the origins of fatigue remain unclear (Artom et al., 2014). Currently, Graded Exercise Therapy (GET) and Cognitive Behavioral Therapy (CBT) represent the most promising treatment approaches (Moss-Morris et al., 2013). However, research about CFS found that automatic cognitive processes (i.e., cognitive biases) play an important role in the beginning and maintenance of fatigue which is not directly targeted in the previously mentioned approaches (Hou et al., 2014).

Automatic cognitive processes are grounded in Dual-Process Theories which propose two different cognitive systems that guide thinking and reasoning. The Dual-Process Theory by Kahneman (2003) specifies two distinctive modes of thinking which are System 1 and System 2. System 1 is a fast system and operates based on intuition. In this system, thinking processes take place automatically and without conscious effort and are not available to reasoning or introspection. Additionally, the thought processes are strongly linked with emotions and external stimuli. System 1 mainly works through automatic connections which are difficult to regulate consciously, and therefore increase the probability for cognitive bias. System 2 is a slow system and operates based on reflection. Processes in this system are based on reasoning and require working memory capacities. Therefore, in this controlled system, conscious effort is required to process information through fixed rules and representation (Kahneman, 2003).

Cognitive bias, as occurring in System 1, are commonly experienced in patients who suffer from chronic illnesses, such as CFS. Attentional bias influence how individuals attend to threatening stimuli. Patients with CFS specifically pay attention to somatic and illness-related information due to their existing illness schema. For example, research showed that individuals with CFS tend to focus their attention on health-threat information and show attentional bias towards fatigue-specific and disease-related information (Hou et al., 2008; Hughes et al., 2017). Since for attentional bias, information related to the illness is prioritized at every stage of information processing, this can negatively impact illness behaviors. For example, by interpreting ambiguous stimuli as threatening, individuals are more likely to hold a pessimistic attitude and to perceive their symptoms as uncontrollable. Feeling unable to control the illness decreases self-management behaviors since individuals consider them as unhelpful (Savioni & Triberti, 2020). This influence of cognitive bias on self-management behaviors demonstrates how cognitive bias are related to the perpetuating, behavioral factors of the CB model and underlines the need for a treatment approach targeting these mechanisms.

Cognitive Bias Modification (CBM) is a novel treatment approach that directly targets cognitive bias and aims at modifying automatic thoughts. In CBM, the Visual Probe Task (VPT) is often used to alter attentional bias and to switch individuals' selective attentional focus (Zhang et al., 2019). The underlying principle of VPT refers to the processes of engagement and disengagement of attention. During the VPT, a stimulus that is emotionally arousing but irrelevant for the target task influences how fast participants respond to the target stimulus. Individuals with attentional bias are considered to show "greater engagement of attention" towards the concept that is to be investigated, for instance, a threatening stimulus and to have "difficulty in disengaging their attention" from the threatening stimulus (Hertel & Mathews, 2011, p.522).

Precisely, during the VPT, a probe, for instance, a cross, appears in the middle of the screen which guides the individual's focus of attention to the center of the screen. Followingly, two stimuli appear whereby one is a neutral stimulus and the other one represents the concept that is to be investigated, for instance, a threatening stimulus (Zhang et al., 2019). The two stimuli disappear, and the probe appears again at the location of the previously neutral stimulus. Individuals are asked to indicate the position of the probe as quickly as possible. During the training process, they practice shifting their attentional focus to the neutral, instead of the threatening stimulus (Starzomska, 2017; Zhang et al., 2019).

Besides attentional bias, where fatigued patients focus their attention to outward threat information, individuals are likely to develop a complementary bias that refers to their internal self-perception. Specifically, chronic ill patients may develop self-identity bias which relate to the self-perception that individuals have of themselves (Savioni & Triberti, 2020).

Over the lifespan, individuals develop schemata about themselves based on past experiences which then guide how they process information about their self-image in social interactions (Markus, 1977).

Chronic ill patients may develop a self-representation based on their illness experiences and consequently categorize themselves as a sick person (Savioni & Triberti, 2020). Corresponding to this, patients with CFS may experience that there is no remedy regarding their condition ("I'm sick and tired of being sick and tired") and categorize themselves as the fatigued person (Jacobson et al., 2019, p.184). Since chronic ill patients usually experienced many years of managing and adapting to the disease, illness-related information is easily presented in memory which contributes to this self-perception (Savioni & Triberti, 2020). For example, research about pain provides evidence that chronic pain patients develop a schema of themselves that is closely related to their pain experiences (Grumm et al., 2008). Addressing self-identity bias is crucial for treatment, particularly if there is a strong discrepancy between an individual's ideal self-representation and their actual self since a strong inconsistency decreases the quality of life and contributes to the development of psychological problems (Savioni & Triberti, 2020).

Currently, regarding the treatment of self-identity bias related to fatigue, no literature is available that investigates the effectiveness of CBM targeting self-identity bias. However, literature indicates that partially, self-identity bias bear resemblance to interpretation bias. For example, individuals may show interpretation bias and hold negative interpretations towards themselves (Reyes et al., 2020). Similarly, individuals may develop a self-representation of themselves in which they categorize themselves as the fatigued person (Jacobson et al., 2019). Hence, it could be argued that both biases influence how fatigued patients interpret their identity. Nevertheless, since self-representations about fatigue are formed over the years of experience with the illness, self-identity bias may refer more to how information about the self is remembered than how it is interpreted (Savioni & Triberti, 2020). The extent to which self-identity bias and interpretation bias may overlap may be an issue of interest for future research. Due to the lack of literature about self-identity bias related to fatigue, in the present study, it will be referred to studies investigating interpretation bias.

In CBM, interpretation bias can be measured with the Implicit Association Task (IAT) which directly targets individuals' implicit attitudes about certain stimuli (Greenwald et al., 1998). Individuals complete different classification tasks on the computer, in which they sort stimuli on the screen into different categories. First, in the target task, individuals are asked to press one key for the positive category (e.g., a vitality-related word) and another key for the negative category (e.g., a fatigue-related word). Second, in the attribute task, participants push one key for the positive attribute (e.g., the word 'self') and a different key for the negative attribute (e.g., the word 'other) (Meissner et al., 2019). In the following compatible task, the attribute task and target task are combined, and individuals press one key for the positive target and the corresponding positive attribute (e.g., vitality-related word and 'self') and the other key for the negative target and the negative attribute (e.g., fatigue-related word and 'other') (Meissner et al., 2019).

Finally, in the incompatible task, participants respond with one key to the negative target and positive attribute (e.g., fatigue-related word and 'self') and the other key for the positive target and the negative attribute (vitality-related word and 'other'). It is assumed that in the case of pre-existing bias, participants are faster in accomplishing the compatible than the incompatible task (Meissner et al., 2019). The strength of the implicit association is revealed in the difference between the compatible and incompatible task (Greenwald et al., 1998). In the present study, the modified SI-CBM was based on the IAT procedure described by Greenwald and colleagues (1998). Additionally, in the treatment module of the SI-CBM, participants practiced assigning vitality-related stimuli to oneself and, hence, training novel implicit associations towards vitality.

