The Impact of Inhibitory Control Training on the Emotional Regulation of Individuals with Alexithymic Symptoms

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Abstract

Emotions influence human behavior and are an important component in everyday-life orientation. Alexithymic persons are not able to interpret their feelings correctly and therefore have a disadvantage in social situations. This study tested the effect of inhibtory control to prime either the defensive or appetitive system in a group of alexithymic individuals and non-alexithymic controls with the intention to mitigate alexithymic symptoms. For priming via inhibitory control an emotional Go/No-Go paradigm was chosen. The goal was to achieve elevated emotional reports after the training compared to the beginning of the training. In order to test this, participants filled out the TAS and were allocated to the conditional or control group, respectively. On three executive days probands would participate in an emotional Go/No-Go training with both a precedent and following PANAS. Lastly, the participants watched and rated videos of the EMDB in terms of their valence and arousal. A large effect size was found for an increase in positive affect after having primed the appetitive system with Go(pleasant)/No-Go(Unpleasant) in alexithymic persons. However, those results did not turn out significant *H2* (1,2) = 1,9 , *p*= .179, η_p^2= .158. Furthermore, the small sample size of *N* = 12 does not allow for an accurate interpretation of the results.

Keywords: alexithymia, emotion regulation, affective priming, defensive system, appetitive system, inhibitory control

Resumo

As emoções influenciam o comportamento humano e são um componente importante na orientação da vida quotidiana. Pessoas alexitímicas não são capazes de interpretar os seus sentimentos corretamente e, portanto, têm uma desvantagem em situações sociais. Este estudo testou o efeito do controlo inibitório para preparar o sistema defensivo ou apetitivo num grupo de indivíduos alexitímicos e num grupo de controlo de não alexitímicos com o objetivo de mitigar os sintomas alexitímicos. Para o priming via controle inibitório, foi escolhido um paradigma Go / No-Go emocional. O objetivo era alcançar elevados relatos emocionais após o treino em relação ao início. Para tal os participantes preencheram a TAS e foram alocados no grupo condicional ou controle. Em três dias executivos, eles participariam num treino Go / No-Go emocional com PANAS precedente e posteriormente. Por último, os participantes assistiram e avaliaram vídeos do EMDB em termos das suas valência e excitação. Foi encontrado um tamanho de efeito elevado para um aumento no afeto positivo após priming do sistema apetitivo com

Go (agradável) / No-Go (desagradável) em pessoas alexitímicas. No entanto, esses resultados não se mostraram significativos H2 (1,2) = 1,9, $p = 0{,}179$, $\eta p2 = 0{,}158$. Além disso, o pequeno tamanho da amostra de N = 12 não permite uma interpretação precisa dos resultados.

Palavras-chave: alexitimia, regulação da emoção, priming afetivo, sistema defensivo, sistema apetitivo, controle inibitório

Introduction

Many psychological systems work together to ensure surviving to its best possibilities. However, there are two main supervising systems working oppositely together, namely the defensive and the appetitive system. The first one, the defense system intervenes in situations of threat by responding with fight, flight or freeze (Lang et al., 1990). Unpleasant emotions are experienced and therefore elicit avoidance behavior. The appetitive system, contrary to that, is triggered in circumstances that promote survival, comprising sustenance, procreation, and nurturance and in turn reflect behaviors such as food consumption, copulation and nursing (Bradley, 2009; Gray, 1976, 1982). Approaching behavior is primed by the activation of the appetitive system through satisfactory, rewarding emotions (Lang, 1995).
Neural circles involved in this are amongst others the amygdala, hypothalamus, and brainstem (e.g. Choi et al., 2010; LeDoux et al., 1988). The amygdala is known for its participation in fear conditioning (Fanselow & Kim, 1994; LeDoux et al., 1990; Maren & Quirk, 2004) and its link to reward associations (Baxter & Murray, 2002; Cador et al., 1989; Cardinal et al., 2002) by receiving sensory information. Subsequently, neuronal signals are sent to the somatomotor systems including the skeletal muscle, and visceromotor systems, directing the approach or avoidance behavior (Lang et al., 1990). To abstract this, both the appetitive and defensive system originate in a sensory input, causing cerebral neural circuits including the amygdalae to induce somatic and autonomic physiological systems of attention and action to respond (Davis, 2000; Fanselow & Kim, 1994; LeDoux, 1990).

However, there are additional dimensions influencing the emotional response. The two most consistent dimensions found throughout different studies are valence and arousal (e.g. Mauss & Robinson, 2009; Smith & Ellsworth, 1985). Valence correlates with the activation of motivation and can be pleasant, which corresponds with a positive hedonic impact and appetitive motivation; or it can be unpleasant, which then corresponds with a negative hedonic impact and defensive motivation (Bindra, 1978; Schneirla, 1959). This is also the affective essences of reward and punishment, and an essential constituent of numerous other emotions (Frijda & Parrott, 2011; Russell & Barrett, 1999; Zajonc, 1980). Arousal, on the other hand, is the level or degree of motivational activation and can be rated as high or low.

To outline, unpleasant emotions are correlated with an activation of the defensive system, and pleasant emotions are correlated with the activation of the appetitive system. It is therefore possible to measure which system is activated by interpreting the valence of given emotional stimuli. Furthermore, the intensity of motivational activation can be indicated by judgements of arousal (Bradley, 2000;

Cuthbert, Schupp, Bradley, McManis, & Lang, 1998; Greenwald, Cook, & Lang, 1989; Lang, Greenwald, Bradley, & Hamm, 1993).

As can be seen, affect and emotion have a vital impact on human behavior, which makes it even more difficult for people to behave according to the norm when they cannot interpret them correctly. About 10.2% in the nonclinical German population (Franz et al., 2008) have a deficient affect regulation and disability to cognitively process affective information (Luminet et al., 2006). This phenomenon is called alexithymia. The word „Alexithymia“, introduced by Sifneos (1973), originates from the Greek terms “A” – inability, “lexis” – word, and “thymos” – feeling, as the inability to find words or speak about feelings and emotions. Alexithymic persons are therefore described to have difficultness to communicate, express and describe feelings, also have hardship identifying one’s feelings (see also Zhang et al., 2012), especially negative ones, and to differentiate feelings from physical perceptions. They additionally lack fantasy and imagination, including daydreaming, and have an external oriented way of thinking (Lausberg et al., 2016; Sifneos, 1973, 1996; Taylor et al., 1991). Because of this “stiffness” that those symptoms lead to, alexithymia was also called “Pinocchio-Syndrom” by Sellschopp-Rüppel & vonRad (1977). However, it is not a classical psychological disorder as defined in the International Classification of Diseases (ICD) or Diagnostic and Statistical Manual of Mental Disorders (DSM) as per today, but rather a personality trait or syndrome. Furthermore, many diagnoses within the clinical population share a comorbidity with alexithymia, such as asthma, hypertension, chronic pain, and especially functional gastrointestinal disorders (Lumley et al., 2007; Porcelli et al., 2004; Taylor, 2000; Taylor & Michael Bagby, 2004).

