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FACULTEIT PSYCHOLOGIE EN

PEDAGOGISCHE WETENSCHAPPEN

Onderzoekscentrum voor gezondheidspsychologie

Are Sighs Conditioned Responses?

Can we learn to sigh?

Master's thesis submitted for the degree of Master of Science in de psychologie by
Ellen Palmers

Supervisor: Dr. Elke Vlemincx
Co-supervisor: Prof. Dr. Omer Van den Bergh

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Previous research on sighs, assumes that sighing is a natural behaviour with psychological and physiological resetting functions. Psychologically, a sighs leads to relief, and is related to both positive and negative emotional states. Physiologically, sighing acts as a resetter for breathing regulation. Sighing restores the homeostasis of the respiratory system. In this study, we want to investigate whether the resetting properties of a sigh could function as positive reinforcement and thus whether sighing can be a conditioned response.

We conducted an experiment to investigate whether participants sighed more during cues that were previously coupled with a reward, consisting of relief of dyspnoea, compared to cues that were previously coupled with a punishment, consisting of a breathing resistance. Besides this main research question, we explored whether the conditioning of sighs was different for persons varying on alexithymia and anxiety sensitivity. To test these questions, 44 subjects participated in this study. First, they were asked to complete some screening questions, the Anxiety Sensitivity Inventory and the Toronto Alexithymia Scale. Participants breathed through a mask while watching several cues on a screen. Sigh frequency and subjective feeling of breathlessness were measured as dependent variables. The experiment consisted of four blocks: two acquisition blocks and two test blocks. Each block consisted of 16 trials, beginning with a dyspnoea phase, followed by relief of dyspnoea. During the acquisition trials, one cue indicated that a sigh during relief of dyspnoea was rewarded with no breathing resistance, while another cue indicated that a sigh was punished with a breathing resistance. All participants completed the four blocks. The cues and the order of the blocks were counterbalanced across participants. We hypothesized that participants would sigh more in response to the reward cue than in response to the punishment cue during the relief of dyspnoea of the test phase. With regard to the exploratory questions, we expected that participants with high anxiety sensitivity and alexithymia would sigh more during the punishment condition. Lastly, we predicted that participants would report fewer feelings of dyspnoea in the reward condition during the relief of dyspnoea of the test phase.

We found conditioning of sighs, independent on the levels of alexithymia and anxiety sensitivity. Further research on the operant conditioning effect of a sigh with panic disorder patients is recommended.

Preface

Acknowledgments

I would like to express my recognition to several people for their support during the whole process of writing my master thesis.

First, I would like to thank Elke. She provided all the help and guidance I needed. Her constructive feedback was essential to bring this thesis to its current shape.

Inhaling and exhaling through a mask for two hours is not the best way to spend your free time. Therefore, I would like to thank all my friends and volunteers for participating in my experiment.

Next, I would like to thank my parents, sister, and partner for the endless reading and rereading of my thesis in search of the last fault. Their unconditional support and interest during the entire process made sure I kept the motivation to conclude this master study successfully.

Finally, I would like to thank my friends and my underwater hockey team for their enthusiasm, help, and the much-needed moments of relaxation and distraction.

Contribution

Two years ago, we had to choose a topic for our master thesis out of a list of more than 1000 subjects. Not an easy choice. Because of my interest in health psychology, “How to sigh through relief” stood out immediately. Sighing, if you think about it, happens more than you realise. In the classroom, when your classmate is bored. During an exam, trying to reduce the stress. After the exam, to express your relief. I was immediately intrigued by the consequences of sighing, and by the ways to use these mechanisms in everyday situations, or with panic disorder patients. On my first meeting with Elke, she showed me the research domain of sighing. She led me through the short history of research on sighing, and explained the most recent developments on this topic.

I chose to write my master thesis as an English article. English, first because the majority of research on sighs is in English, which makes it easier to use the correct terms and references. And secondly because I would learn a lot by writing an article in a foreign language. I chose to write in article format because I want to become familiar with this format to easier digest and better appreciate research in the future.

It is always difficult to start a project like this. Dr. Vlemincx (Elke) created the design of the experiment. She also trained me to conduct the experiment with a couple of test trials and assisted with the first participant. After that, I conducted the experiments of the other participants on my own. Elke cleaned the data of the experiments, because it consisted of rows and rows of different variables, of which I only needed a selection for my research questions. Because of some setbacks with this data processing, Elke did most of the analysis. Afterwards, I did all the analyses on my own and compared them with her results. Analyzing the data autonomously taught me a lot, and having this backup ensured me I was right.

During the writing process, Elke was always available when a question arose or to give tips and tricks to improve my writing. Several complex interpretations emerged during the study. When my reasoning got stuck, I could rely on her to discuss these topics and find a way out. These conversations often led to fresh and new points of view. Hereby boosting my moral to finish my master thesis.

Content

Are Sighs Conditioned Responses?

Can we learn to sigh?

1. Introduction

Do you sigh often? Do you know why? And do you do it on purpose? A sigh of a colleague can disturb us. It may be a sign of boredom or stress. But sighing can also be such a relief. Sighing is such a natural response that you do not reflect on it. But is it just a response? Or is it a behaviour that can be learned, just like any other human behaviour?