With regard to the perpetuating, cognitive bias of the CB model, research repeatedly demonstrated that a CBM intervention effectively modified attentional bias and interpretation bias in several psychological disorders, including depression or anxiety (Jones & Sharpe, 2017). For example, for Generalized Anxiety Disorder (GAD), CBM modified bias related to worrying and rumination which was associated with a decrease in depressive symptoms (Hirsch et al., 2018). CBM reduced interpretation bias and improved symptoms of anxiety and stress reactivity in anxious individuals (Rozenman et al., 2020). Furthermore, CBM based on a modified IAT paradigm, significantly modified implicit associations regarding contamination concerns (Dusend et al., 2019). However, until now, no research examined the effectiveness of CBM targeting bias related to fatigue in kidney patients. The following research will investigate whether CBM modifies attention-, and self-identity bias related to fatigue in chronic kidney patients.

Regarding the perpetuating, behavioral path of the CB model, currently, very little literature is available on the effectiveness of CBM aiming at behavioral outcomes related to fatigue. Most evidence for the effectiveness of CBM targeting behavioral outcomes comes from the field of addictions. For example, CBM modified action tendencies towards alcohol and converted approach bias into avoidance bias (Eberl et al., 2013; Wiers et al., 2011). Additionally, in research about social anxiety, participants were confronted with positive and negative interpretation bias and followingly their behavioral response towards the stimuli was investigated. In one experiment, using the AAT, individuals' behavior regarding emotional multi-facial pictures (i.e., emotional crowds), was predicted by their positive or negative interpretation bias. However, in a second experiment, these effects were not maintained in a behavioral task of approaching or avoiding emotional crowds (Lange et al., 2010). Hence, there still exists uncertainty in the field of CBM on whether effects of CBM aimed at reducing cognitive biases apply to other cognitive, emotional or behavioral outcomes (Lange et al., 2010; Stevens et al., 2018). The following research will analyze whether CBM improves avoidance behavior and all-or-nothing behavior in kidney patients.

As described above, CBM may be an effective novel treatment approach to modify attentional bias and self-identity bias related to fatigue in kidney patients. However, it remains unclear whether there are individuals with certain characteristics who benefit most from CBM. In line with the Dual-Process Theories described above, CBM alters cognitive bias by addressing automatic cognitive processes which have a considerable influence on individuals reasoning (Kahneman, 2003). Hence, it could be assumed that individuals who report strong bias before the start of the CBM intervention will benefit most compared to individuals who report weaker bias at baseline.

Research in the field of alcohol addictions provides evidence for the assumption of baseline bias as a possible moderator of effectiveness. For example, the strength of approach bias towards alcohol at pretest predicted changes in bias after a CBM intervention (Eberl et al., 2013). Correspondingly, research about social phobia showed that participants with greater attentional bias at baseline who were more likely to focus their attention on social threat cues experienced a greater decrease in anxiety symptoms (Amir et al., 2011). Therefore, in the following study, it is hypothesized that the treatment effect of CBM is moderated by the strength of attentional bias and self-identity bias at baseline and proposed that CBM is most effective for individuals with strong attentional bias and self-identity bias at baseline.

Despite the evidence for the effectiveness of CBM, it is also still unclear whether these effects can be maintained in the long term. In a meta-analysis by Jones and colleagues (2017), it was found that for attentional bias, there were no long-term effects between two weeks and four months after the end of the CBM intervention. Regarding interpretation bias, there is evidence that effects can be maintained for addictive disorders, but not for affective outcomes (Jones & Sharpe, 2017). Nevertheless, Hirsch and colleagues (2018), showed that improvements in bias related to depressive symptoms, worry and rumination were maintained at one-month follow-up. Hence, the following research will investigate whether there are changes in attentional bias and self-identity biases related to fatigue in kidney patients and whether these changes can be maintained for a follow-up period of three weeks.

The present study aims at exploring the overall effectiveness of CBM in reducing attentional bias and self-identity bias and avoidance behavior and all-or-nothing behavior in renal patients with fatigue and exploring for which group of individuals CBM may be most effective. In line with the Dual-Process Theories described above, it will be explored whether individuals who profit most from CBM and report a change of bias will also report lower avoidance behavior and all-or-nothing behavior compared to individuals for whom CBM is less effective. It is hypothesized that individuals who are classified as CBM responders show a more positive change in avoidance behavior and all-or-nothing behavior compared to individuals who are classified as non-responders. Therefore, the following hypotheses are tested:

H_1: CBM significantly reduces attentional biases and self-identity biases regarding fatigue in renal patients.

H_2: After receiving CBM, individuals report significantly lower avoidance behavior and all-or-nothing behavior on post-test than on baseline.

H_3: The treatment effects of A-CBM and SI-CBM are maintained for a period of three weeks follow-up.

H_4: The treatment effect of CBM targeting attentional bias and self-identity bias is moderated by the strength of attentional bias and self-identity bias at baseline.

H_5: CBM responders show a more positive change in all-or-nothing behavior and avoidance behavior compared to CBM non-responders.

Methods

Study Design

The design of this study was a single case ABA series design. There was a 7 days or 14 days baseline phase and followingly, participants began with a single attentional CBM (A-CBM) or self-identity CBM (SI-CBM) in first treatment week. After a varying baseline phase (7 days or 14 days), there was a 2-week treatment phase (A-CBM or SI-CBM) and a 3-week follow up on primary (cognitive biases) and secondary (avoidance behavior and all-or-nothing behavior) outcomes. Participants were randomly allocated to one of the four conditions by an independent researcher who applied a computer-generated randomization list. The design and measurements of the present study are demonstrated in Table 1 below.

The single case ABA series design was chosen due to its high level of experimental control. Additionally, this design enables to examine whether a treatment is feasible in a real-life context before testing the intervention in large scale studies (Byiers et al., 2012). Since CBM represents a novel treatment approach for attentional bias and self-identity bias related to fatigue in chronic kidney patients, the single case ABA series design was considered suitable to pilot the effectiveness of CBM in a real-life setting. Finally, the present study was reviewed and approved by the Medical Ethical Committee Twente (METC).

Table 1

Table 1 Time schedule of the single-case series design, including the planned outcome measurements.