The symptoms of alexithymia are supported by neuroimaging groundwork, as alexithymic persons do not show the same brain activation in areas known to be of vital importance for emotion evaluation and processing as healthy subjects, namely limbic and paralimbic areas (Huber et al., 2002). Naming emotions supports downregulating the emotional limbic response (Fakra et al., 2008; Foland-Ross et al., 2010; Hariri et al., 2000), which would make it harder for people who experience difficulty naming their emotions, such as alexithymic, to adjust their emotions (Neumann et al., 2017). Subsequently, alexithymic individuals are incapable of efficiently recognizing and regulating their response towards emotional stimuli (Starita et al., 2020).

In addition, people with alexithymia show a dysfunction in rejecting distracting information (Zhang et al., 2011), not only when it comes to emotional stimuli but also when it comes to neutral stimuli in emotional Go-/No-Go trials, suggesting a generalized deficiency in inhibitory control (Correro, 2020). An emotional priming study of alexithymic individuals by Vermeulen, Luminet & Corneille (2006) composing of three sub-studies, collectively revealed a decreased priming effect and inhibition effect for high alexithymic scores for congruent priming and target depending on the valence. The authors imply a burden in alexithymic persons when processing and employing high arousal emotional input in order to respond to accompanying behavioral demands. They ascribe this to a malfunctioning anterior cingulate cortex (ACC) in high alexithymic scoring individuals, building up on Damasio's somatic markers hypothesis (1999). This agrees with the results of further research, which has pointed out correlations between the ACC while processing negative emotional stimuli (Stadler et al., 2007) and therefore abnormal activity in the ACC during emotional stimuli processing in alexithymics in general (Berthoz et al., 2002), and a decreased cerebral activation in the dorsal ACC (dACC) during emotional movie clips (Karlsson et al., 2008) and painful visual stimuli (Moriguchi et al., 2007). Those results are consistent with a cross-modal ERP study on affective priming of alexithymia through affective music and speech prosody by Goerlich, Witteman, Aleman & Martens (2011). Here, high alexithymics showed lower affective priming effects for prosody targets, but not for music and word targets. The authors propose a minimized sensitivity for the affective characteristics of speech and music during emotional categorization in alexithymic persons. ACC activation is also positively correlated to facial expressions of anger (Adolphs, 2002). Further research shows that limbic areas, which are directly connected to the ACC, show less activation in alexithymics trying to sense another ones feeling or even their own state. It is suggested that especially the dACC plays a pivotal function in conscious awareness of emotion (Lane et al., 1998; McRae et al., 2008). Additionally, it is vital in executive functions, notably including inhibitory processes (Fallgatter et al., 2002; Fellows & Farah, 2005; Swick & Jovanovic, 2002), and hence also response inhibition in alexithymia.

To clarify, response inhibition encompasses the suppression of actions that intervene with goal-oriented behavior and that are inappropriate in a certain situation (Mostofsky & Simmonds, 2008). The relation between emotion and response inhibition and its neural correlates have been studied comprehensively (Zhang et al., 2012). Neurocognitive research has agreed on especially strong associations between inhibitory control and the prefrontal cortex, which is also strongly interconnected and modulates motor processing (Aron, 2007; Duncan, 2001; Hampshire & Sharp, 2015). In non-alexithymic individuals, functioning in motor inhibitory control and in affect regulation are positively correlated (Tabibnia et al., 2011).

However, up to this day, the mechanisms behind alexithymia await further research, as they are poorly understood (Starita et al., 2020).

Deduced by the above mentioned, the objective of this study is to test the effects of the affective inhibitory control paradigm designed to prime either the primary systems of defense or approach in participants with alexithymia symptoms and healthy controls. To test this, a group of participants with alexithymia and healthy controls underwent an intrasubject emotional Go/No-Go paradigm in three conditions – pleasant, unpleasant and neutral.

Concludingly, the following hypothesis will be tested:

H1.1: The Accuracy in the Go/No-Go trainings increases across trials.

H1.2: The reaction time in the Go/No-Go trainings decreases across trials.

H2.1: After priming the appetitive system with the Go(pleasant)/No-Go(Unpleasant) training task the positive affect will be increased.

H2.2. After priming the defensive system with the Go(unpleasant)/No-Go(pleasant) training task the negative affect will be increased.

H3. After priming the appetitive system with Go(pleasant)/No-Go(unpleasant), the rating "pleasant valence" will be increased.

H.4: After priming the aversive system with Go(unpleasant)/No-Go(pleasant), the rating "unpleasant valence" will be increased.

Method

Even though the majority of people show the same reaction to unambiguous appetitive and aversive stimuli, e.g. appetitive – fresh food – leading to an approach; aversive – moldy food – leading to avoidance, there are also differences in evaluating the stimuli. Judging the stimuli may be affected by, for instance, personality factors, especially neuroticism and extraversion, by a simultaneously occurring aversive state (e.g., hunger or deprivation; see Rolls, 2000), or by the context of stimuli (Fowles, 2006). A contextual example here would be the different reaction to the noise of an explosive on a rather normal day compared to on New Year's evening. However, as aforesaid, there are ambiguous stimuli that cause approach to one individual but more of an avoidance behavior to another, such as for instance a certain type of food, like licorice. Furthermore, when using aversive and appetitive stimuli in experimental settings, the motivational activation needs to be consistent. To avoid these types of inferential hazard in this study, only distinct stimuli that were matched according to their activation of motivational systems are used. Distinct stimuli are sexual stimuli of the opposite gender and opposite-sex erotica. Those type of pictoral stimuli educed the most apparent physiological reactions, such as the largest skin conductance responses, inhibited startle reflex, and additionally disposed the greatest arousal ratings (Bradley et al., 2001).

The present study employs a quantitative design to assess the effect of emotionally priming the appetitive and aversive systems in alexithymic persons in comparison with non-alexithymic persons.

Participants

Participants self-selected into the online study through the blackboard of an alexithymia forum (alexithymia.com) and an asperger forum (asperger-forum.de), as asperger and alexithymic symptoms often co-occur (Fitzgerald & Bellgrove, 2006). Furthermore, a part of the sample had been informed about the study through ad-hoc recruitment. The total sample initially included 16 persons, of which 4 showed missing data and were therefore not considered for analysis. The remaining 12 participants‘ age ranged from 23 to 58 years with a mean of M = 32.67 (S = 11,56).

This research was conducted in German language, with one exception coming from Switzerland, of which 4 (33.3%) were female and 8 (66.7%) male. The participants were allocated to the conditional group (alexithymia) or control group (non-alexithymic) according to their Toronto-Alexithymia-Scale (TAS) score, which was designed to identify individuals with alexithymia. Female individuals were identified as alexithymic with a score ≥ 52, male participants were allocated to the alexithymic group when scoring 53 or above.

Participants signed an informed consent including the generation of a participant code for anonymization purposes. They did not receive a reimbursement, other than the outcome of their TAS score, if requested. There were no other exclusion criteria besides not approving the consent form and it was mandatory to participate using a laptop for the stimuli resolution. The purpose of this study was transparent to the participants.

This study was approved by the ethics committee of the University of Coimbra.