Sighing itself is a specific sort of breathing. In this article and during the experiment, a sigh will be defined as a deep breath, with a tidal volume at least twice as large as the mean tidal volume in a surrounding representative time interval (Wilhelm, Trabert, & Roth, 2001). A sigh has an important function. Whereas the physiological functions of a sigh have been known, the psychological functions of a sigh have been focus of research only recently.

Although many people consider breathing as static and stable, the respiratory system is complex and dynamic with many feedback mechanisms (Vlemincx et al., 2013). Under the influence of homeostatic processes, the respiratory system aims for stability. This stability is important to maintain the blood CO_2 and O_2-levels. Within a changing environment, stability is not enough to survive. The homeostatic process has to be sensitive as well. It has to be able to adapt to changing gas levels under the influence of internal and external perturbations. Research conducted by Baldwin et al. (2004) showed that there are important fluctuations in breathing, that consist, however, of correlations between successive breaths, both on the short term (short-range respiratory memory) and on the long term (long-range respiratory memory). Other researchers have found similar results (Bruce & Daubenspeck, 1995).

Bruce and Daubenspeck (1995) pointed out that total respiratory variability consists of non-random and random variability. Non-random variability is caused by the delay in the feedback loops when the respiratory system interacts with other internal physiological systems. Non-random variability is an example of the dynamic homeostatic process of respiration. Breathing patterns are also influenced by external demands, such as emotions. These external perturbations cause noise, or random variability. Random variability is important for a flexible and adaptive response to environmental demands. Too much randomness can be noticed by an increase in total variability (random) and the loss of the short-range memory or non-random variability (Baldwin et al., 2004).

Vlemincx, Van Diest, Lehrer, Aubert and Van den Bergh (2010) showed that regulating respiratory variability is an important function of a sigh. The experiment of Vlemincx, Van Diest, et al. (2010) identified that, due to an increase in correlated variability, variation changes to more non-random variability after a sigh. The change in variation suggests that a sigh acts as a resetter of non-random breathing variability, and therefore is an important regulator of respiratory stability and flexibility. Different mechanisms influence the occurrence of a sigh: chemical, physiological, and psychological parameters play a role in the path towards and directly after a sigh. Chemically, a lower O_2 and higher CO_2 level in the blood act as facilitators for a sigh to occur (Soltysik & Jelen, 2005), hereby reducing hypoxia and hypercapnia. Physiologically, sighing is important to prevent the collapsing of the lung alveoli (Bendixen, Smith & Mead, 1964). A sigh promotes lung compliance and the efficiency of gas-exchange (Antonaglia, Pascotto, De Simoni, & Zin, 2006). Patroniti et al. (2002) found that patients with acute respiratory distress syndrome (ARDS) could improve their lung mechanics by sighing more frequently. Another important characteristic of a sigh is the switch from sympathetic activity to parasympathetic activity. The importance of this switch was mostly illustrated in relation to babies with SIDS (Sudden Infant Death Syndrome; Franco et al., 2003; Galland, Taylor, Bolton & Sayers, 2000). Lastly, research shows that sighing not only affects chemical and physiological responses; emotion regulation is also an important function of sighing.

An experiment of Vlemincx, Van Diest and Van den Bergh (2015) shows that most sighs are observed during a negative low-arousal, or any high-arousal emotional state. The resetting character of a sigh can explain this, since a sigh occurs when there is less correlated variability (Vlemincx, Van Diest, Lehrer, Aubert & Van den Bergh, 2010), which is the case with negative and high-arousal emotions. Psychologically, a sigh relates to negative events such as stress, and appears more frequently with patients with panic disorder (Wilhelm, Trabert & Roth, 2001). Other research indicates a relation between sighing and relaxation, so that relaxation training often uses deep breaths to suppress dyspnoea (Hirose, 2000) and to decrease craving (McClernon, Westman & Rose, 2004). Relief is one of the emotions that have been investigated in combination with sighing.

In three experiments, Vlemincx et al. (2009) examined this relation between sighing and relief. They propose that the association with relief also exists in a stressful context without any specific ending of the stressor. They argue that relief is an elicitor as well as a result of sighing. Therefore, the psychological feature of sighing is to relieve stress. If a relief effect can be seen after the occurrence of a sigh, Vlemincx et al. (2009) asked themselves if it is possible that people sigh to experience relief? This could explain the frequent sighing by patients with a panic disorder (Wilhelm et al., 2001). Wilhelm et al. (2001) found that these patients sigh more often and deeper than a control group. Moreover, the CO2 levels of patients with a panic disorder did not return to the baseline after three breaths following a sigh, as was the case in controls. This explains the hypocapnia observed with patients with a panic disorder. Wilhelm et al. (2001) argued that the hypocapnia within these panic disorder patients could be caused by sighing too often. The question arises whether panic disorder patients sigh too often because they learned from experience that the relief effect will follow a sigh.