Week	1	2	3	4	5	6	7
Phase	A Baseline	A Baseline	B CBM	B' CBM	A' Post	A' Post	A' F-up
Group							
I			A-CBM	A+SI			
2 week B-line II			A-CBM	A+SI			
III			SI-CBM	SI+A			
2 week B-line IV			SI-CBM	SI+A			
Measures[a]	Mon-Sun[b]	Mon-Sun	Mon-Sun	Mon-Sun	Mon-Sun	Mon-Sun	Mon-Sun
Brief measures							
SI-BIAT+B-VPT VAS-F+VAS-V	■□■□□□■	□■□■□■□	■□□□■□□	■□□■□□□	■□□□□□□	■□□□□□□	■□□□□□■
Full measures							
SI-IAT+VPT+CIS+SVS Behaviors	■□□□□□□	■□□□□□□	□□□□□□□	□□□□□□□	■□□□□□□	□□□□□□□	□□□□□□■

[a] *The baseline repeated measurements in week 1 only apply to Groups II and IV. Groups I and III will start with measurements in week 2, according to the variable baseline SCED design*
[b] *The days at which repeated measurements are planned of the brief biases (SI-BIAT, B-VPT), Visual Analogue Scale for fatigue and vitality (VAS-F, VAS-V) are highlighted in blue; full measurements of biases and fatigue and vitality (IAT, VPT, CIS, SVS) are highlighted in red.*

Participants

Participants were recruited from two Dutch Hospitals (ZGT Almelo, Isala Zwolle). It was aimed at including individuals in the study with Chronic Kidney Disease (CKD) stage 5 who received hemodialysis or individuals with CDK stage 4 who were treated in a pre-dialysis outpatient clinic and were expected to receive renal replacement therapy within one year. Participants were individually approached by their nurse specialists and nephrologists at scheduled visits and received more detailed information about the study after initial consent.

The sample of the current study consisted of 22 participants, of which 11 were male and 11 were female. Out of the total sample, 75.0 percent of the participants reported a western ethnicity, 3.6 percent indicated another nationality and 21.4 percent did not report a nationality. Additionally, 39.3 percent indicated that they receive dialysis and 14.3 percent classified themselves as pre-dialysis patients. Regarding the highest level of education, 3.6 percent achieved primary education, 10.7 percent lower vocational education (LBO, VMBO), 17.9 percent secondary general advanced education (MAVO), 21.4 percent secondary vocational education (MBO), 14.3 percent higher general preparatory scientific education (HAVO, VWO), 3.6 percent (post) scientific education and 7.1 percent indicated another highest level of education.

Inclusion criteria were adequate fluency in Dutch, elementary internet skills, sufficient visual faculty to work with the computer and self-reported moderate to severe levels of fatigue. Participants were excluded from the study if they were likely to receive transplantation within the next 3 months or if they were affected by physical or psychological comorbidity that may prevent adherence to the CBM program.

Materials

The CBM computer application that was used in the present study contained both training modules (A-CBM and SI-CBM) and measurement modules for attentional bias and self-identity bias. The measure for attentional bias was based on the Visual Probe Task (VPT) and consisted of 160 trials (Eysenck et al., 1987). In the middle of the computer screen, a cross appeared for 500 ms and followingly, word pairs consisting of a fatigue-related word and a vitality synonym appeared randomly for 500 ms above and below the cross, respectively. At the location of one of the words, a target probe (the letter E or F) was presented and remained until the participants reacted to this correctly. The position of the probe was randomly varied corresponding to a 50/50 proportionality. Participants were required to finish a 20-trial practice block before they completed an 80-trial measurement block.

To enable frequent measures and simultaneously to prevent overburdening of participants, a brief version of the VPT (B-VPT) was used between baseline and follow-up. The B-VPT included 16 practice trials and 80 responses. Full measurements were applied in the first baseline week, at post-treatment and follow-up.

The measure for self-identity bias was based on the Implicit Association Task

(Greenwald et al., 1998). Participants were asked to assign four different kinds of stimuli (self, other, fatigue, vitality) to two conditions. In the first half of the SI-IAT, participants were asked to respond to self-related words and fatigue-related words with one key and to answer to other-related and vitality-related words with a different key (fatigue congruent condition). In the second half, participants were asked to react to self-related words and vitality-related words with one key and to respond to fatigue-related words and other-related words with the other key (vitality-congruent condition). The strength of association between the respective concepts was displayed in the different response times in the fatigue congruent condition and the vitality congruent condition. As with B-VPT, a brief version of the IAT (SI-BIAT) was used for repeated measurements.

The SI-IAT consisted of seven blocks in total. Participants started with five practice blocks before they completed two measurement blocks. After the first practice block (fatigue vs. vitality, N=20), a practice block with the other two categories (me vs. other, n=20) and the combination of the two conditions followed (fatigue + me vs. vitality and other, n=20). The first measurement block was added and after that, the IAT started with the first practice block (vitality vs. fatigue, n=20). Followingly, the other two categories (me vs. other, n=20) and then the combination (vitality + me vs. fatigue + other) was practiced. Finally, participants finished the second measurement block. Participants were only asked to conclude the practice blocks in the first week of the CBM intervention and for the first 3 measurements. In the remaining weeks, the SI-IAT directly started with the measurement of the congruent condition (n=40), followed by a switch (n=20) and the second measurement block (n=40). Similarly, in the VPT, only one measurement block (n=100) was conducted after the first week.

Moreover, in the current study, the keys with which participants responded to the stimuli on the keyboard were modified. In the initial IAT, participants pressed the keys ‘E’ and ‘I’ when presented with the respective concepts on the screen. To ensure that participants could perform the CBM measurement and training modules during dialyses with only one available hand, participants used the arrow keys in the present study.

For the psychometric properties of the VPT, past research frequently questioned the reliability and validity of this measure (Dear et al., 2011; Risløv Staugaard, 2009). For example, Dear and colleagues (2011) found low levels of internal consistency and test-retest reliability in a pain-related sample. Nevertheless, research indicates that VPT measures may yield more reliable results in between-group approaches (Risløv Staugaard, 2009). Moreover, an extended testing period and multiple sessions, as implemented in the present study, may improve validity and test-retest reliability validity and test-retest reliability since the experience with the VPT may increase the reliable occurrence of bias (Aday & Carlson, 2019).

Regarding the psychometric properties, the IAT was shown to have adequate construct validity and moderate predictive validity (Greenwald et al., 2009; Nosek et al., 2005). Additionally, for IAT measures usually, a satisfactory internal consistency between 0.70 and 0.90 is achieved (Schnabel et al., 2008).

Finally, avoidance behavior and all-or-nothing behavior were evaluated with the behavioral subscales of the self-reported Cognitive and Behavioral Responses to Symptoms Questionnaire (CBSQ). The avoidance scale contained 8 items, and the all-or-nothing scale comprised 5 items that participants answered with statements ranging from ‘strongly disagree’ to ‘strongly agree’ (e.g., “I am afraid that I will make my symptoms worse if I exercise”) (Skerrett & Moss-Morris, 2006). The questionnaire was found to be reliable with an internal consistency of 0.76. Moreover, the CBSQ is frequently used with CFS patients and was found to have a satisfactory construct validity (Loades et al., 2019). In the present study, the avoidance scale and the all-or-nothing scales of the CBSQ had high reliabilities, with Cronbach’s $\alpha = 0.91$ and Cronbach’s $\alpha = 0.81$ respectively.

A combination of the online survey and experiment applications ‘Qualtrics’ and

'Gorilla sc.' were used in the current study. The different questionnaires were administered via Qualtrics (https://www.qualtrics.com/de/) and the CBM measurement and training modules were provided with Gorilla sc. (https://gorilla.sc).