Go/No-Go Paradigm

To reliably measure response inhibition, an *emotional Go/No Go Task* was chosen.
In the classical Go/No-Go Task (Falkenstein et al., 1999), the proband is shown a series of stimuli, of which most (>70%) are so-called “go-stimuli” and remaining are called “no-go-stimuli”. Those stimuli or cues can for example be squares (go-cue) and circles (no-go-cue). To participant has to react as fast as possible to

the go-stimuli/square but retain to respond to the no-go-stimuli/circle. Because of the much higher frequency of go-stimuli, the proband is proned to react to this kind of stimuli, so whenever a no-go-stimuli is shown, the prepotend response must be inhibited. In the case of the emotional Go/No-Go training, the stimuli used are emotional, instead of neutral, and therefore serve as a reliable measure of the emotional adjustment of behavioral inhibition. To bias the appetitive and aversive system, particular emotional stimuli (pleasant/unpleasant) had been paired with the go and no-go cues of squares and circles.

This part of the experiment was programmed in Open Sesame 3.3.8 and presented via Jatos on the participants' computers/laptops.

A . The emotional stimuli

The *International Affective Picture System (IAPS)* is based on the work by Hamm & Vaitl (1993) and was initially developed realting to SAM by Lang et al. (1998). Due to the cooperation with a fellow student of the University of Coimbra, the images scoring the most similar used for the pleasant und unpleasant groups according to their means and standard deviations using the normative values of the European Portuguese adaption (Soares et al., 2015) were matched. To achieve activation as high as possible in the motive systems with the use of static images, only erotic images were used, as research found the highest arousing values for this category in accordance with larger prompted physiological responses, namingly electrodermal responses and startle modulation (Bradley et al., 2001). This accounted only for images of members of the opposite sex in erotic poses. The same was found for unpleasant images of the category "threat" (Bradley et al., 2001). Additionaly, only women are sensitive to reasonable negative stimuli, but both women and men are sensitive to the influence of intensly negative images (Li et al., 2008). Because of that only highly negative stimuli of the categories mutillation and violence were chosen. Neutral images for the Go-condition were also matched to neutral stimuli of the No-Go-condition according to their mean values and standard deviations of motive systems.

The stimuli were shown in their original IAPS format of 1024 x 768 pixels.

B. The Go/No-Go Paradigm

All Go/No-Go trainings included 3x four experimental blocks, with 24 Go and 6 No-Go stimuli, equaling 360 trials. The emotional neutral Go/No-Go training task consisted of 24 Go *square* framed emotional neutral images, and 6 No-Go *circle* framed emotional neutral images. For priming of the appetitive system/pleasant training, the stimuli obtained 24 Go square framed pleasant and 6 No-Go circle framed unpleasant images. For priming the defensive system/unpleasant training the stimuli were conversed to the before mentioned appetitive system, still using square frames for Go-stimuli and circle frames for No-Go-stimuli. A fixation stimulus (+) was used ahead of presenting the next stimuli, and the duration of image presentation as well as the intertrial interval lasted 1000ms.

Instruments

Data collection strategies included quantitative online records of psychometric tests, including self-assessments, an emotional Go/No-Go paradigm to assess response inhibition, and sociodemographic data. The following psychometric tests were used:

The German version of the *Toronto Alexithymia Scale-20* (TAS; Kupfer et al., 2001), initially developed by Taylor et al. (1992), is a reliable measurement to capture the construct alexithymia through self-assessment on a 5-point Likert-scale. It was used at the beginning of this experiment to categorize the participants into the conditional group and control group. Whereas in research studies a restrictive cut-off of ≥ 61 is suggested for the category of high alexithymia, Franz et al. (2008), propose to use the 66th percentile for the identification of high alexithymia, which equals a cut-off of ≥53 in men and ≥52 in women. The latter thresholds are considered to classify alexithymia in this study.

It was normed by a German sample (*N*=2047), however, it turned out to show a poorer internal consistency for the factor “daydreaming” than in the original English version of the TAS-26 item-version. It was therefore reduced by the factor “daydreaming”. It now includes the subscales 1 – difficulty identifying emotions, 2 – difficulty describing emotions, and 3 – externally-oriented thinking, which measures the tendency of the participant to focus their attention externally (Kupfer et al., 2001). Being divorce, single or having a lower social status is associated with higher sum scores (Franz et al., 2008).

The *Beck Anxiety Inventory* (BAI; Margraf & Ehlers, 2007) and *Beck Depression Inventory (BDI)* on the one hand ensured the participants in the control group to be healthy individuals, able to feel a circumference of emotions, unlike some anxious and depressed people. On the other hand, the construct “alexithymia” repeatedly show correlations to negative affect, especially anxiety and depression (Lumley, 2000; Mattila et al., 2008; Müller et al., 2003). The tests therefore also functioned as a differentiation between these constructs.

Dependent Measures

The *Positive and Negative Affect Scale (PANAS)* by Breyer & Bluemke (2016) was used immediately before and after each treatment, meaning at two measurement time points each day. Surveying the states, it functioned as a measurement variable regarding mood ramifications on two factors, positive affect and negative affect. The PANAS has shown good reliability and validity in a variety of populations. The scales are shown to be internally consistent (Neumann et al., 2017).

The *Emotional Movie Database (EMDB)* consists of affective muted movieclips, each of about 40 seconds in duration, chosen to stimulate the emotional motivational systems - appetitive and defensive. Which system is activated can be indicated by the valence of the stimulus. As beforementioned, pleasant ratings indicate an activation of the appetitive system whereas unpleasant ratings point towards the activation of the aversive system. Arousal, on another term, indicates the *degree* of activation while being exposed to the stimuli (e.g. Lang & Bradley, 2010). The ratings of a further construct "dominance" are ordinarily used, but because the dominance does not seem to explain sufficient variance, it is neglected in further calculations of this study. It is suggested that dominance is of more importance in social interactions (Bradley & Lang, 2007).

Research has shown that videos are more suitable than images for the evaluation of the activated motivational system, because film clips are more successful in educing emotions for longer periods of time, not only on the subjective but also physiological level (Carvalho et al., 2012). Probands need multiple seconds to acquire the psychological meaning of the given scene (Kaczmarek et al., 2021). An advantage of using movie clips is also that participants are exposed to a conceivable real-life scenario without exposing them in vivo (Schaefer et al., 2010).

To evaluate the responses of the EMDB, the Self-Assessment Mannekin (SAM) (Bradley & Lang, 1994) was used. Initially, it was developed to evaluate the subjectively perceived dimensions valence (pleasant-unpleasant), arousal (calm – aroused) and dominance (led – dominant) with respect to ascertain the activation of the appetitive and aversive systems in relation to the International Affective Picture System (IAPS), which is used in this study as well. However, here, SAM is used for the assessment of EMDB. The valence therefore indicates the direction of perceived affect, whereas arousal indicates the degree of emotional activation. It is a valid measurement that is language-independent, as it works with pictoral mannekin. This instrument is highly reliable with respect to valence $r = .99$ ($p<.001$) (e.g. Lang et al., 2008). It was deployed after each Video of the Emotional Movie Data Base, whereas the images of the IAPS were used in the emotional Go/No-Go training.

