Implicit Processes in Fatigue and Vitality, a longitudinal single group experiment

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Abstract

Introduction - Fatigue is a subjective feeling, which 5-20% of the Dutch population experienced in the past two weeks (Connolly, et al. 2013). Vitality is the feeling of 'having energy to the self', and is experienced as a positive feeling. The self-concept consists of the cognitions an individual has about one-self, and can be measured explicit and implicit. The Implicit Association Test (IAT) aims to measure implicit attitudes by humans response time between two associative tasks. In this study the focus is on the implicit self-concept of participants. The IAT-CBM aims to intervene on the implicit level, and therefore strengthen (*self* and *vitality*) and or weaken (*self* and *fatigue*) an association between two concepts. The aim of this study was to measure the test-retest reliability of the IAT, with a one-day interval. A second aim of this study was to evaluate the efficiency of intervening with the IAT-CBM. Measured by the IAT, the Checklist Individual Strengths (CIS) and the Dutch Vitality Scale (VITA-16).

Method – This longitudinal single group study concluded 33 participants at baseline. A 16-day intervention period was conducted, with IAT measurement moments at baseline, halfway and post intervention. At the first and second day a test-retest reliability test was conducted. VITA-16 and CIS results were retrieved at baseline and post measurement. IAT-CBM training was presented to participants through SoSciSurvey training environment. During the IAT-CBM participants were presented with *self* and *vitality* trails (40) and *others* and *fatigue* trials (40). Participants received a daily reminder in their mail. Data was analyzed in SPSS.

Results - Results showed a test-retest reliability of .381 (α) in 32 participants. Overall, there were no significant results of the training according to the IAT, CIS and VITA-16. However, participants (N=12) with a fatigue bias at baseline measurement showed a significant positive difference towards vitality between baseline- and halfway measurement. CIS results showed a significant improvement in the second training group (N=19).

Discussion - Compared to other research, the test-retest correlation of the IAT found in this study is moderate. Therefore, interpretation of the IAT results of the IAT-CBM training should be done with caution. This study was performed with a small group of participants, which fitted the design of this study. Effect of the IAT-CBM was measured implicit and explicit. Further research on the IAT-CBM in the fatigue-field should emphasize a control group, a bigger intervention group and fatigue bias at baseline, before implementing the intervention in practice. The IAT-CBM training is a potential low-cost, easy-to-use, effective intervention method for people with fatigue, but needs to be studied more before the intervention could be carried out in practice.

Abstract (Dutch)

Introductie – Vermoeidheid is een subjectief gevoel dat 5-20% van de Nederlandse bevolking heeft ervaren in de afgelopen twee weken (Conolly, et al. 2013). Vitaal is het gevoel van 'energie hebben voor jezelf' en wordt ervaren als een positief gevoel. Het zelfconcept bestaat uit de cognities die een individu heeft over zichzelf. Deze cognities kunnen zowel impliciet als expliciet gemeten worden. De Impliciete Associatie Test (IAT) heeft als doel impliciete attitudes te meten aan de hand van reactiesnelheid tussen twee associaties. In deze studie ligt de focus op het impliciete zelfconcept van deelnemers. De IAT Cognitieve Bias Modificatie (IAT-CBM) heeft als doel te interveniëren op het impliciete niveau en daarbij de associatie tussen *zelf* en *vitaliteit* te versterken en/of de associatie tussen *zelf* en *vermoeidheid* te verzwakken. Het doel van deze studie is om de test validiteit van de IAT te meten, met een één dag meetinterval. Tevens streeft deze studie ernaar de effectiviteit van de IAT-CBM te meten. Met de IAT, CIS en de VITA-16 als meetinstrumenten.

Methode – 33 participanten hebben meegedaan in deze studie. De interventie duurde zestien dagen met IAT meetmomenten bij start, halverwege en na afloop, CIS en VITA-16 meetmomenten bij start en na afloop. Voor de validatie meting is de IAT afgenomen op dag één en twee. Participanten ontvingen dagelijks een link via Sosci Survey, inclusief twee keer over zes IAT-CBM trainingen. Gedurende de IAT-CBM training ontvingen participanten *zelf* en *vitaliteit* (40) en *anderen* en *vermoeidheid* (40) associaties. Data is geanalyseerd in SPSS.

Resultaten – Een test-retest correlatie van .381 (α, N=32) is gevonden in deze studie voor de IAT. Er waren geen significante resultaten van de training, gemeten met de IAT, CIS en VITA-16. Echter, participanten met een vermoeidheidsbias (N=12) bij start van de training toonden een significant verschil richting vitaliteit tussen de start van de training en halverwege. Er was een significante verbetering in CIS-resultaten voor de tweede trainingsgroep (N=19).

Discussie – In vergelijking met andere literatuur was de test-retest correlatie van de IAT zwak. Interpretatie van de resultaten van de IAT in deze studie moet met enige voorzichtigheid worden gedaan. De trainingsgroep was klein (N=33) in deze studie, passend bij een experiment. Effect van de IAT-CBM was zowel impliciet als expliciet gemeten Dit gaf inzicht in effecten op beide levels. Verder onderzoek naar de IAT-CBM voor vermoeidheid zal de nadruk moeten leggen op een controle groep, een grotere trainingsgroep en aanwezigheid van vermoeidheid. De IAT-CBM training is mogelijk een goedkope, makkelijk te gebruiken en effectieve interventie. Meer onderzoek zal gedaan moeten worden voor implementatie in de praktijk.

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1. Introduction

1.1. Fatigue

Fatigue is a feeling any person experiences from time to time. A subjective feeling that 5-20% of the general population experiences as a persistent and troublesome problem in daily life, half of these individuals remain having this feeling after 12 months (Connolly, O'Toole, Redmond & Smith, 2013). Cardol et al. (2005) even state that fatigue is a feeling which more than one third of the population experienced in the last two weeks. Fatigue causes limitations in mental, physical and social functioning of the individual, and has a social-economic impact on society, such as increased medical consumption and not able to attend work (van 't Leven, Zielhuis, van der Meer, Verbeek & Bleijenberg, 2010). Individuals, experiencing chronic fatigue complaints, are not only more likely to be absent from work over a long period of time. These individuals also have a lower work quality, which in turn increases work-related stress (Ricci, Chee, Lorandeau & Berger, 2007). Although, fatigue is a common feeling among people, there is no clear definition given in literature. Different definitions share an overlap in components of fatigue. The main focus is that fatigue is a subjective, private experience of the individual which interferes with the desired activities in life. The definition used in this study, derives from a study of Bol, Duits, Hupperts, Vlaeyen and Verhey (2009): "*Fatigue is a subjective lack of physical and/ or mental energy that is perceived by the individual (or caregiver) to interfere with usual and desired activities."*