Procedure

After agreeing to participate in the study, participants started with a one-week or two-week baseline phase (week 1 and 2) in which they completed the brief measures of the IAT (SI- BIAT) and VPT (B-VPT) and full measures of the IAT, VPT and CBSQ. In the third week, participants started with the CBM treatment and practiced with the treatment module either for attentional bias or self-identity bias. Moreover, they filled in the mentioned brief measures again. In the fourth week, the second CBM treatment module was added, and participants filled in the brief measures. In the post-test phase (week 5 and 6) and the follow-up phase (week 7), participants filled in the brief measures and the full measures again.

CBM treatment

In the CBM treatment module targeting attentional bias (A-CBM), participants observed a fatigue-related word and a vitality-related word. Subsequently, the target probe (the letter E or F) appeared at the position of the vitality-related words which prompted participants to concentrate on the vitality-related word. Hence, participants were trained to concentrate on positive vitality-related stimuli instead of the fatigue-related stimuli.

The treatment module for self-identity bias (SI-CBM) aimed at training participants to categorize vitality-related stimuli together with the self and to assign fatigue-related stimuli to other individuals and, hence, building novel associations. The CBM treatment sessions took place daily for 10 minutes for two weeks. In the first treatment week, one CBM treatment was introduced and the second CBM was added in the second treatment week. The order of the CBM treatment varied per condition as there were two cross-lagged study arms.

Each CBM session included 160 responses and participants practiced with 320 responses per daily session in the second treatment week. In total, the treatment took 5 to 15 minutes.

Data analysis

Data were analyzed using the statistics software IBM SPSS (version 27). Before analyzing the data to answer the research question, the dataset was screened for missing values. The data of 6 participants were removed because the participants did not complete all measures and the data of 22 participants were used for further investigation. Followingly, descriptive statistics were calculated to obtain an overview of the data. Demographic statistics were calculated, as well as baseline-, pre-, and post-test scores of the respective measures. Subsequently, the hypotheses were tested. For all statistical tests, an alpha level of 0.05 was used. No imputation of missing values was applied due to the limited sample size and the restricted number of measurement points.

To test the first hypothesis, D-scores were calculated by subtracting the mean of the fatigue congruent trials (fatigue + me vs. vitality + other) from the vitality congruent trials (vitality + me vs. fatigue + other), divided by the standard deviation from all trials. A more favorable attitude towards fatigue than towards vitality is demonstrated by a positive D-score (Greenwald et al., 2003).

The bias scores in the different stages were calculated from a series of measures in each phase. Baseline self-identity bias scores were computed from the mean of all available D-scores during the baseline phase (measure 1 to 6). Post-test bias scores were calculated from the mean of all available D-scores during the post-test stage (i.e., measure 9 to 12). Followingly, a paired-sample t-test was conducted to compare the mean bias scores from baseline and post-test.

VPT scores were calculated by subtracting the fatigue mean from the vitality mean for every participant and every meeting from baseline to post-test. Subsequently, baseline attentional bias scores included the mean of all available VPT scores during baseline (i.e., measure 1 to 6) and post-test (i.e., measure 9 to 12) respectively. The mean bias scores from baseline and post-test were compared by conducting a paired-sample t-test. Furthermore, bootstrap methods were conducted, and the bootstrapped confidence interval based on 1000 bootstrap samples was reported.

To test the second hypothesis, the participants' level of avoidance behavior was compared by first calculating the baseline mean of avoidance behavior from all available scores of the two baseline measurements. The post-test mean of avoidance behavior was calculated from the scores of the three post-test measurements. Followingly, the difference in means from avoidance behavior at baseline and post-test was compared by performing a paired sample t-test. Correspondingly, the baseline-mean and the post-test mean of all-or-nothing behavior was computed and compared with a paired sample t-test. Correspondingly, bootstrapping procedures were conducted.

To test the third hypothesis, general linear models-repeated measures with three time points, namely baseline, post-test and follow-up were performed. Time was added as a within-subject factor with three levels. Followingly, it was examined whether this model, was significant and whether there was a main effect of time across the three levels. In case of a significant main effect of time, further post-hoc tests were performed to analyze for which specific time points the means differ. It was compared whether the treatment effects of CBM differed from baseline to post-test (T1-T2), from baseline to follow-up (T1-T3) and from post-test to follow-up (T2-T3) and hence whether the effects were maintained to 3 weeks follow-up. Specifically, the maintenance hypothesis was not rejected if the treatment effect from baseline to follow-up was significant. For the post-hoc tests of the GLM, the Bonferroni correction was applied.

To test the fourth hypothesis, moderation analysis was performed using general linear models-repeated measures with baseline bias scores and post-test bias scores as within-subject factor and the strengths of baseline bias scores added as a between-subject factor. A median split was performed to transform the continuous variable of the participant's strengths of bias at baseline into a binary variable with the two values high and low. Values above the median were coded as 1 and values below the median as 0. Subsequently, general linear models-repeated measures were performed and the modified moderator variable, strength of baseline bias, was added as a between-subject factor.

To test the fifth hypothesis, participants' difference scores for baseline attentional bias and post-test attentional bias were computed. Followingly, a median split was performed to code participants as responders or non-responders in a categorical variable. Individuals with a score above the median on the difference between baseline bias and post-test bias were coded as responders (coded as 1) and participants with a difference below the median were classified as non-responders (coded as 0). General linear models-repeated measures were performed with baseline-, and post-test all-or-nothing behavior scores as within-subject factor and the categorical responders vs. non-responders variable added as a between-subject factor. The same analyses were repeated with avoidance behavior scores as within-subject factor. Correspondingly, general-linear models repeated measures were performed for self-identity bias.

Results

Regarding the first hypothesis, it was hypothesized that CBM would significantly reduce attentional bias and self-identity bias related to fatigue. For self-identity bias, a paired-sample t-test showed, on average, a shift in self-identity bias towards a more positive vitality-self association after CBM on post-test (M= -0.23, SE= 0.04) compared to baseline (M= -0.01, SE= 0.05). In line with the hypothesis, this difference (0.22, 95% BCa CI: 0.11 to 0.35), was significant ($t(14)= 3.13$, p= 0.01). For this statistical test, the aggregated mean of the measures of post-test and follow-up was used (measure 9 to 12). The effect size Cohen's d was obtained by calculating the mean differences between bias at post-test and at baseline and dividing this difference by the standard deviation of baseline bias. Furthermore, effect sizes were calculated using SPSS which revealed a large effect of d= 0.81 (Field, 2013b).

For attentional bias, a similar result was found in a paired-sample t-test which revealed that on average, after CBM, participants experienced a shift in bias from fatigue-oriented towards vitality-oriented at post-test (M= -21.23, SE= 8.05) compared to baseline (M= 22.94, SE= 19.41). Since the bootstrapped confidence interval (44.17, 95% BCa CI: 10.39 to 92.91) did not contain zero, there was a high probability that the true value of the mean differences was different from zero and, therefore, the difference in attentional bias from baseline to post-test was significant (Field, 2013a). SPSS revealed a medium effect size of d= 0.56.