Further behavioral dependent measures included the accuracy and reaction times of the inhibitory control trainings.

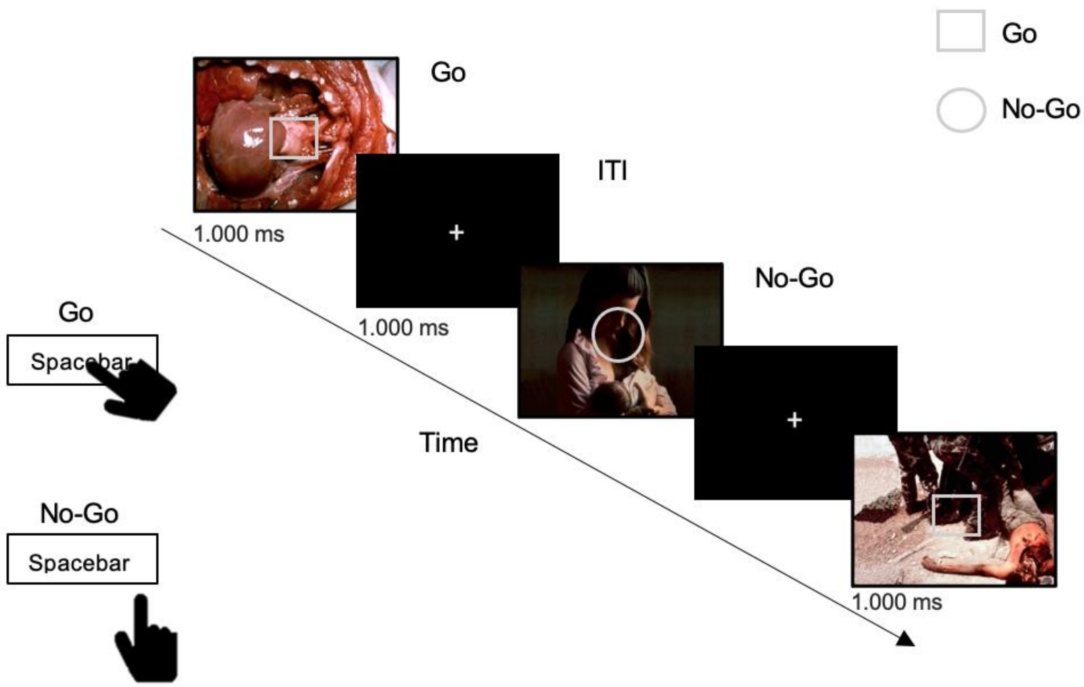
Study Design and Procedure

The 12 probands were randomly allocated to the groups “N”-neutral, “P”-pleasant, or “U”-unpleasant, which determined the order of training, either N-P-U, P-U-N or U-N-P. This was merely to minimize the variance of order effects. They had to partake in the training on three consecutive days, which is why they chose the beginning of the experiment themselves. They were sent a consent form, study procedure, and brief outline of the study purpose and used tests prior to the actual beginning of the experiment. On day one, they filled out the sociodemographic data, TAS-20, BAI, and BDI-II in addition to the following. The actual training resembled throughout the three consecutive days. Participants filled out the PANAS, proceeded with the respective neutral, pleasant, or unpleasant Go/No-Go Training to prime the appetitive/aversive system, immediately after filled out another PANAS, and lastly, watched movies of the EMDB, of which they had to evaluate each according to its valence, arousal, and dominance, using SAM.

The actual training, the emotional Go/No-Go, included 3x four experimental blocks, with 24 Go and 6 No-Go stimuli, equaling 360 trials. The emotional neutral Go/No-Go training task consisted of 24 Go square-framed emotional neutral images, and 6 No-Go circle-framed emotional neutral images. For priming of the appetitive system/pleasant training, the stimuli obtained 24 Go square-framed pleasant and 6 No-Go circle-framed unpleasant images. For priming the defensive system/unpleasant training the stimuli were conversed to the before mentioned appetitive system, still using square frames for Go-stimuli and circle frames for No-Go-stimuli. A Fixation stimulus (+) was used before the next stimuli was presented, and the duration of image presentation lasted 1000ms. Here, participants were instructed to press the keyboard space bar whenever a Go-stimuli was presented. When shown a No-Go stimuli, the probands were advised not to press a key but withhold a response. Find Figure 1 for a visual explanation. They underwent a training session with visually displayed feedback, either alerting them when they falsely pressed the space bar or did not press it when they were supposed to, and likewise confirming when they rightly pressed the space bar or when they withheld the response correctly.

Figure 1.

Go (unpleasant)/No-Go training structure example.



Note. Pictures from the IAPS (Soares et al., 2015). Reprinted with permission.

Data Analysis

The statistical analysis was carried out using SPSS (SPSS Inc., 2007) Mac Version 25.0. Nevertheless, the small sample size violated the assumptions of normality, a parametric test was used, because of the explorative component of this study. Mean values were compared by analysis of variance (ANOVA) with three training intrasubject conditions (pleasant, unpleasant, neutral) and two between factors of condition (alexithymic versus controls). ANOVAs were carried out separately for the dependent measures of reaction time, accuracy, PANAS and EMDB. The significance level was set at α = 0,05.

Missing data accumulated within the second and third days of trial due to technical problems such as internet connection. In case of missing data, the respective probands data were precluded. This left only complete cases with recorded data over all measurement timepoints for analysis purposes.

Results

A total of 12 probands were included in this study, of which 5 were categorized in the conditional group of alexithymia and 7 were categorized in the control condition according to their TAS-20-score. Probands in the alexithymia condition showed a mean score of 66,0 (*SD* = 8,0) in the TAS-20, the controls on the other hand scored a mean of 35,0 (*SD*=10,3). Both the BAI and BDI scores were higher in the alexithymia group with BAI *M* = 32,0 (*SD* = 3,2) and BDI *M* = 44,0 (*SD* = 16,1). The control condition scored lower for BDI *M* = 23,0 (*SD* = 3,1) and BAI *M* = 24,0 (*SD* = 2,6). An overview of the descriptive results can be found in Table 1.

Table 1. Descriptive Statistics with Respect to Conditional Groups

Condition		*N*	*Min*	*Max*	*M*	*SD*
Non-Alexithymic	TAS_Score	7	22.0	50.0	35.3	10.3
	BAI_Score	7	21.0	28.0	24.1	3.1
	BDI_Score	7	21.0	27.0	23.9	2.6
Alexithymia	TAS_Score	5	59.0	78.0	66.2	8.2
	BAI_Score	5	21.0	47.0	32.2	10.6
	BDI_Score	5	26.0	61.0	43.6	16.1

Note. Abbreviations: Toronto Alexithymia Scale – TAS, Beck Anxiety Inventory – BAI, Beck Depression Inventory – BDI, Number of participants - *N,* Minimum - *Min*, Maximum - *Max*, Mean - *M*, Standard deviation – *SD.*

Hypothesis Testing

All judgment of effect sizes are according to Cohen (1988).

Behavioral Measures, H1.1: The Accuracy in the Go/No-Go trainings increases across trials.