Fatigue can be divided into *physical*, *cognitive*, and *mental fatigue*, according to Finsterer and Mahjoub (2014). *Physical fatigue* symptoms are described as decreasing muscle performance; decreased performance and decreased ability in performing mental tasks. It often occurs after intensive exercise; inflammation; (chronic) disease or a long period of increased stress. *Cognitive fatigue* is a subjective experience of the individual, and is defined as 'a decrease in or an inability to sustain a certain level of task performance throughout the duration of a continuous information processing process'. Cognitive fatigue symptoms are self-reported feelings of fatigue; tiredness; weakness; exhausting; and lack of energy. Last, *mental fatigue* is described as the temporarily inability of a mentally tired person to maintain optimal mental performance. Fatigue is a multidimensional phenomenon, with often a combination of physical, cognitive, and mental aspects.

Normal feelings of fatigue in healthy individuals are often a consequence of intense activity. This feeling is, often, predictable; easy to reduce by rest and does not interfere with daily

life (Finsterer & Mahjoub, 2014). This sort of fatigue is also called *acute fatigue*, which refers to the feeling of fatigue being present for less than a week. If the feeling of fatigue is present in the individual from one week up to one month, the feeling is called *transient fatigue*. *Prolonged fatigue* is referred to when the feeling is present from one month to six months, and *chronic fatigue* when the feeling is present for six months or longer (Jones, Kohl, Ahmadipour, et al. 2007). Chronic fatigue can be caused by a (chronic) disease, an extended period of stress, a psychiatric cause or the chronic fatigue syndrome (CFS). CFS is characterized by the experience of persistent and severe fatigue in addition to other symptoms like pain, sleep disturbance, and reported cognitive deficits over a period of 6 months or longer (Band, Barrowclough, Caldwell, Emsley & Wearden, 2017). The prevalence of CFS in the Dutch population is estimated at 30.000 to 40.000 people (van 't Leven, Zielhuis, van der Meer, Verbeek & Bleijenberg, 2010). Diagnosis of CFS can only be set after excluding physical and/or psychiatric causes.

1.2. Vitality

If fatigue decreases, feelings of vitality might increases. Vitality is known as the opposite feeling of fatigue and emphasizes the feeling of 'having energy available to the self' (Nix, Ryan, Manly & Deci, 1999). Ryan and Frederick (1997) described that subjective vitality reflects a humans' well-being and covers both physical and psychological factors that impact the feeling of having energy to the self. Niemiec, Ryan, Patrick et al. (2010) described vitality as a positive indicator of psychological health. Vitality is also described as a salient and dynamic state, which has restorative and regenerative aspects (Nix, et al. 1999). This means that feelings of vitality changes over time, and the individuals are able to notice this change in vitality. Several aspects have a positive influence on feelings of vitality, namely freedom of conflicts, autonomy, positive feeling of health and feeling of being capable. Vitality is also associated with less depressive symptoms and a better overall health (Niemiec, et al. 2010). However, according to the two continua model (Westerhof & Keyer, 2009) vitality and fatigue can be related but also are able to exist besides each other. Indicating that a person can experience feelings of fatigue, but also can report a positive feeling of vitality or other aspects of mental well-being. Feelings of vitality fits in the new definition of health, with a switched focus on abilities instead of disabilities; *'the ability to adapt and self-manage in the face of social, physical, and emotional challenges'* (World Health Organization).

Just as fatigue, vitality has different aspects and is a multidimensional phenomenon. Comparable to the feeling of fatigue, vitality also has three components; energy, motivation, and

resilience (Strijk, Wendel-Vos, Picavet, Hofstetter, Hildebrandt. 2015). Energy is characterized by the feeling of having enough energy, physical as well as mental. Motivation is assumed to be important to feel vital by achieving goals. For achieving goals an individual is required to put energy in a certain goal, and will be rewarded after achieving this goal. In this process motivation is an important motive. Lastly, resilience is an aspect of vitality, which according to Strijk et al. (2015), the ability to recover and to bounce back after a setback.

Individuals could perceive themselves as vital or fatigue, these perception is related to the self-concept an individual has about oneself.

1.3. Self-concept

The self-concept consists of cognitions an individual has about one-self. Asendorpf, Banse and Mücke (2002) define self-concept as an associative network containing all associations of the concept of self with attribute concepts describing one's personality. To visualize this, the associative network in the human brain is a network of nodes. If one node is activated the nodes having a strong association with the self-concept are more easily reached.

For example, individuals show a quicker response to 'tired' or 'tired-cues' if they associate oneself with fatigue (Cunningham & Turk, 2017). This phenomenon is called the self-concept bias. Assuming nodes strongly related to one's (unconscious) perception of oneself are stronger associated, and therefore have a quicker response time. One's self-concept can be measured by response time to a stimulating cue. For example, if the 'self' node is activated, there will be a quicker response to the node 'tired' if the individual has a strong association between the 'self' and 'tired'.

1.4. Measurement of self-concept

According to the dual process theory, individuals process information through two different systems; the implicit system and the explicit system. Greenwald and Banaji's (2000) are founders of a recent development which states that people process social information not only explicit but also implicit. Explicit processes are characterized as slow, conscious and controlled processes. Until now, self-report measurements are mostly used to measure self-concept and/ or personality, for example the Checklist Individual Strengths (CIS); the Dutch Vitality Scale (Vita-16); or a self-report questionnaire. Explicit measuring of the self-concept has a relative high internal reliability and test-retest reliability (Lindgren, Neighbors, Gasser, Ramirez, & Cvencek, 2016). But also has disadvantages, humans have a poor introspective knowledge about themselves

because they are motivated to keep unpleasant and anxious thoughts and feelings outside awareness (de Cuyper, de Houwer, Vansteelandt, Perugini, Pieters, Claes, & Hermans, 2017). To compliment explicit measurement of self-concept, the self-concept can also be measured in an implicit manner.

Implicit measurement of the self-concept is based on information that is not intentionally given to inform about the self (Asendorpf, Banse & Mücke, 2002), and therefore is characterized as unconscious, reflexive, fast and automatic. Implicit self-concepts that are activated more over time are assumed to become active quicker, when exposed to an associated cue (Lindgren, et al., 2016). The distinction between implicit and explicit evaluating cues is mainly interesting if these two differ from each other.