With regard to the second hypothesis, it was hypothesized that after receiving CBM, individuals would report significantly lower avoidance behavior and all-or-nothing behavior at post-test than at baseline. For avoidance behavior, a paired-sample t-test showed that on average, participants reported the same levels of avoidance behavior on post-test (M= 2.34, SE= 0.13) as on pre-test (M= 2.34, SE= 0.10). This difference (0.00, 95% BCa CI: -0.12 to 0.13) was not significant ($t(15)= 0.07$, p= 0.94).

For all-or-nothing behavior, a similar result was found. On average, after CBM treatment, participants reported similar levels of all-or-nothing behavior on post-test (M= 2.54, SE= 0.17) than on baseline (M= 2.59, SE= 0.20). Since this difference (0.05, 95% BCa CI: -0.10 to 0.20) was not significant ($t(15)= 0.62$, p= 0.55), the second hypothesis was rejected.

Regarding the third hypothesis, it was hypothesized that the treatment effects of CBM for attentional bias and self-identity bias would be maintained for a time period of 3 weeks follow-up. For attentional bias, Mauchly's test indicated that the assumption of sphericity in the GLM had been violated ($\chi^2(2) = 33.50$, p= 0.00), therefore the Greenhouse-Geisser corrected tests were reported (ε=.51). The results show that the overall general linear model was not significant, (F(1.02, 12.29)= 2.67, p= 0.13). Thus, there was no main effect of time across the three time points, baseline, post-test and follow-up. Since for A-CBM, no main treatment effect of time was found, further post-hoc tests were not reported.

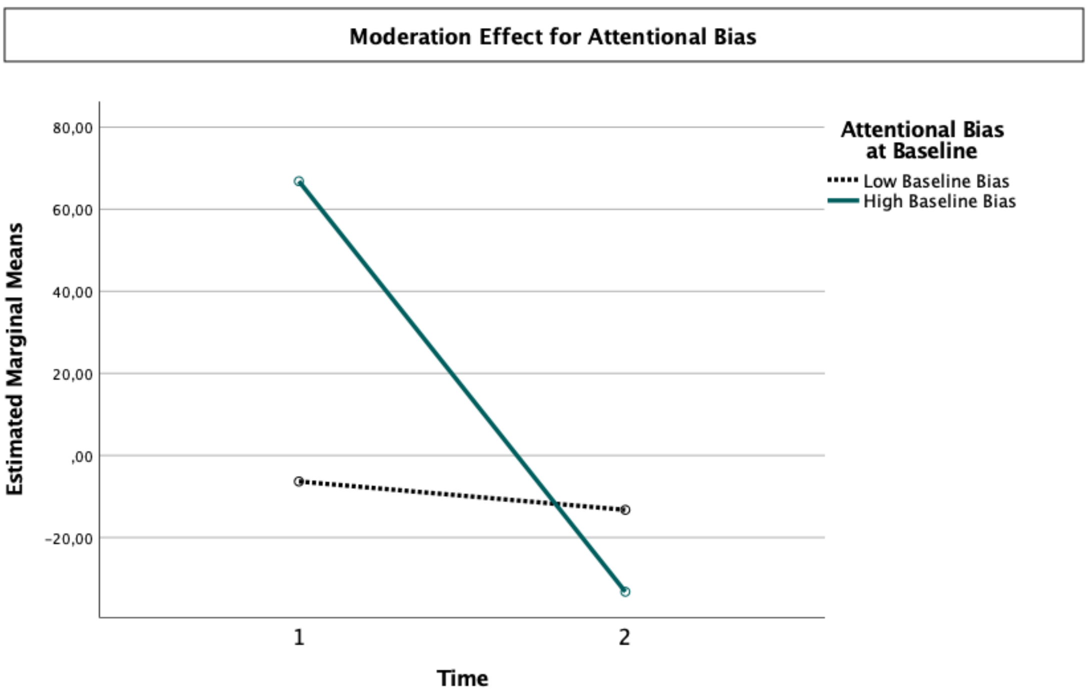
For self-identity bias, the Greenhouse-Geisser corrected tests are presented (ε= 0.58) since Mauchly's test showed that the assumption of sphericity had been violated (χ^2 (2)= 14.42, p= 0.00). The results show that the treatment effects for self-identity biases were sustained for the follow-up period (F(1.16, 13.87)= 8.83, p= 0.01). More specifically, in post-hoc contrast tests, the difference in means from baseline to post-test was significant (M= 0.23, SE= 0.08, p= 0.04). Correspondingly, the difference in means from baseline to follow-up remained significant (M= 0.25, SE= 0.08, p= 0.03). However, the difference in means from post-test to follow up was not significant (M= 0.02, SE= 0.03, p= 1.00). Therefore, in line with the hypothesis, the treatment effects were maintained.

With regard to the fourth hypothesis, it was hypothesized that the treatment effect of CBM targeting attentional bias and self-identity bias would be moderated by the strength of attentional bias and self-identity bias at baseline. For the following two statistical tests, the assumption of sphericity was met (ε= 1.00). Furthermore, as with the first hypothesis, for this statistical test, the aggregated mean of the measures of post-test and follow-up was used again (measure 9 to 12). For attentional bias, the results show that sphericity assumed, the moderating effect of the strength of attentional bias at baseline was significant (F(1)= 7.94, p= 0.02). A similar result was obtained for self-identity bias and the moderating effect of self-identity bias at baseline was significant (F(1)= 7.23, p= 0.02). The graphs of the moderation effects for attentional bias and self-identity bias, respectively, are shown below. As displayed in the graphs, the moderation effect was amplifying and higher bias at baseline increased the treatment effect.

Regarding the fifth hypothesis, it was hypothesized that CBM responders would show a positive change in all-or-nothing behavior and avoidance behavior compared to CBM non-responders. In the following analyses, the assumption of sphericity was fulfilled (ε= 1.00). For attentional bias, CBM responders (M= 2.40, SD= 0.65) did not show a more positive change on avoidance behavior (F(1)= 1.28, p= 0.28) compared to CBM non-responders (M=2.48, SD= 0.64). A similar result was found for all-or-nothing behavior (F(1)= 0.00, p= 0.96). Correspondingly, for self-identity bias, SI-CBM responders (M= 2.19, SD= 0.32) did not demonstrate a more positive change on avoidance behavior (F(1)= 0.57, p= 0.46) in comparison to non-responders (M=2.62, SD=0.72). Regarding all-or-nothing behavior, there also was no difference between SI-CBM responders and non-responders (F(1)= 0.06, p= 0.81).