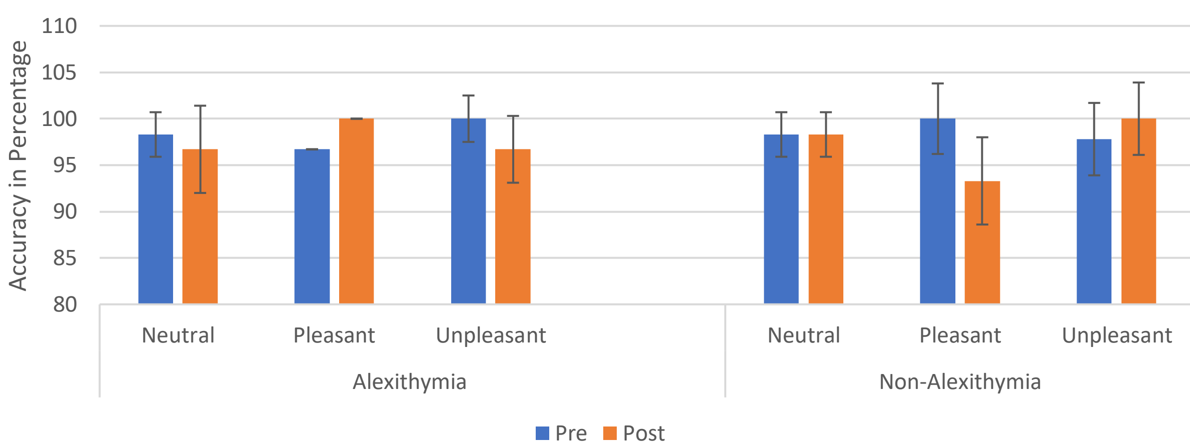
The descriptive statistics show that no clear pattern or differences within and between the groups can be revealed with the data of this study. To test this hypothesis an ANOVA over the first and last (third) measurement time point and the accuracy were considered into the analysis. As presaged by the descriptive statistics in Table 2 and Figure 2, no significant effects of emotional priming on accuracy were found $F(1, 2) = 0.02$, $p= .894$, $\eta_p^2 = .002$.

Table 2. Descriptive Statistics*:* Accuracy of the Go/No-Go Training in Alexithymia and Controls with respect to the priming condition.

Priming Condition	Alexithymia *M (SD)*	Non-Alexithymia *M (SD)*
Neutral		
T1	98,3 (2,4)	98,3 (2,4)
T3	96,7 (4,7)	98,3 (2,4)
Pleasant		
T1	96,7 (0,0)	100,0 (3,8)
T3	100,0 (0,0)	93,3 (4,7)
Unpleasant		
T1	100,0 (2,5)	97,8 (3,9)
T3	96,7 (3,6)	100 (3,6)

Figure 2

Accuracy of the Go/No-Go Training in Alexithymia and Controls with respect to the Priming Condition; Mean and Standard Deviation.



H1.2: The reaction time in the Go/No-Go trainings decreases across trials.

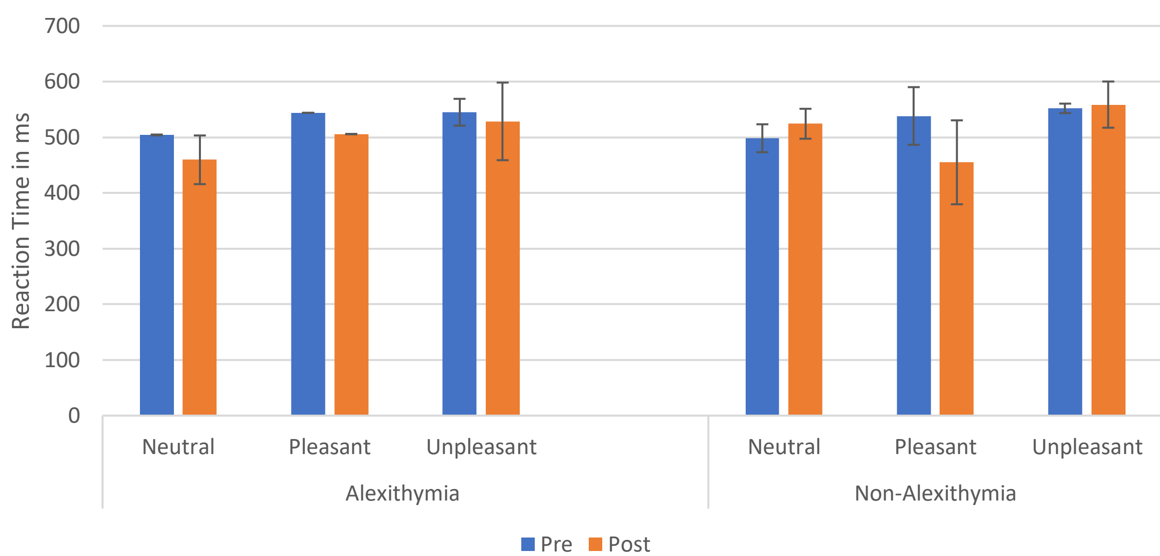
This hypothesis was tested similarly to H1.1.. The descriptives in Table 3 reveal that reaction times slightly decreased in the alexithymic group over time, which can be visualized in the bar graphs in Figure 3, but this pattern did not occur in the control group. This effect could also not be validated by the calculations of an ANOVA, including the reaction time as dependent variable, as no significant results showed up $F(1, 1) = 0.21$, $p= .660$, $\eta_p^2= .020$.

Table 3. Descriptive Statistics of Reaction Times Over Time of Alexithymics and Controls with Respect to the Priming Condition.

Priming Condition	Alexithymia *M (SD)*	Non-Alexithymia *M (SD)*
Neutral		
T1	504,1 (0,8)	498,2 (25,1)
T3	459,5 (43,7)	524,2 (26,9)
Pleasant		
T1	543,9 (0,0)	538,2 (51,8)
T3	505,7 (0,0)	455,0 (75,4)
Unpleasant		
T1	544.9 (24,1)	551,9 (8,5)
T3	528,5 (69,7)	558,6 (41,5)

Figure 3

Reaction Times Over Time of Alexithymics and Controls with Respect to the Priming Condition.