The Implicit Association Test (IAT) is the most common tool for measuring implicit self-concept (Cuyper, et al., 2017). The IAT aims to measure strengths of associations between concepts by comparing response times in two combined discrimination tasks (Egloff, Schwerdtfeger & Schmukle, 2005). The IAT is a computer based test which measures reaction time to sort stimuli belonging to four different categories. For example, when having this four categories: *self, others, fatigue* and *vital*, self-concept is measured by the difference in reaction time between two concepts. For example the difference between *self* and *fatigue* and *self* and *vital*. The difference in reaction times is assumed to be the relative strength of the associations in (implicit) memory. Advantages of the IAT are that it is a relative quick measurement tool, non-sensitive to faking and it has a relative high internal consistency (Lindgren, et al., 2016). The test-retest reliability of the IAT is higher than the reliability in other implicit measurements, but lower then explicit measurement (Cuyper, et al., 2017). In this paper, a test-retest analysis will be conducted using the IAT, measuring the implicit self-fatigue bias in individuals to assess the reliability of the IAT.

1.5. Cognitive Bias Modification

Cognitive Bias Modification (CBM) is identified by Cristea, Kok and Kuijpers (2016) as '*The direct manipulation of a target cognitive bias, by extended exposure to task contingencies that favor predetermined patterns of processing selectively.'.* There are different biases which can be influenced by CBM, for example, interpretation bias, attention bias and self-concept bias as discussed earlier. In this paper the focus is on the self-concept bias of fatigue and vitality in individuals.

Pincus and Morley (2001) found in their meta-analysis that cognitive bias is related to the presence and intensity of pain in individuals, and that these individuals showed an information processing bias towards pain stimuli. In this paper, the focus is on the experience of fatigue and vitality, just as pain a subjective experience of an individual. A stronger bias at baseline predicts a higher impact of the CBM training, in CBM interventions aimed at anxiety (Wiers, Gladwin, Hofmann, Salemink & Ridderinkhof. 2013).

CBM, which occurs over a period in multiple sessions, has been found to have a larger and more stable effect then single session CBM for depression and anxiety (Hallion, & Ruscio, 2011). Krahé, Mathews, Whyte and Hirsch (2016) found a positive effect of CBM in a 10-session period, to examine whether repeatedly training positive interpretations reduces negative interpretation bias in anxiety and depression. In this study, a multiple CBM session of twelve sessions over a period of sixteen days is conducted, with a halfway measurement.

For this paper, the assumption is made that this phenomenon can also influence the self-concept bias in fatigue. By strengthening the association between *self* and *vital,* and thereby weakening the association *self* and *fatigue.* The CBM of the self-concept bias can be established through an adjustment of the IAT. By not only measuring the association of the concept, but also intervening by linking the concept *self* to *vital* and the concept *fatigue* to *others*, over a period of twelve IAT-CBM sessions.

1.6. Aim of the study

First, this study aims to discover the reliability of the Implicit Association Test (IAT), measuring the implicit process of *self* and *fatigue,* compared with *vital* and *others* with a one-day interval. The reliability of the IAT is discovered in this study, to determine if the IAT is a suitable measurement tool to assess the efficacy of the IAT-CBM on the implicit level.

Second, this study aims to evaluate the efficacy of intervening with the IAT-CBM training by strengthening the association between *self* and *vital*. The evaluation would be assessed by the IAT, the Checklist Individual Strengths (explicit fatigue self-report measurement) and the VITA-16 (explicit vitality self-report measurement).

Study design for this study is a longitudinal single group experiment, to explore the feasibility of the IAT-CBM in fatigue. Literature indicates multiple IAT-CBM sessions are more effective. The experiment contains twelve IAT-CBM sessions and four days with a regular IAT, with a halfway measurement with the IAT. Fatigue and vitality are also measured at explicit

level, with the Checklist Individual Strengths and the Dutch Vitality Scale (VITA-16), at baseline and post measurement.

1.7. Research questions

- Does the D-score of the IAT-CBM significantly improve towards the vitality bias after the 16-day training?
- Does the Modified Implicit Association Test (IAT-CBM) training significantly decrease feelings of fatigue after the intervention period, measured by the Checklist Individual Strengths (CIS)?
- Does the Modified Implicit Association Test (IAT-CBM) training significantly increase feelings of vitality after the intervention period, measured by the Dutch Vitality scale (Vita-16)?

1.8. Hypothesis

- There is a positive correlation between the first Implicit Association Test (IAT, day 1) and the second Implicit Association Test (IAT, day 2).
- After the twelfth day IAT-CBM training, participants will report a significant lower score on fatigue, and a higher score on vitality measured by the Implicit Association Test (IAT); the Checklist Individual Strengths (CIS); and the dutch Vitality Scale (Vita-16).

2. Method section

2.1. Study design

In this study, a longitudinal single group experiment was conducted. All participants went through the same intervention process, over a period of 16 days, with a baseline, halfway and post measurement. An IAT-CBM training was used in between the measurement moments. Fatigue was measured implicit and explicit at the baseline, and post-measurement. Implicit by the IAT, and explicit by the Checklist Individuals Strengths (CIS) and Vita-16, materials will be explained in chapter 2.3. Also, at baseline personal details such as gender, age and profession were asked. Halfway through the intervention the IAT is measured, to track progress in the participants. See figure 1 for a schedule of the study process.

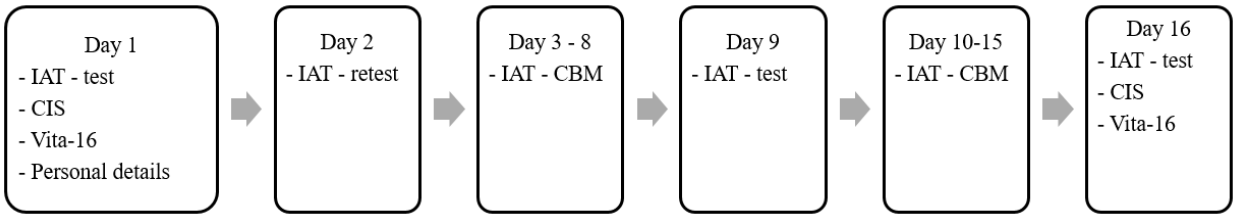

Figure 1. Schematic overview study design

Inclusion criteria for participation in this study were age 18 years or older, having a working internet access during the intervention period, mastering the Dutch language and appropriate internet- and email skills. Exclusion criteria for participation were acute illness, no working internet connection, no active email address, not mastering the Dutch language and being aged under 18.