Figure 1

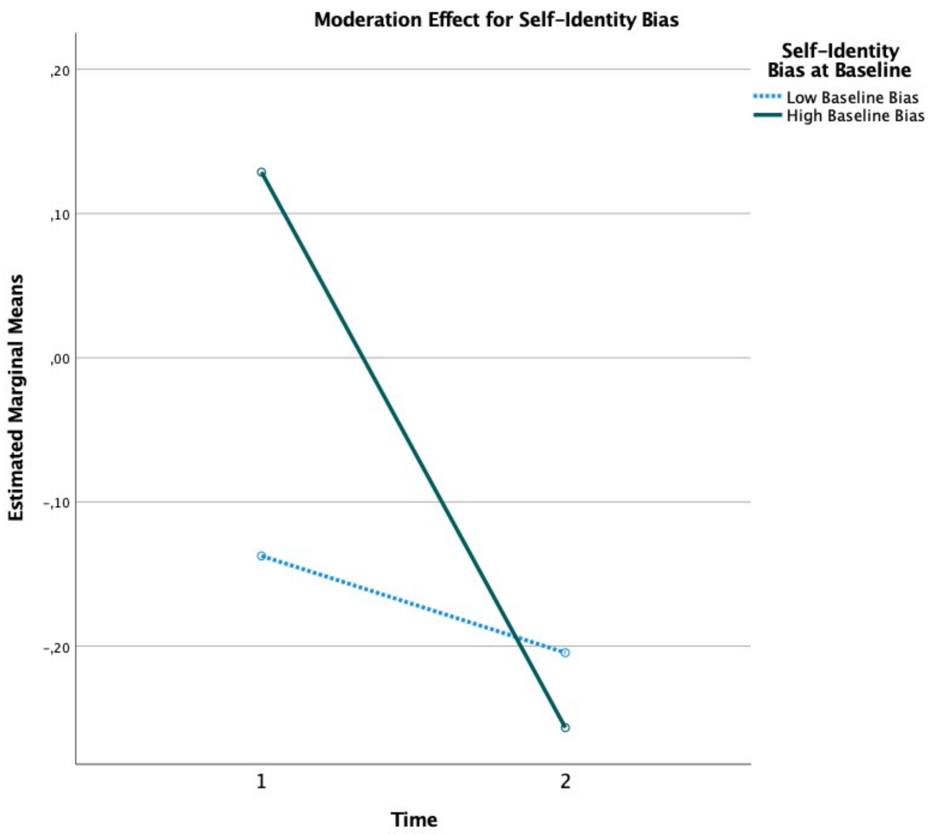
Line graph showing the moderation effect for attentional bias



Note. This figure shows an amplifying moderation effect for the strength of attentional bias at baseline. For A-CBM, higher attentional bias at baseline increase the treatment effect (N=15, p= 0.02).

Figure 2

Line graph showing the moderation effect for self-identity bias



Note. This figure shows an amplifying moderation effect for the strength of self-identity bias at baseline. For A-CBM, higher attentional bias at baseline increase the treatment effect (N=15, p= 0.02).

Discussion

The present pilot study aimed at investigating the effectiveness of CBM and at reducing attentional bias and self-identity bias targeting fatigue and secondary outcomes in renal patients. As expected, the current study showed that a CBM intervention significantly reduced attentional bias and self-identity bias regarding fatigue. This finding is in line with existing research which demonstrates that CBM modified attentional bias and interpretation bias in different psychological disorders, such as depression and anxiety (Hirsch et al., 2018;

Jones & Sharpe, 2017). Further evidence from CBM research on anxiety states that participants of a 12-week CBM intervention reported less interpretation bias and improved anxiety symptoms and stress reactivity (Rozenman et al., 2020).

Nevertheless, caution is needed when comparing the results of SI-CBM with I-CBM. Although literature indicates that self-identity bias and interpretation bias may bear resemblance in some aspects, the tasks in SI-CBM and I-CBM differ (Jacobson et al., 2019; Reyes et al., 2020). Furthermore, I-CBM in itself has different forms and is applied for a range of distinctive aims (Reyes et al., 2020). However, due to the lack of literature about CBM targeting self-identity bias related to fatigue, in the present study, it is partly referred to research about I-CBM. This emphasizes the novelty of the present study, since to our knowledge, this is the first study targeting fatigue related self-identity bias with an IAT-based CBM approach.

In the present study, the reduction of self-identity bias and attentional bias were medium in size for attentional bias and large in size for self-identity bias. Hence, a larger treatment effect was found for self-identity bias than for attentional bias. This finding is in line with the meta-analysis by Jones and colleagues (2017) which stated that the effect sizes for A-CBM in the 8 included studies varied from small to large. In earlier research, larger effect sizes were established than in more recent papers. The researcher stated that the median effect size of the included studies and thus the probably accurate effect size is 0.61 for A-CBM and 0.65 for I-CBM (Jones & Sharpe, 2017). Therefore, with effect sizes of 0.81 for self-identity bias and 0.56 for attentional bias, the results of the present research fall within this range.

The finding of the different effect sizes is in line with research which indicates that I-CBM may yield larger effects than A-CBM. In the meta-analyses by Jones and colleagues (2017), of the three studies which compared A-CBM and I-CBM, one study found better results for I-CBM regarding anxiety and depression (Jones & Sharpe, 2017). Furthermore, I-

CBM was shown to be effective for modifying bias related to anxiety and depression and to be superior to sham training and waitlist conditions. On contrary, A-CBM only yielded significant results in post-hoc-sensitivity analyses and when excluding post-traumatic stress disorder (Fodor et al., 2020). For social anxiety, CBM, in general, yielded small but significant effects on negative cognitive bias and symptoms of social anxiety. However, when comparing the two approaches, I-CBM was more effective than A-CBM.

Possibly, A-CBM may be particularly effective for changing automatic processing mechanisms in the short term (Liu et al., 2017). Similarly, I-CBM may have advantages for symptom reduction and A-CBM may be particularly suitable for weakening the vulnerability towards a stressful event. (Jones & Sharpe, 2017). However, as mentioned before, caution is needed regarding the transfer of the described findings to SI-CBM since SI-CBM and I-CBM entail different procedures. Still, the findings provide a valuable starting point for further investigations and add to the results of the present pilot study indicating that as I-CBM, SI-CBM may be a beneficial treatment approach.

Contrary to the hypothesis, after receiving CBM, individuals did not report significantly lower avoidance behavior or all-or-nothing behavior on post-test than on baseline. Since this study was the first to investigate whether CBM actually modifies avoidance behavior or all-or-nothing behavior related to fatigue, limited literature was available to base the hypotheses on. Partial support for the influence of CBM on behavioral outcomes comes from research on social anxiety which found that CBM targeting positive and negative interpretation bias was related to participant’s automatic avoidance response to emotional crowds in one experiment. However, the effects of CBM did not transfer to the behavioral task of approaching or avoiding emotional multi-facial pictures in the second experiment (Lange et al., 2010).