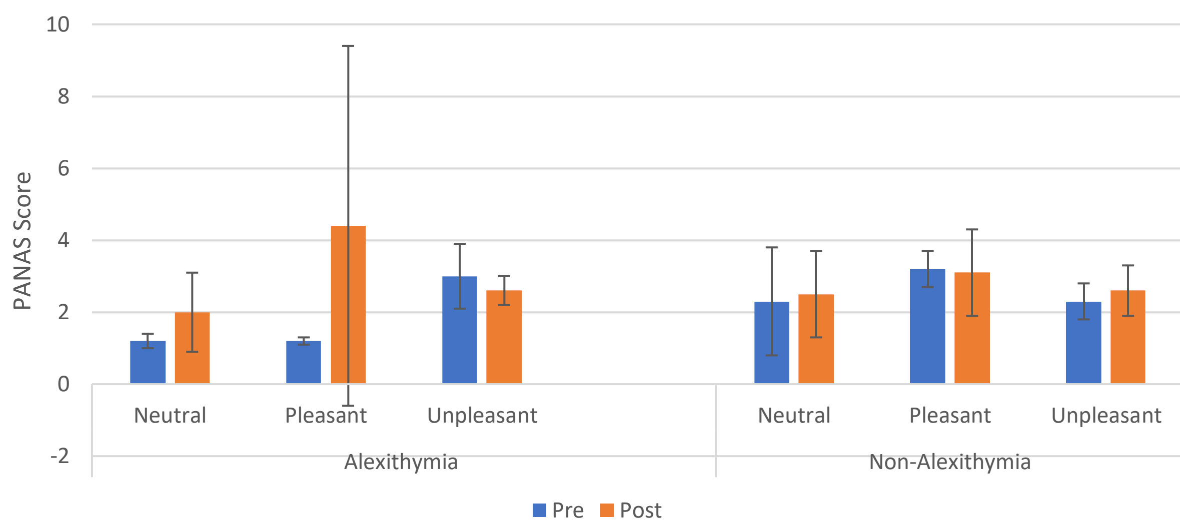
H2.1: After priming the appetitive system with the Go(pleasant)/No-Go(Unpleasant) training task the positive affect will be increased.

For testing this hypothesis, the ratings of the pre- and post- PANAS factor "positive affect" of were compared with each other under consideration of the conditional and control group and the day of performance of the Go(pleasant) training. The descriptive statistics express that this positive effect was especially altered in the pleasant group of alexithymics, with an increase from *M* = 1,2 (*SD* = 0,1) to *M* = 4,4 (*SD* = 5,0), as can be seen in the bar chart in Figure 4. In the control group, the anticipated effect could only be obtained in the pleasant group and to a smaller extend. To a lower degree, this pattern occurred in the neutral group, too, with an increase from *M* = 1,2 (*SD* = 0,2) to *M* = 2,0 (*SD* = 1,2). In the unpleasant group on the other hand, a slight opposite effect showed with *M* = 3,0 (*SD* = 0,9) decreasing to *M* = 2,6 (*SD* = 0,4) in the alexithymic group.

Again, an ANOVA considering the particular measurement timepoint (MTP) of performing the pleasant training was executed with respect to the condition and PANAS "Positive Affect" as dependent measurement. The result did not turn out significant $F(1,2) = 1,9$, $p = .179$, $\eta_p^2 = .158$. Nevertheless, the large effect size and a post-hoc test indicate that this effect accounts for alexithymics of the pleasant group.

Figure 4

Means and Standard Deviation of the Positive Affect Scale of PANAS after Priming Go(pleasant)/No-Go(unpleasant) over the MTPs with Respect to the Groups in Alexithymic Individuals.



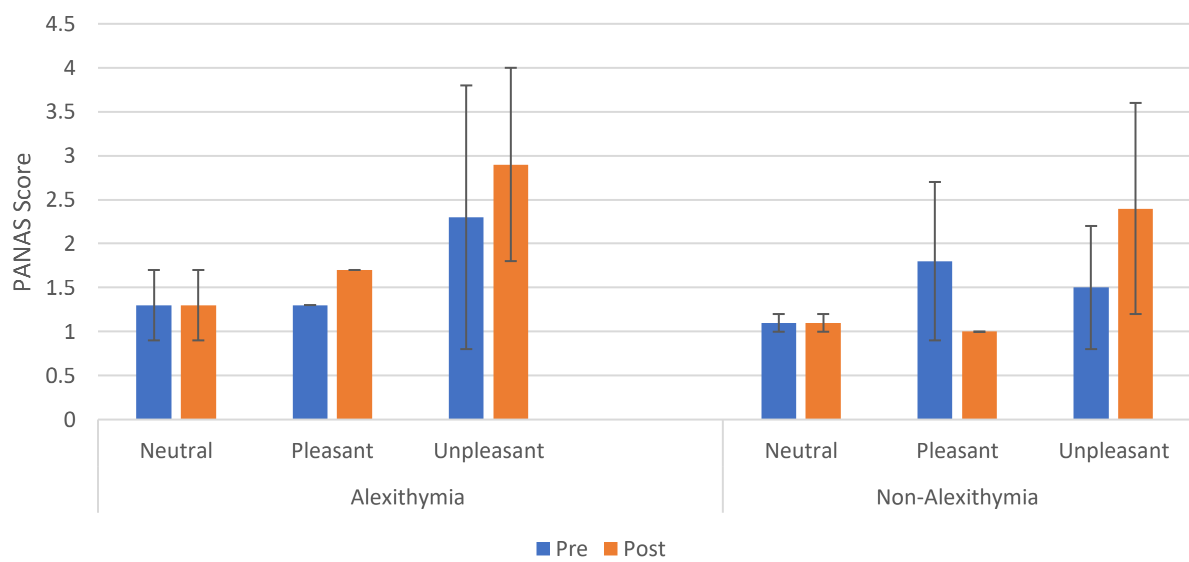
H2.2. After priming the defensive system with the Go(unpleasant)/No-Go(pleasant) training task the negative affect will be increased.

This hypothesis was tested like the H2.1, but with due regard the ratings of the PANAS for the factor "Negative Affect" and Go(unpleasant) training. Again, the results of the pre- and post-PANAS were compared with each other with respect to the day the training was executed. When looking at the descriptive statistics in Figure 5 it becomes evident that the PANAS mean scores for "Negative Affect" increased from *M* = 1,3 (*SD* =1,5) to *M* = 2,9 (*SD* = 1,1) in the conditional group and from *M* = 1,5 (*SD* = 0,7) to *M* = 2,4 (*SD* = 1,2) in the controls, but for the unpleasant group, only.

For testing the hypothesis, the ratings of the post-PANAS factor "Negative Affect" of the pre- and post- PANAS scores were compared with each other under consideration of the conditional and control group and the timepoint of when the Go(unpleasant) training was implemented. Again, an ANOVA considering the day of performing the unpleasant training was calculated. The result did not turn out significant $F(1,2) = 0{,}81$, $p = .461$, $\eta_p^2 = .075$.

Figure 5

Means and Standard Deviation of the Negative Affect Scale of PANAS after Priming Go(unpleasant)/No-Go(pleasant) over the MTPs with Respect to the Groups in Alexithymic Individuals.