2.2. Participants

Participants were recruited through the social network of the researcher and social media (Facebook and Instagram). A total of 42 participants subscribed to the training by email and 33 participants started the training at day one. Reasons for dropping out before starting the training were; not receiving the email (N=3), being on a holiday (N=2), being sick (N=1) and unknown (N=2). Mean age of the participants was 31.48 years (SD=10.81), with a minimum age of 22 and a maximum of 55. 75.8% was female (N=25) and 24.2% was male (N=8). 22 participants worked, 6 participants were studying, 4 participants worked and studied at the same time, and one participants didn't work or study. All participants signed the informed consent with 'yes I understand' at the first day of the questionnaire.

A total of 33 participants started the training at day 1, 32 participants finished the test-retest. 30 participants followed the training till the halfway measurement. 30 participants completed the training, of which 26 did the baseline, halfway and post measurement. 4 filled in two or one measurement moments. This means 78.8% completed the intervention, and there was a dropout rate of 21.2%.

2.3. Materials

In this study the IAT, the IAT-CBM, the CIS and the VITA-16 were used. In this paragraph these materials are described.

2.3.1. Implicit Association Test

The Implicit Association Test (IAT) is used to measure implicit vitality in this study. The IAT is a computerized reaction-timed word sorting task, asking participants to sort words into pairs and/or categories as quick as possible with as less errors (Goldring, & Strelan, 2016). The IAT is used since the last two decades as a measurement tool for implicit attitudes and/or associations in psychology. The IAT is also widely used for measuring implicit attitudes in clinical, social and experimental domain of psychology (Hussey & De Houwer, 2017).

The IAT contains four categories, two target categories and two attitude categories. In this study the two target categories where *self* and *others,* and the two attitude categories where *fatigue* and *vital.* Words used for the four categories are described in appendix D, retrieved from a previous thesis by Bol (2017). The IAT is a computer bases measurement tool, participants can discriminate *fatigue* and *vital* words to the right target category (*self* and *others*) by using the ‘E’ or ‘I’ key on the keyboard. The IAT contains seven blocks, described in table 1.

Table 1

Sequence of trial blocks in the fatigue/vitality IAT

Block	No. of trials	Function	Items assigned to left-key response	Items assigned to right-key response
1	20	Practice	Self-words	Other-words
2	20	Practice	Fatigue words	Vitality words
3	20	Practice	Self-words + Fatigue words	Other-words + Vitality words
4	40	Test	Self-words + Fatigue words	Other-words + Vitality words
5	20	Practice	Other-words	Self-words
6	20	Practice	Other-words + Fatigue words	Self-words + Vitality words
7	40	Test	Other-words + Fatigue words	Self-words + Vitality words

2.3.2. Modified Implicit Association Test

For the aim of this study, the IAT as described above (paragraph 2.3.1.) is modified, further called the IAT-CBM (Cognitive Bias Modification). Instead of only measuring implicit vitality, the IAT-CBM aims to interfere on the implicit level. Hypothesized is that by only linking the concepts *self* with *vitality* and *other* with *fatigue* the implicit association between *self* and *vitality* will become stronger, therefore the participant will feel more vital. This is measured explicitly by the Checklist Individual Strengths and Vita-16 and measured on the implicit level with the IAT. With the IAT-CBM participants stop the test after block 4, by closing the window. The structure of the IAT-CBM is presented in table 2.

Table 2

Sequence of trial blocks in the IAT-CBM

Block	No. of trials	Function	Items assigned to left-key response	Items assigned to right-key response
1	20	Practice	Other-words	Self-words
2	20	Practice	Fatigue words	Vitality words
3	20	Practice	Other-words + Fatigue words	Self-words + Vitality words
4	40	Test	Other-words + Fatigue words	Self-words + Vitality words

2.3.3. Checklist Individual Strengths

The Checklist Individual Strengths (CIS) is a 20-item measurement tool, measuring four aspects of fatigue. Subjective feeling of fatigue is measured with 8 items, concentration in 5 items, motivation in 4 items and physical activity in 3 items. Measured by a 7-point Likert Scale (1= No, that is not true and 7= Yes, that is true), half of the items need to be recoded. The CIS is a measurement originally developed for clinical measurement of chronic fatigue syndrome (Bültmann, de Vries, Beurskens, Bleijenberg, Vercoulen, & Kant. 2000). The CIS is also applicable in the general population, Worm-Smeitink et al. (2017) found a high internal consistency (α = 0.84-0.95) and test-reliability (r = 0.74-0.86) of the CIS in the Dutch general population (n = 2288). The complete CIS questionnaire is described in appendix A.

2.3.4. Vita-16

The Vita-16 is a Dutch Vitality measurement based on the positive view on health. Vitality was defined in this questionnaire in three aspects (1) energy, (2) motivation and (3) resilience (Strijk, Wendel-Vos, Hofstetter, & Hildebrandt, 2017). Resilience was measured using 5 items, energy was measured by 5 items and motivation was measured by 6 items. On a 7-point Likert scale (1= No, that is not true and 7= Yes, that is true), with a higher score indicating a higher subjective vitality. Strijk, Wendel-Vos, Picavet, Hofstetter, and Hildebrandt (2015) developed the Vita-16 and found a high internal consistency and reliability of the scale (α=0,95). Including the three subscales energy (α=0.90), motivation (α=0.89) and resilience (α=0.90). The total vitality score is

estimated as according to: vitality score = mean (0.4 * energy + 0.3 * motivation + 0.3 * resilience). The Vita-16 questionnaire is described in appendix B.

2.4. Procedure

In this study an online platform, SoSci Survey, was used to combine the online survey (CIS and Vita-16) with the IAT and IAT-CBM training sessions. The participants were recruited through the social network of the researcher and through social media. The study protocol was approved by the Ethics Committee of the University of Twente (file number: BCE18014), at 02 / 07 / 2018. The first invitation emails were sent at 01 / 29 / 2018 and the platform was closed at 03 / 13 / 2018. The study was conducted in the Dutch language. During the test-period participants received daily reminders at their personal email-address. Before starting the surveys, participants signed an informed consent (see appendix C) stating that the participants could stop participating in the study at any time and that all information is treated confidentially.