Moreover, in the field of alcohol addictions, CBM effects have been reported for approach-, and avoidance tendencies. For addictions, CBM aims at modifying “the automatically triggered action tendency to approach alcohol" (Eberl et al., 2013a, p.39). Next to research showing that CBM transformed approach bias into avoidance bias, research demonstrated that in comparison to a control group, people who followed CBM were more likely to avoid alcohol and to stay abstinent at one year follow up (Eberl et al., 2013; Wiers et al., 2011). Besides this evidence for addictive behaviors, there still exists uncertainty in the field of CBM about whether effects of CBM on cognitive bias apply to other cognitive, emotional or behavioral outcomes (Lange et al., 2010; Stevens et al., 2018). Due to the scarce literature, more research is needed about whether CBM effects on bias level transfer to effects on a behavioral level.

The transfer of CBM effects may depend on whether there is overlap or 'near transfer' between the outcomes. 'Near transfer' occurs if the cognitive processes that are trained in CBM correspond to the processes which are induced for a certain behavioral outcome. Hence, whether CBM activates a shared process determines whether CBM effects are transferred to behavioral outcomes (Hertel & Mathews, 2011; Stevens et al., 2018). For example, Stevens and colleagues (2018) investigated CBM-I targeting biases related to social anxiety and its effect on other behavioral components. They found that the combination of CBM and imaginal exposure (IE) reduced behavioral avoidance compared to receiving relaxation or neutral thinking before CBM. Possibly, effects sizes of CBM-I and the transfer to behavioral outcomes can be enhanced by including components that address behavioral and/or emotional outcomes which also facilitate 'near transfer' (Stevens et al., 2018).

Regarding the applicability of near transfer in the present study, the used SI-CBM was only partly suited for encouraging near transfer. For instance, the specific activities of the behavioral outcomes avoidance behavior and all-or-nothing behavior were not induced in the stimuli of SI-CBM, as the used stimuli only related to the concepts of vitality and fatigue. Still, near transfer may represent a valuable direction for further investigations and future research may analyze whether the concept of near transfer also applies to the behavioral outcomes related to fatigue. Due to the lack of literature in the field, future research should investigate whether CBM effects transfer to avoidance behavior and all-or-nothing behavior and how near transfer to behavioral outcomes can be facilitated. The present study provides a first step in filling this gap of knowledge.

Another reason for the lack of finding a transfer to behavioral outcomes may be that the follow-up period of 3 weeks was too short for behavioral change to take place. Moreover, the intervention duration of the CBM intervention may have been too short and possibly a greater number of sessions is needed to modify behavior. For example, one well-known model that may explain how change takes place is the Memory Systems Model of Implicit Social Cognitions (Amodio & Ratner, 2011). The model is based on the Dual Process Model but in addition to System 1 and System 2, it incorporates the processes through which cognitive processes interplay with behavior. These processes are different implicit memory systems which influence cognitions and behavior through learning mechanisms, such as instrumental learning, fear conditioning and semantic associative memory. Since these learning mechanisms require, for instance, that connections between cognitive concepts are slowly learned by repeatedly combining two stimuli, it appears unlikely that a lasting change occurs within three weeks after treatment (Amodio & Ratner, 2011).

The results show that for attentional bias, the maintenance of treatment effects could not be verified, and the observed data suggest that treatment effects were not sustained for the follow-up period of three weeks. In contrast, for self-identity bias, the treatment effects for CBM were maintained for three weeks. The finding that treatment effects were sustained for only self-identity bias, was surprising. However, this result corresponds to the mixed literature in the field regarding the durability of CBM effects. Some studies established that CBM treatment effects for interpretation bias were maintained for a one-month follow-up period (Hirsch et al., 2018; Rozenman et al., 2020). However, a recent meta-analysis failed to find long term effects both for attentional bias and interpretation bias (Jones & Sharpe, 2017).

Due to these mixed findings in literature, further research is needed to clarify whether CBM treatment effects for attentional bias and self-identity bias can be maintained and for which period.

One reason why this study was unable to establish long-term effects may be insufficient statistical power. The general linear model for the three time points, baseline, post-test and follow-up reduced the total number of participants to 13 which represents low power. Therefore, future research should aim at repeating the analysis with a bigger sample of participants to achieve adequate power. For example, using G*Power, the sample should consist of N= 40 participants, with a desired medium effect size of f= 0.25, alpha of 0.05 and a power of 0.80 (Salkind, 2012). Alternatively, since in the current dataset, many data points were missing, future research may apply a mixed modeling approach that can deal with random missing data-points. Furthermore, in the present study, a GLM repeated measures model with three levels was used to test the maintenance hypotheses. In comparison to the paired samples t-test used for the first hypothesis, two additional individuals were lost in the GLM in an already small sample. Thus, an alternative approach for a replication of the analysis may be to conduct a paired samples t-test from baseline to follow-up.

As expected, the treatment effect of CBM on attentional bias and self-identity bias was moderated by the strength of attentional bias and self-identity bias at baseline. In line with the Dual-Process Theories, individuals who indicated strong attentional bias or self-identity bias at baseline benefited more from the CBM treatment than participants with lower bias at baseline (Kahneman, 2003). Although, it could be considered that individuals with high bias have more room for improvement than individuals with a lower level of bias, there is literature which agrees with this finding. In line with the argumentation of Dual process theories, research on social anxiety found a baseline effect for A-CBM targeting attentional bias related to anxiety (Amir et al., 2011). Participants with a strong attentional focus on social threat cues at baseline showed a stronger decrease in anxiety symptoms after the CBM intervention compared to participants in the other conditions. The researcher concluded that for this specific group of patients, CBM appears to be most promising (Amir et al., 2011). Therefore, the results of the present study add to the limited literature on how the strength of biases at baseline affects CBM outcomes.

Moreover, the findings give promising indications for using CBM as a treatment. Practitioners may keep in mind the relevance of baseline bias when considering CBM as an adjunct to treatment for renal patients with fatigue. Nevertheless, there is the risk that the findings represent a statistical artefact due to regression to the mean tendency. Hence, future research should replicate the analyses with larger samples. For example, future research may test whether the moderation effect is linear and hence, whether higher baseline bias predict a stronger CBM treatment effect. Additionally, future research may investigate whether the effects remain after controlling for other potentially confounding variables.

It was hypothesized that CBM responders would show a more positive change in avoidance behavior and all-or-nothing behavior compared to CBM non-responders. Contrary to expectations, CBM responders showed similar levels of all-or-nothing behavior and avoidance behavior as non-responders. One reason why the results differ from the hypothesis may be due to the very small sample size. The smallest subsample for the responders contained 4 participants in VPT and 5 individuals in IAT. The sample size may have been too small to detect changes in the desired outcome variables. Hence, future research should repeat the analysis with an adequate powered sample to achieve reliable indications for whether responders differ from non-responders.

The findings of the present study need to be considered in the context of its limitations. The first limitation concerns the ‘black box’ nature of the CBM training and the psychometric properties of the CBM bias measure. Although in literature, VPT and IAT measures were found to have acceptable reliability and validity, it was not reviewed beforehand of the study (Greenwald et al., 2009; Schnabel et al., 2008). Furthermore, in the field of CBM, the psychometric properties of the bias measures remain a matter of debate. For example, the VPT is frequently applied in the field of CBM, however, findings of the reliability of this task differ (van Bockstaele et al., 2020). Regarding the IAT, the evidence for validity is more robust and indicates a poor predictive validity (Meissner et al., 2019).