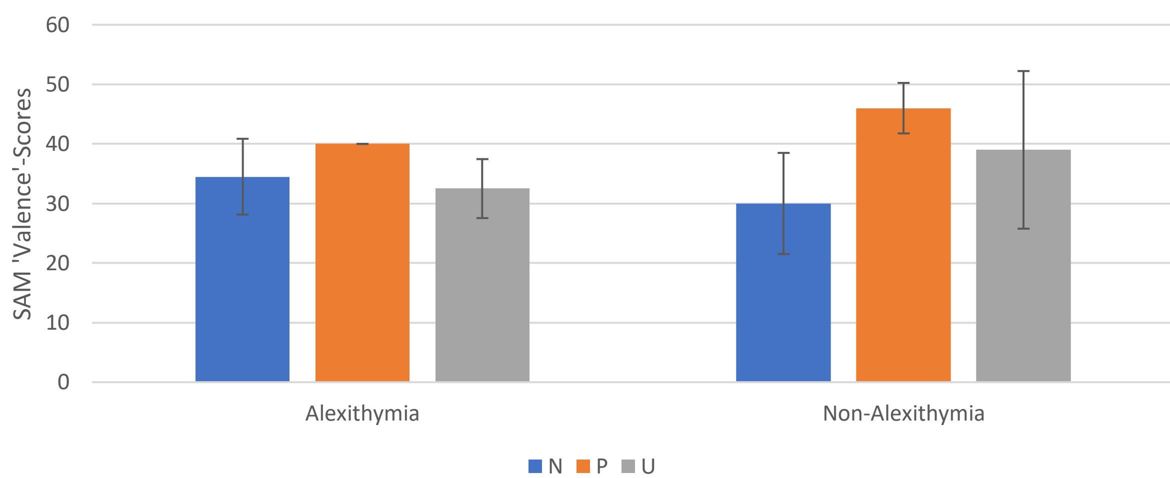


H3. After priming the appetitive system with Go(pleasant)/No-Go(unpleasant), the rating "pleasant valence" will be increased.

In Figure 6, the mean scores and standard deviations of valence ratings can be seen as bar graphs. They identify that the mean scores of valence generally manifest at a lower level in the alexithymic group, with exception for the neutral group, compared to non-alexithymic probands. The most obvious differences can be found in the pleasant group with a mean valence of *M* = 40,0 (*SD* = 0,0) for alexithymia (included only one proband) and *M* = 46,0 (*SD* = 4,2) for non-alexithymia, and in the unpleasant group, with *M* = 32,5 (*SD* = 5,0) for alexithymia and *M* = 39,0 (*SD* = 13,2) for non-alexithymia.

An ANOVA was calculated to test this hypothesis. Variables included were the SAM-scores for valence with respect to priming the appetitive system via the pleasant Go/No-Go training. Again, results did not turn out significant $F(1,2) = 0.97$, $p = .396$ $\eta_p^2 = .088$. The post-hoc bar charts suggest the opposite of what was expected. A decrease of rating for pleasant valence over all three MTP for both alexithymic and non-alexithymic seems to be the case with stronger manifestation in the alexithymic condition. Considering the different chronological orders of the groups (neutral, pleasant, unpleasant) this pattern is still shown, but interestingly, only in alexithymic persons the ratings decreased continuously over all groups. In the non-alexithymic condition this pattern did not appear.

Figure 6. Mean and Standard Deviations of Sam Scores for "Valence" for Go(pleasant)/No-Go(unpleasant) in Alexithymia and Controls with Respect to Group (= day the Go(pleasant) training was executed)



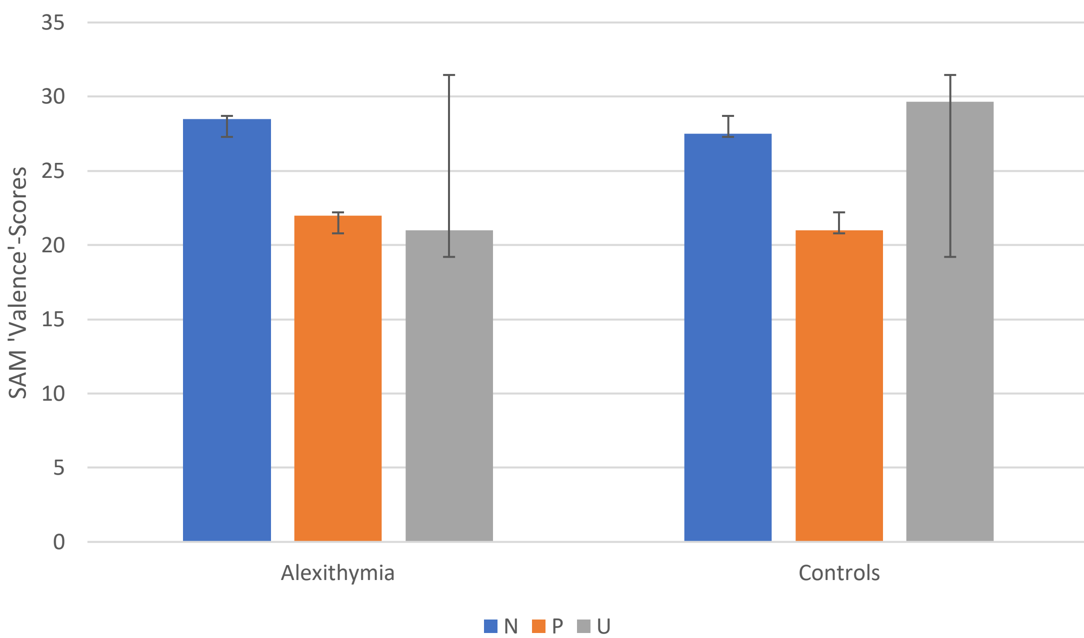
Note. Abbreviations Neutral – N; Pleasant – P; Unpleasant – U.

H.4: After priming the aversive system with Go(unpleasant)/No-Go(pleasant), the rating “unpleasant valence” will be increased.

Looking at the descriptive statistics in Figure 7, the most striking difference between alexithymics and non-alexithymics can be found in the unpleasant groups (alexithymic: *M* = 21,0; *SD* = 8,5; controls: *M* = 29,7; *SD* = 5,8), whereas the ratings are similar in the other groups.

For testing the rating of unpleasant valence, an ANOVA with SAM-scores for valence with respect to priming the aversive system via the unpleasant Go/No-Go training were included as dependent variables. Again, results did not turn out significant $F(1, 2) = 0.91$, $p = .420$, $\eta_p^2 = .083$, but the bar charts of the post hoc analysis imply that the expected hypothesis seems to be the case for both conditions.

Figure 7. Sam Scores for "Valence" for Go(unpleasant)/No-Go(pleasant) in Alexithymia and Controls with Respect to Group (=day the Go(unpleasant) training was executed).



Note. Abbreviations Neutral – N; Pleasant – P; Unpleasant – U; Pre-Measure – 1; Post-Measure – 2.

Discussion

This study tested the effect of inhibtory control to prime either the defensive or appetitive system in a group of alexithymic indivduals and non-alexithymic controls. For priming via inhibitory control an emotional Go/No-Go paradigm was chosen. The goal was to achieve elevated emotional reports after the training compared to the beginning of the training, and therefore mitigate alexithymic symptoms in the conditional group. For this purpose, participants filled out the TAS-20 and were allocated either to the conditional or control group, depending on their score. On three executive days they participated in an emotional Go/No-Go training with both a precedent and following PANAS, each. Lastly, the participants watched videos of the EMDB and thereafter rated them in terms of their valence and arousal level.
The results of this study are first going to be discussed in the interest of the hypotheses. Subsequently, the limitations of this study are going to be debated. Finally, methodological limitations of this study and implications for further research are considered.