The first measurement at day one, further called the baseline measurement, consists of five components, namely (1) demographic characteristics, (2) personal code, (3) CIS, (4) Vita-16 and (5) the IAT. Demographic characteristics contained questions about gender, age and having a job and/ or study. The personal code is formed by requesting the first letter of the participants first and last name plus the last two numbers of their year of birth. The CIS, Vita-16 and IAT are explained in the paragraph materials (2.3.). The baseline measurement took approximately 15 minutes to complete.

The second measurement was conducted at day two. The aim of the second day is to re-test the reliability of the IAT, this measurement contains the personal code and the IAT. From day three till day eight and from day nine till day 15, the training contains two components; the personal code and the IAT-CBM. The IAT-CBM aimed to intervene and therefore has a different design than the regular IAT, see paragraph 3.3.2. for further explanation on the IAT-CBM. On day eight the regular IAT is tested as a halfway measurement, containing the personal code and the IAT. On day sixteen the post measurement was taken from the participants, containing four elements: (1) personal code, (2) CIS, (3) Vita-16 and (4) the IAT. After completing the training period, a personal email was sent to participants providing the email address of the researcher. Offering the possibility to receive the results of the study and personal results if requested so.

2.5. Plan of analysis

The plan of analysis is described according to the hypothesis in this study, as described in paragraph 1.7..

Hypothesis 1:

There is a positive correlation between the first Implicit Association Test (IAT, day 1) and the second Implicit Association Test (IAT, day 2).

Data was analyzed and processed in IBM SPSS Statistics version 25. The first hypothesis was explored by a test-retest correlation using a paired samples correlation test. The SosciSurvey automatically calculates the D-score of the IAT, representing the mean by the standard deviation of all the latency scores in the two test blocks (Greenwald, Nosek, Banaji. 2003). Which resulted in a D-score for day one of the intervention period, and a D-score for day two. A negative D-score indicated a vitality bias and a positive D-score indicated a fatigue bias. Data was analyzed in SPSS and a correlation test was conducted between the two D-scores. The group was analyzed as a whole group, and also divided in participants with a fatigue bias at baseline measurement and participants with a vitality bias at baseline measurement.

Hypothesis 2:

After the twelfth day IAT-CBM training, participants will report a significant lower score on fatigue, and a higher score on vitality measured by the Implicit Association Test (IAT); the Checklist Individual Strengths (CIS); and the Dutch Vitality Scale (Vita-16).

For the second hypothesis implicit outcome (IAT) and explicit outcome (CIS and VITA-16) were analyzed separately. Significance of .05 or lower ($p \leq 0.05$) was used in all analysis.

The implicit outcome was analyzed with a paired samples t-test of the D-score baseline, halfway and post-measurement. D-scores were analyzed in the whole group of participants and also the group was split in two subgroups. A subgroup with a vitality bias at baseline and in a subgroup with a fatigue bias at baseline measurement. Expectations were that the fatigue bias subgroup would show a bigger improvement of the IAT-CBM training.

The CIS was conducted at baseline measurement (day 1) and post measurement (day 16), a higher score indicates a higher subjective feeling of fatigue (Likert scale 1-7). With a minimum score of 20, and a maximum score of 140. Cut-off point is 76 for fatigue, with a specificity of 90% and sensitivity of 73% (Bultmann et al. 2000). A paired samples t-test was conducted in the

whole group, and analyzed in the first training group (n=10) and second training group (n=19). This was done because of a possible external influence in the first training group, a national holiday. Mean score of overall CIS-score, baseline and post measurement were analyzed in SPSS. The subscales: activity, motivation, concentration and subjective feeling of fatigue were also analyzed.

Along with the CIS, the VITA-16 was measured at baseline measurement (day 1) and post measurement (day 16). A higher score indicates a higher feeling of vitality. The overall score was calculated according to the formula: mean (0.4 * energy + 0.3 * motivation + 0.3 * resilience). VITA-16 is divided in subscales: energy, motivation and resilience. Mean scores baseline and post measurement were calculated in SPSS, with a paired samples t-test, for the overall score and the subscales. Results were analyzed for the whole group as well as the first (n=10) and second training group (n=19).

3. Results

3.1. Test-retest

Hypothesized was that there would be a positive correlation between the first and the second IAT, with a one-day interval. 30 participants filled in the test measurement (day 1) as well as the retest measurement (day 2), those 30 datasets are used to conduct a test-retest analysis. A positive correlation indicates a positive relation between day one and day two of the intervention. The correlation test showed a correlation of .318, with a significance of .086. Meaning that there is no significant difference between the D-score on day one and the D-score on day two of the IAT measurement. However, when the sample is split into fatigue bias and vitality bias at baseline measurement, results showed a correlation of .574 in the participants with a vitality bias with a significance of .013 (p=.013). A correlation of .102 (p=.752) was found in the participants with a fatigue bias at baseline measurement. Indicating that the vitality biased group had a significant correlation between the measurement on day one and on day two. Results are presented in table 3.

Table 3

Test-retest paired samples correlation

	N	Correlation	Significance
D-score baseline measurement and retest measurement	30	.318	.086
D-score baseline measurement and retest measurement vitality bias	18	.574	.013
D-score baseline measurement and retest measurement fatigue bias	12	.102	.752

3.2. Results of CBM on implicit fatigue / vitality bias

Paired sample t-test of the D-score baseline, halfway, and post measurement did not show a significant difference between means, in the whole group. However, analysis with a distinction between a positive (fatigue bias) and a negative (vitality bias) D-score at baseline measurement showed two significant differences. Firstly, analysis showed that there was a significant difference between D-score baseline measurement and D-score post measurement in the vitality bias group. With a difference towards zero, indicating a decrease in vitality. Secondly, a significant difference between D-score baseline measurement and D-score halfway measurement in the fatigue bias group. With a difference towards zero, indicating an improvement of the fatigue bias was found. However, this effect was not found in the fatigue bias group comparing pre measurement with post measurement. Which indicates a declined intervention effect between day eight of the training and day sixteen of the training.

Table 4

Paired samples Test D-score baseline, halfway, and post measurement.