Possibly, the poor reliability of the attentional bias measure can account for the inconsistency in findings on whether CBM reliably induces bias and how bias measures predict other constructs (e.g., anxiety) (van Bockstaele et al., 2020). For example, van Bockstaele and colleagues (2020) aimed at a systematic investigation of the psychometrics of different measures of attentional biases for anxiety. They found the VPT to have poor internal consistency and there was no significant correlation with other measures of attentional bias or measures of anxiety. Therefore, the authors highlight the need to assess the psychometric properties in attentional bias research (van Bockstaele et al., 2020).

Regarding the 'black box' nature of CBM, the present research identified a change of attentional bias and self-identity bias after the CBM intervention. However, earlier research already questioned what constitutes this change of bias and whether it can be attributed to a learning effect (van Bockstaele et al., 2017). In a recent study by van Bockstaele and colleagues (2017), it was suggested that if A-CBM based on the VPT paradigm can modify attentional bias, the effects should also occur when using other attentional bias measures. However, the effects of the VPT did not transfer to other measures (i.e., the exogenous cueing task, visual search task). One reason for this finding may refer to the exact nature of bias. For example, for attentional bias, the components of the bias remain unclear, and it may be questionable whether they represent a one-dimensional construct (van Bockstaele et al., 2017). Nevertheless, in a study by Wiers and colleagues (2013), the same change in approach bias found with an AAT could be adapted to an approach-avoidance IAT. Hence, more research is needed in this direction. For example, future research may investigate whether the CBM effects that were established in the present study depend on VPT for A-CBM and on

IAT for the SI-CBM or whether similar effects can be found with other measures. Additionally, future research may review whether CBM inherently modifies automatic thought processes or if a learning effect applies.

Another relevant issue in the present study is that all subjects were exposed to both, A-CBM and SI-CBM. If the underlying processes that are trained in the tasks are similar, the specific effects of either CBM cannot be reliably distinguished. Although participants in the present study started with either A-CBM or I-CBM, they followingly participated in both CBM tasks. Therefore, future research may consider designing the CBM intervention in a way that enables investigating the effects of A-CBM or SI-CBM separately.

A second limitation of the current study was that a large part of the already small sample was not included in the statistical models due to incomplete data. Since participants did not answer all questions, there were a lot of missing data which reduced statistical power and affects the reliability and validity of findings. No imputation of missing values was applied because of the limited sample size of the dataset. Additionally, the limited number of measurement points did not provide a reliable database for the implementation approach. Nevertheless, using only the observed data may increase the chance of selection bias since only data of participants who completed the CBM treatment, and all measures were used. No information is available about participants who dropped out of the intervention and did not finish all measures which makes it difficult to determine whether these participants differ in other characteristics than the CBM intervention (Nunan et al., 2017).

Despite the limited number of participants, the results of the present study give a valuable direction for future research since, until now, no studies investigated CBM targeting attentional bias and self-identity bias in the context of fatigue. This research adds to the limited literature in the field of CBM and fatigue and contributes to filling this gap of knowledge. Still, future research is suggested to replicate the analyses of this study with more participants and adequate statistical power.

Next to the described limitations, this research had several strengths. The first strength of the present research was that to our knowledge, this study was the first to investigate the effectiveness of CBM targeting attentional bias and self-identity bias related to fatigue in renal patients. Past research already provided evidence for the effectiveness of CBM in modifying attentional bias and interpretation bias for several psychological disorders, including depression, anxiety and eating disorders (Hirsch et al., 2018; Jones & Sharpe, 2017; Yiend et al., 2014). Nevertheless, currently, little literature is available which investigates CBM targeting bias related to fatigue. Additionally, until now, no research examined the effectiveness of CBM on self-identity biases. The current study provides the first preliminary evidence suggesting the effectiveness of CBM aimed at reducing bias related to fatigue.

A second strength of the current study was that this was the first study to explore the effect of CBM on all-or-nothing behavior and avoidance behavior related to fatigue. Little research is available that investigates the effect of CBM on behavioral outcomes and therefore, this research addresses this gap of knowledge. Moreover, for fatigue and the related cognitive bias, currently, no extensive treatment is available (Artom et al., 2014). The current study investigates a promising treatment approach that addresses the automatic cognitive processes which underlie the maintenance of fatigue and which are not targeted in the available treatments (Hou et al., 2014). Furthermore, since the present study refers to Dual-Process Approaches, this research contributes to finding a treatment for fatigue in renal patients which is based on an exhaustive theoretical model (Kahneman, 2003).

The Single Subject Design (SED) represents a third strength of the current study. Since SEDs reliably show whether an intervention works in real life and are easily implemented, they are a suitable design for investigating a novel approach like CBM. Hence, this design provides the possibility to obtain valuable indications about a new treatment before implementing research on a larger scale (Byiers et al., 2012).

A final strength of the current study was that the CBM intervention contained multiple sessions. Although Yiend and colleagues (2014) established the effectiveness of a single-session CBM targeting cognitive bias, other research found an effect in a multiple-session CBM training (Hirsch et al., 2018). Correspondingly, a recent meta-analysis established that a multiple session CBM intervention is more effective than a single session CBM (Jones & Sharpe, 2017).

In conclusion, this study aimed to investigate CBM targeting attentional bias and self-identity bias regarding fatigue and secondary outcomes in renal patients. As expected, the CBM intervention significantly reduces attentional bias and self-identity bias related to fatigue and the strengths of bias at baseline moderates this treatment effect which adds to the internal validity of the present study. In the present research, participants did not report lower avoidance behavior and all-or-nothing behavior at post-test than at baseline. Since this finding corresponds with the uncertainty in the field about the transfer of CBM on non-cognitive outcomes, more research is needed in this area. Future research should check whether CBM effects transfer to avoidance behavior and all-or-nothing behavior and how ‘near transfer’ to clinical outcomes as symptoms of fatigue can be facilitated.

The present research showed that only for self-identity bias, the effects were significantly maintained for three weeks follow-up. Due to mixed findings in the current literature on the sustainability of CBM effects and the lowered statistical power in the present study, future research should repeat the analyses in a larger sample. Furthermore, the present study explored the underlying mechanism of CBT and aimed at analyzing for which group of individuals CBM is most effective. Contrary to expectations, individuals evaluated as CBM responders showed similar levels of avoidance behavior and all-or-nothing behavior as non-responders. Since the analyses in the present study lowered the statistical power, future research is suggested to review whether responders differ from non-responders with an adequate powered sample.

Finally, the present study underlined the importance of investigating an efficacious treatment approach for fatigue in renal patients. Since currently no comprehensive treatment for fatigue is available, the present study contributed to investigating a treatment approach that targets the maintaining cognitive factors of fatigue which are not addressed in current treatment approaches and that is based on an exhaustive theoretical model. This study presents a valuable starting point for the further investigation of a novel treatment approach and contributes to filling the gaps in the current literature.

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