Hypothesis 1.1 postulates that the accuracy in the Go/No-Go increases over both conditions of alexitymic and non-alexithymic individuals. Even though the descriptive statistics show differences between the different MTP and groups, no clear pattern can be dedcuded hereof. In the conditional group the accuracy rises in the pleasant group only, but drops in the unpleasant and neutral group. The control group oppositely shows an increase in accuracy only in the unpleasant group and it drops in the pleasant group. The interpretation of this is highly risky, as the alexithymic condition of the pleasant group, which showed the expected outcome, only included one participant. All other groups included two to three probands. However, Alexithymic people also seem to have difficulties especially with negative emotions, which may explain why the expected effect of improved accuracy occurred in the pleasant group only for this condition. Additionally, having perceived emotional stimuli such as neutral, pleasant or unpleasant images, prior to executing inhibitory control tasks can significantly compromise the participant’s performance (Verbruggen & De Houwer, 2007; Yang et al., 2014). Per definition, alexithymic people have difficulty to describe one’s feelings and to communicate, express feelings, and to identify ones feelings (see also Zhang et al., 2012). This may also have had a preventing effect on the beforementioned performance compromise after having seen emotional stimuli.

This may be explained by the risen motivation of alexithymic people to keep up the attention throughout all measurement time points whereas non-alexithymic may have shown more fatigue effects. It is interesting to see that in the non-alexithymic group there could be seen a decrease in the the group starting with the pleasant Go/No-Go task only whereas the effect was directly the opposite for the alexithymic group, which corresponds with the results of other studies postulating that response inhibition seems to be better for negative in comparison to positive stimuli (Chiu et al., 2008; Schulz et al., 2007). The alexithymic group showed a slight decreases in both other groups, neutral and pleasant, but an increase accuracy for the group beginning with the Go-pleasant training.

For the second part of hypothesis one, H1.2 the reaction times were tested using an ANOVA. They did decrease, as expected, in both conditions and even more so in the alexithymia condition, but the differences were not statistically significant. Likewise, other studies with non-alexithymic probands have reported that the reaction times in emotional Go/No-Go tasks decrease with repetition (e.g. Thigpen et al., 2018). Concerning the alexithymic population, the results of this study are not far from results by Zhang et al. (2012), who did not find significant differences but effects only of individuals with alexithymic symptoms for Go/No-Go tasks with respect to speed and accuracy. Furthermore, did the alexithymic probands score faster in the incongruent trial (M = 528,515, SD = 69,742) than congruent trial (M = 544,865, SD = 24,134) in the unpleasant group, which is congruent with other studies (Pan et al., 2016; Yao et al., 2019).

The results are congruent to the results of other studies exposing affective priming effects for positive but not for negative primes in a lexical decision-priming task (Yao & Wang, 2013) or stronger for negative than positive primes in facial expression processing (Aguado et al., 2018).

The second hypothesis H.2.1 postulated an increase in pleasant affect when the appetitive system was primed priorly. Large effect sizes of η_p^2= .158 for the go-pleasant training in liasion with post hoc bar charts indicate the expected especially in alexithymics and to a lower degree for non-alexithymics, too. On the contrary, no clear pattern elevates for the other groups, even though they had carried out the Go-pleasant training to prime the appetitive system, merely in a different chronological order. This indicates that the Go/No-Go training generally did not have a softening influence on the symptoms of alexithymia, but when the Go-pleasant training was initiated as the very first training, it did.

Hypothesis H2.2, similarly as H2.1 postulated an increase in negative affect, when the defensive system was primed priorly. Alike the results above, the descriptive statistics expose an elevated effect for the unpleasant group, in which the Go(unpleasant) training was run at the first measurement time point.

Considering both hypotheses H2.1 and H2.2, it becomes apparent that the expected effects arise solely when the respective Go/No-Go training matching the seeked primed system is implemented on the first day (priming appetitive system – Go(pleasant) training on first day; priming aversive system –

Go(unpleasant) training on first day). This hints at the participants becoming more uninvolved throughout the days, which is comprehensible, as the tasks were repetitious and monotonous.

With regards to the third hypothesis H3, postulating an increase in pleasant valence after having primed the appetitive system, neither did the results turn out significant, nor did they show a large effect size. The bar charts of the descriptive statistics suggest the oppsite of what was expected. A decrease of rating for pleasant valence over all three measurement time points for both alexithymic and non-alexithymic seems to be the case with stronger manifestation in the alexithymic condition. Considering all groups of chronological order (neutral, pleasant, unpleasant) this pattern is still shown, but interestingly, only in alexithymic persons the ratings decreased continusoly over all groups. In the non-alexithymic condition this pattern could not be shown. However, for both conditions, the ratings were the strongest for their first measurement time points, which may be explained by the valence congruency of prime and stimulus (positive – positive) as has been found in previous studies (Zhang et al., 2012).

Moving on to the fourth hypothesis H4, which was structured as the aforementioned hypothesis, but for unplesant valence ratings once having primed the defensive system, a medium effect size of η_p^2=.083 was exposed. Even though there was less fluctuation in the alexithymic group compared to the non-alexithymic group over the three experimental days, those results did not turn out significant. The hypothesis seems to apply to non-alexithymics only, which, again, may be caused by alexithymics struggling with negative emotions the most. This means that the training did not have had the expected cause in alexithymics.

Generally said, statistical significant effects may had been found in a larger sample. The insufficient sample size of only 12 people did most likely not reflect the results accurately and therefore make it difficult to interpret those. Based on the results of this study, a sample size of at least 66 people would be adequate as calculated via G*Power (2007) to reinforce and verify the found results. Furthermore did the stimuli not change throughout the different days, but reoccur and most likely strenghtened the inattention of the participants on training day two and three. Pleasant pictures and videos, for instance, were the same throughout the different measurement time points. This very probably also had an habitual effect on the participants throughout both conditions of alexithymic and non-alexithymic probands, as discussed in H1.1 and H1.2.

Another limitation is that most measures taken in this study were based on subjective ratings. However, alexithymic individuals have poor emotional awareness which could have influenced the validity on all subjective emotional measures, just as Kammerer (2016) had highlighted specifically with respect to the TAS-20. Bermond et al. (2006) suggest to include a cognitive component into testing for alexithymia to affirm the grading of alexithymic characteristics.

As inhibitory phenomena demonstrably are not allocated to one common neural substrate, it is hard to refer back to and draw conclusion from specific neural areas that may have impacted the experiment of this study in a way otherwise than expected. This makes further neurocognitive research on the subject-matter of inhibiton still a relevant topic, up until today, as already Munakata et al. (2011) have hinted towards.

To conclude, these mixed results in combination with the small sample size leave too much space for interpretation, however it seems as though the training does not have the expected comprehensive positive outcome on individuals with alexithymic symptoms. It would be worth trying to have three conditional groups of purely pleasant and unpleasant emotional trainings over all training days, to amplify the found effect sizes, instead of having every proband run all three (pleasant, unpleasant and neutral) trainings, as it was the case in this study and see if main effects emerge. Future studies should also consider including different tasks of response inhibition, such as a mix of Go/No-Go trainings with Stop-Signal tasks, to elevate their attention and keep probands motivated to participate. Additionally, repeating the same training setup three times with the same stimuli lead to detachment, which may be overcome by using a larger repertoir of stimuli.

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