	Mean baseline measurement	Mean post measurement	t	p
All D-score (n=28)	-.084	-.132	-.691	.496
Vitality bias group - Negative D-score (n=16)	-.337	-.134	-2.317	.035
Fatigue bias group -Positive D-score (n=12)	.248	.094	1.554	.148
	Mean baseline measurement	Mean halfway measurement	t	p
All D-score (n=28)	-.084	-.132	.565	.577
Vitality bias group - Negative D-score (n=16)	-.348	-.215	-1.299	.213
Fatigue bias group - Positive D-score (n=12)	.269	-.021	2.560	.027
	Mean halfway measurement	Mean post measurement	t	p
All D-score (n=26)	-.106	-.051	-.768	.450
Vitality bias group - Negative D-score (n=15)	-.186	-.126	-.575	.575
Fatigue bias group - Positive D-score (n=11)	.002	.051	-.492	.634

3.3. Results of CBM on explicit fatigue / vitality bias

3.3.1. Results Checklist Individual Strengths

At baseline measurement the mean of the CIS was 73.69 points (SD 23.76; min 32; max 115). Mean score at post measurement was 71.55 (SD 24.89; min 32; max 118). Both scores are below the cut-off point of 76. An increased score indicates an increase of subjective feeling of fatigue. However, when CIS outcomes were analyzed separately in the first training group (n=10) and the second training group (n=19), there is a significant difference in CIS-outcome in the second training group in favour of vitality. Mean CIS-score at baseline measurement in the second training group was 78.11 (n=19; SD 24.79). Mean score at post measurement was 70.89 (n=19; SD 25.92). Paired samples test showed a significant difference (p = .048) between baseline measurement and post measurement in the second training group. Also, the participants in the second training group scored at baseline above the cut-off point (76), and post measurement below the cut-off point of the CIS.

CIS is divided in four subscales: activity, motivation, concentration and subjective feeling of fatigue. No significant improvement was found in any subscales, also when the data was split into the first training group and the second training group. The score on the subscale subjective feeling of fatigue significantly increased (p <.001) in the whole group, and in both subgroups. See table 5 for an overview of the mean scores of the CIS and subscales.

Table 5

CIS Score, and subscales physical activity; concentration; motivation; and fatigue severity scores, divided in all participants; training group 1; and training group 2 (n=19)

		mean CIS score baseline measurement	mean CIS score post measurement	t	p
overall CIS score (20 items)	All participants (n=29)	73.69 (SD 23.76)	71.55 (SD 24.87)	.631	.533
	Training group 1 (n=10)	65.3 (SD 20.21)	72.80 (SD 24.06)	-1.134	.286
	Training group 2 (n=19)	78.11 (SD 24.79)	70.89 (SD 25.92)	2.121	.048
subscale physical activity (3 items)	All participants (n=29)	10.46 (SD 4.73)	11.00 (SD 4.08)	.666	.511
	Training group 1 (n=10)	9.00 (SD 4.29)	10.30 (SD 4.59)	-.831	.427
	Training group 2 (n=19)	11.63 (SD 4.99)	10.11 (SD 4.62)	1.673	.112
subscale motivation (4 items)	All participants (n=29)	12.61 (SD 5.32)	13.64 (SD 4.79)	.426	.673
	Training group 1 (n=10)	10.30 (SD 3.68)	12.90 (SD 4.68)	-1.409	.192
	Training group 2 (n=19)	14.00 (SD 5.59)	11.89 (SD 4.93)	1.603	.126
subscale concentration (5 items)	All participants (n=29)	16.64 (SD 6.31)	18.6 (SD 5.45)	-1.612	.118
	Training group 1 (n=10)	16.50 (SD 4.60)	19.60 (SD 6.36)	-1.663	.131
	Training group 2 (n=19)	16.74 (SD 7.01)	17.21 (SD 5.97)	-.569	.576
subscale subjective feeling of fatigue (8 items)	All participants (n=29)	25.06 (SD 9.447)	31.21 (SD 10.87)	-5.021	<.001
	Training group 1 (n=10)	21.60 (SD 8.81)	30.00 (SD 11.14)	-4.494	.002
	Training group 2 (n=19)	26.26 (SD 10.41)	31.68 (SD 13.54)	-3.225	.005

3.3.2. Results VITA-16

Outcomes of the VITA-16 showed no significant results in the whole group of participants (n=29), first training group (n=10) and second training group (n=19). See table 6 for an overview of the score on the VITA-16 and the scores on the subscales energy, motivation and resilience.

Table 6

VITA-16 score, and subscales energy, motivation and resilience scores, divided in all participants (n=29), training group 1 (n=10) and training group 2 (n=19)

		mean VITA-16 score baseline measurement	mean VITA-16 score post measurement	t	p
overall VITA-16 score (16 items)	All participants (n=29)	132.24 (SD 38.02)	128.76 (SD 44.94)	.675	.505
	Training group 1 (n=10)	134.49 (SD 37.67)	123.42 (SD 47.85)	1.100	.300
	Training group 2 (n=19)	131.06 (SD 39.18)	131.57 (SD 44.42)	-.086	.933
subscale energy (5 items)	All participants (n=29)	21.07 (SD 6.63)	20.21 (SD 6.41)	.925	.363
	Training group 1 (n=10)	22.90 (SD 5.915)	20.60 (SD 6.47)	1.223	.252
	Training group 2 (n=19)	20.11 (SD 6.94)	20.11 (SD 6.51)	.000	1.000
subscale motivation (6 items)	All participants (n=29)	33.24 (SD 5.11)	32.93 (SD 5.82)	.741	.465
	Training group 1 (n=10)	32.80 (SD 5.63)	31.50 (SD 6.43)	1.081	.308
	Training group 2 (n=19)	33.47 (SD 4.96)	33.47 (SD 5.73)	.000	1.000
subscale resilience (5 items)	All participants (n=29)	25.34 (SD 3.810)	25.55 (SD 4.171)	.310	.759
	Training group 1 (n=10)	24.50 (SD 3.87)	24.10 (SD 5.36)	.364	.724
	Training group 2 (n=19)	25.79 (SD 3.89)	25.68 (SD 4.35)	.122	.904

3.4. Overall result

After the twelve day training, participants showed no significant difference on the D-score measured by the IAT at baseline, halfway and post measurement. However, vitality bias group at baseline (D-score < 0) showed a significant difference in IAT-outcome baseline - post measurement towards no bias (0). Also, a difference was found in the participants who showed a

fatigue bias (D-score > 0) at baseline measurement. This group significantly improved at halfway measurement. This effect decreased at post measurement, showing no overall significant result. However, the D-score was closer to zero at post measurement.

CIS score did not show an improvement in analysis with all participants but when the first training group and the second training group were analyzed individually, analysis showed a significant improvement in the second training group. VITA-16 showed no significant improvement in the overall score, nor in subscales.

4. Discussion

4.1. Comparison of existing literature with hypothesis and results of this study

Firstly, this study aimed to discover the reliability of the Implicit Association Test (IAT). Measuring the implicit association between *self* and *fatigue* compared to *vital* and *others*, with a one-day interval. Until now, IAT outcomes have a higher reliability correlations then other implicit measurements. Reliability correlations of the IAT normally lie between .60 and .70 (Lindgren et al. 2016). However, in the study of Egloff and Schmukle (2002) several test-retest correlation were presented variating from a .32 to a .69 correlation. Dasgupta and Greenwald (2001) found a test-retest correlation of .65 in an automatic attitudes IAT, with a one-day interval between measurements. In this study a correlation of .32 was found with an one-day interval, and a significance of .086. However, the participants with an vitality bias at baseline showed a correlation of .574 and a significance of .013. Which could indicate that the vitality group is experiencing less burden from the IAT. All correlations measured in this study were positive, however further research should be conducted to validate the IAT measurement for fatigue/ vitality. Results of the IAT in baseline, halfway and post measurement should be interpreted with the moderate correlation kept in mind.

The words used for the *self, others, fatigue* and *vitality* in the IAT (see appendix D), were retrieved from a former thesis (Bol, 2017). However, Bol found no significant correlation between two IAT measurement moments with a one-week interval. Applicability of words used in the Dutch fatigue/vitality IAT should be reconsidered in further research. A change exist that Dutch individuals do not relate strongly to words used for the different categories in this study, which could influence the validity of the IAT.

Secondly, this study aimed to evaluate the efficacy of intervening with the IAT-CBM, by strengthening the association between *self* and *vital*. It was hypothesized that after the twelve training days, participants will report a significant lower score on fatigue, and a higher score on vitality, measured by the Implicit Association Test (IAT); the Checklist Individual Strengths (CIS); and the Dutch Vitality Scale (Vita-16). Macleod and Mathews (2012) stated that experiments using multiple sessions of CBM across a extended time of period have a greater effect on the attentional and interpretive bias, in contrast to a single session CBM. This is supported by the research of Krahe et al. (2016) and Hallion and Ruscio (2011). In contrast to Fu, Du, Au and Lau (2013) who found an immediate effect of CBM after a single session but did not test this effect over a longer period of time. In this study twelve sessions of IAT-CBM were

presented to participants in a timespan of two weeks. However, a positive effect was found between baseline and halfway measurement in the fatigue biased group, only after 6 IAT-CBM sessions. This effect declined between halfway and post measurement, indicating 6 IAT-CBM sessions would be more effective in the fatigue biased group compared to a 12 sessions IAT-CBM. To determine how many sessions of the IAT-CBM would be most effective, further research should be done. Including a follow-up measurement to determine IAT-CBM effect over time.

Main findings showed no significant difference in all the participants, if analyzed as one group. In this study a sample of people with no specific fatigue complaints and / or Chronic Fatigue Syndrome was studied, which could have influenced the intervention effect. Research on CBM interventions in anxiety or pain, mostly include participants having this health complaints at baseline (Bowler, et al. 2012 & Sharpe, et al. 2011). To explore influence of fatigue complaints at baseline in this study, the responses were splitted into vitality bias and fatigue bias as measured at baseline.

The vitality biased group, significantly declined towards no bias between baseline and post measurement. Indicating a negative effect of the IAT-CBM on the self-concept bias, in participants starting with a vitality bias. In the fatigue biased group main difference was shown between baseline and halfway measurement, the fatigue biased group significantly improved towards vitality bias. The effect declined between halfway and post measurement, and was not significant between baseline, and post measurement. This indicates a positive effect of the IAT-CBM in the fatigue biased group, but not in the vitality biased group. Both fatigue, and vitality bias moved towards no bias during the IAT-CBM training, according to the IAT. This could mean that training an association which is already present, does not have a positive effect or even an adverse effect on the self-concept bias. But training an association (*self* and *vitality*) which is not present at baseline, has a stronger intervention effect of the IAT-CBM on the self-concept bias and could be a useful intervention in this group.

In the IAT-CBM training *vitality* - *self* words and *fatigue* - *other* words were trained. Woud, Hutschemaekers, Rinck and Becker (2015) conducted a study of the IAT presenting alcoholic related scenarios and neutral scenarios. In their study a training effect was found in the alcohol related group, with a stronger association after the training towards alcohol. Lack of effect on the neutral training group could be explained by using neutral and therefore less strong scenarios. In this study, fatigue words were used but instead of neutral words, vitality words were

used to train the participants. It should be noted that words used in the IAT-CBM should be highly relatable to fatigue and vitality to optimize the training effect. Using *self-vitality* and *others-fatigue* associations, instead of *self-vitality* and *other-neutral* words, could have contributed to a stronger training effect of the IAT-CBM.

Besides the IAT, also the explicit fatigue (CIS) and vitality (VITA-16) was measured with validated questionnaires at baseline and post measurement. Hofmann, Gawronski, Gschwender, Le and Schmitt (2003) state that there is a low but significant correlation between the IAT and explicit measurements, but that implicit and explicit measurement should be handled as complementing each other. Explicit measurement showed a significant improvement of the fatigue outcome, in the second training group (n=19), but not in the first training group (n=10). This difference could be explained by the presence of a national holiday (carnival), which took place at the post-measurement. This event could have influenced the explicit fatigue outcome of the first training group. In this study a small group of participants was used, and therefore these events could have had an influence on the explicit fatigue outcome.

Vitality did not show any effect of the intervention, nor if data was analyzed separately for the first and second training group. This supports the two continua model (Westerhof & Keyer, 2009), the feeling of fatigue and vitality could be related but can also exist besides each other. Meaning for this research, explicit measurement of fatigue showed a significant decline of fatigue but a significant improvement of vitality was not found in explicit measurement of vitality.

Implicit results were analyzed separately for fatigue bias and vitality bias at baseline, however explicit results on fatigue and vitality were not. Further research should emphasize the difference in bias at baseline, implicit as well as explicit. To determine of the positive effect of the IAT-CBM in this group can also be measured, and therefore experienced, at the explicit level. The main effect was smaller than hypothesized at baseline, but can be seen in combination with the IAT outcomes as an indication for effectiveness of the IAT-CBM.

4.2. Strengths and limitations of the study

A couple limitations of this study design should be mentioned. Firstly, this study included a small sample size of 33 participants. Therefore, results could not be translated to the general population. Small sample size could be seen as a limitation as well as an strength of this exploratory study. Strength was seen in the individualistic approach of the researcher towards participants, resulting in a greater insight of the information and the experience of the training.

Participants could reach the researcher by email and/ or phone with any questions about the training and questionnaires. Response was always given on the same day.

Secondly, participants were not selected on the basis of fatigue at baseline. Meaning both, vital and fatigued, participants were included in this study. However, in data analysis the group was analyzed as a whole group, and also separately analyzed in fatigue bias and vitality bias group. Which gave more insight in the effectiveness of the IAT-CBM in these groups. Because of the natural environment the participants live in, results of the explicit measurement and the IAT could not only be completely assigned to the IAT-CBM. This study was a single group experiment, therefore there is a lack of comparison with individuals living in comparable circumstances not receiving the IAT-CBM. For example, the first training group conducted the post measurement during a holiday which included less sleep and more alcohol consumption than average, reported by participants. This could be an influencing factor on the results in the first training group. This study adapted to this influence by analyzing the explicit results separately for the first training group and the second training group.

Thirdly, the IAT-CBM was programmed with a "stop-screen" in between block 4 and 5 of the IAT, requesting participants to close the browser-window. If participants did not read this request, or by accident touched the space bar, the IAT-CBM continued with block 5, 6 and 7, completing a full IAT. This could be resulting in a 'de-training' session, in which the association between *self* and *vitality* is equally presented as the association between *self* and *fatigue*. However, the researcher monitored the data during the training period and noticed it when the participant completed the full IAT instead of the IAT-CBM. No participants made this error consequently, therefore the researcher did not intervene in the training.

There was a low dropout rate in this study. 78.8 % of the participants completed the whole 16-day training period. No reward was offered to the participants, besides the possibility of experiencing an increased feeling of vitality after the training, what could indicate a high internal motivation and a low burden of the training. This could be promising for implementing the training in practice.

4.3. Recommendations for further research

It could be concluded that effects found in this study, were smaller then hypothesized at baseline but promising for further research. Further research should emphasize a larger sample size and a control group, to minimize external influences. Targeting on participants with Chronic Fatigue

Syndrome or people with fatigue complaints at baseline should be considered, to get a clearer picture on efficacy of the training in this particular group. Using a daily reminder is recommended to improve adherence of the training and motivation in participants, as was done in this study. It will be desirable to optimize the IAT-CBM training environment, to avoid days with no training and/or de-training. The IAT-CBM training is a potential low-cost, easy-to-use, effective intervention method for people with increased feelings of fatigue. Further research should be conducted to validate results and to optimize the training design of the IAT-CBM training before implemented in practice.

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Appendix A Checklist Individual Strengths

1.	I feel tired	S
2.	I feel very active	M
3.	Thinking requires effort	C
4.	Physically, I feel exhausted	S
5.	I feel like doing all kinds of nice things	M
6.	I feel fit	S
7.	I think I do a lot in a day	A
8.	When I am doing something, I can keep my thoughts on it	C
9.	I feel weak	S
10.	I think I do very little in a day	A
11.	I find it easy to concentrate	C
12.	I feel rested	S
13.	I takes a lot of effort to concentrate on things	C
14.	Physically I am in a bad shape	S
15.	I have a lot of plans	M
16.	I tire easily	S
17.	I get little done	A
18.	I don’t feel like doing anything	M
19.	My thoughts easily wander	C
20.	Physically I feel I am in good shape	S

S = fatigue severity item

A = activity item

C = concentration item

M = motivation item

Translated and used in Dutch:

1. Ik voel me moe
2. Ik zit vol activiteit
3. Nadenken kost me moeite
4. Lichamelijk voel ik me uitgeput
5. Ik heb zin om allerlei leuke dingen te gaan doen
6. Ik voel me fit
7. Ik ben lichamelijk erg actief
8. Als ik ergens mee bezig ben, kan ik mijn gedachten er goed bijhouden
9. Ik voel me slap
10. Ik ben lichamelijk weinig actief
11. Ik kan me goed concentreren
12. Ik voel me uitgerust
13. Het kost me moeite ergens mijn aandacht bij te houden
14. Lichamelijk voel ik me in een slechte conditie
15. Ik zit vol plannen
16. Ik ben gauw moe
17. Mijn lichamelijk activiteitenniveau ligt laag
18. De zin om dingen te ondernemen ontbreekt mij
19. Mijn gedachten dwalen gemakkelijk af
20. Lichamelijk voel ik me in een uitstekende conditie

Based on a 7-point Likert scale, items positive and negative formulated.

Appendix B Vita-16

1.	Ik heb genoeg energie om al mijn dagelijkse activiteiten te kunnen volbrengen	E
2.	Ik bruis van energie	E
3.	Mijn batterij is 100% opgeladen aan het begin van de dag	E
4.	Na het avondeten zit ik vol energie	E
5.	Ik verheug mij op elke nieuwe dag	E
6.	Ik maak plannen voor de toekomst	M
7.	Als ik een doel heb, maak ik direct plannen om dit doel te bereiken	M
8.	Het behalen van mijn doelen maakt mij gelukkig	M
9.	Ik krijg energie van het maken van toekomstplannen	M
10.	Ik vind het heel belangrijk om mijn doelen werkelijkheid te laten worden	M
11.	Ik ga meteen aan de slag met nieuwe uitdagingen	M
12.	Ik kan heel goed omgaan met tegenslagen	R
13.	Ik kan heel goed oplossingen vinden in moeilijke situaties	R
14.	Na een moeilijke periode ben ik snel weer de oude	R
15.	Door mijn ervaring voel ik mij sterker in moeilijke tijden	R
16.	Elke ervaring in het leven maakt mij sterker	R

E = energy item

M = motivation item

R = resilience item

Vitality score = mean (0.4 * energy + 0.3 * motivation + 0.3 * resilience)

Based on a 7-point Likert scale, all items are positive formulated

Appendix C informed consent

Appendix D IAT-categories

Category	Words (in Dutch)
A – self-words	Ik
	Me
	Mij
	Mijn
	Zelf
B – other-words	Anderen
	Hij
	Ander
	Zij
	Hun
C – Fatigue-words	Uitgeput
	Vermoeid
	Moe
	Futloos
	Slap
	Traag
	Slaperig
	Duf
D – Vitality-words	Vitaal
	Energiek
	Fit
	Levenslustig
	Sterk
	Snel
	Wakker
	Attent