When people sigh with no physical or chemical cause, it is not an automatic response anymore, but a behaviour. The learning theories formed within behavioural psychology may provide an answer to this typical behaviour. The operant condition theory by Skinner explains this by learning the association between a sigh and the relief effect that follows the sigh (Hermans, Eelen & Orlemans, 2007). If sighing in a stressful context leads to relief, then the sigh will make an end to a negative situation. This escaping behaviour, known as negative reinforcement, can be defined as a certain behaviour that will end a negative situation. On the other hand, it is possible that relief could act as a positive reinforcement of a sigh. Both reinforcement mechanisms would lead to the same result: the person will perform the behavior more often. The person learns that sighing leads to a relief effect on the one hand, and the end of the stressful context on the other hand. So it is possible that this person will sigh more often, just to experience relief or to escape the stressful situation. However, Greenspoon (1962) found that acquiring this relation is not always done consciously. Sometimes, discovering the relation between a behaviour and its consequence can happen unconsciously and automatically.

Learning theories could also explain the maladaptive sighing behaviour of panic disorders patients (Wilhelm et al., 2001). These patients have learned to escape a stressful situation by sighing. A sigh only helps to bring your respiratory system back to baseline when you encounter an acute stressor. A chronic stressor could mean that sighing alone is not enough to go back to the baseline-breathing pattern. When the sigh-rate is disproportionate, the short term memory will be lower, and the breathing pattern will be irregular, as can be seen in patients with a panic disorder (Wilhelm et al., 2001). The relation between sighing and conditioned responses is not yet researched.

In this experiment, our main research question is: Are sighs conditioned responses? People can learn that sighing leads to different outcomes. If participants learn that by sighing in certain conditions, they experience reward in the form of relief of a breathing resistance, whilst in other conditions, it leads to a punishment, being a heavier breathing resistance, we predict that they will sigh more often in the reward conditions. Because literature shows that panic disorder patients show a different sighing pattern, and that alexithymia and anxiety sensitivity are risk factors for panic disorder patients (Cucchi et al., 2012), we want to explore whether the conditioning of sighs is different for persons with high alexithymia or anxiety sensitivity, compared to persons with low alexithymia or anxiety sensitivity. Since panic disorder patients sigh often despite hypocapnia following a sigh, a punishment after a sigh may not lead to lower sigh frequencies in persons with high alexithymia and/or anxiety sensitivity.

2. Method

2.1 Participants

Fifteen men (M_{age}: 22.29; SD_{age}: 2.31) and 29 women (M_{age}: 21.86; SD_{age}: 3.11) volunteered to participate in exchange for course credits or a compensation of 15 euro. They all reported to be in good health and free of any respiratory and cardiovascular diseases. The Ethics Committee of the Faculty of Psychology and Educational Sciences and the Faculty of Medical Sciences approved the experiment.

2.2 Measurements

2.2.1 Physiological measures.

The NeXus-10 MK II® (Mind Media B.V.) was used to collect all physiological data. Two electrical wires sewn into two elastic bands, to assess rate and volume of breathing, were placed around the ribcage and abdomen. Two pre-gelled electrodes, measuring electromyography (EMG), were placed on the forehead to detect muscle tone of the medial Frontalis. Together with three pre-gelled electrodes to measure electrocardiography (ECG), two sensors to measure skin conductance at the medial phalanges of the index and middle finger, and one control electrode on the C1 vertebra were connected to the NeXus. The NeXus sent the physiological data to BioTrace software for real-time feedback and data storage. Capnography (POET II, Criticare) was used to continuously monitor pCO_2 from the exhaling tube.

2.2.2 Self-report measures (Appendix C).

A health questionnaire was used to determine the health status of the participant. Specifically the questions about heart diseases and respiratory problems were important for the rest of the experiment. The validated Dutch translation of the Anxiety Sensitivity Index – 3 (ASI: Taylor et al., 2007; De Jong, 2008) and of the Toronto Alexithymia Scale (TAS: Bagby, Parker & Taylor, 1994) were used to determine the level of respectively anxiety sensitivity and alexithymia. Bagby, Parker and Taylor (1989) define alexithymia as a construct with four essential parts: "(a) difficulty in identifying and describing feelings, (b) difficulty in distinguishing between feelings and bodily sensations, (c) restrictive imaginative processes and (d) a cognitive style that is concrete and reality-based.". A self-report scale (Appendix A) was used to measure the perceived dyspnoea during the experiment. Whenever the participant felt a shortness of breath, they were asked to indicate this on a scale from zero (No perceived dyspnoea) to one hundred (Maximally imaginable dyspnoea).

2.3 Procedure

The participants were individually invited to participate in the study 'Catch Your Breath', a study on the influence of breathing resistance on different physiological and psychological parameters.

Upon arrival, participants were asked to complete the informed consent (Appendix B), and to fill in the health questionnaires, the ASI and the TAS on the computer. For the preparation of the physiological measurements, the participant was asked to wash their left hand with cold water, to have a better skin conductance signal. Their forehead was scrubbed, again to have a better signal. Then the experimenter placed the five electrodes on the participant and connected these with the NeXus. After checking the quality of the physiological data, the experimenter gave the specific instructions of the experiment (Appendix D). The participant was informed about the structure and goal of the experiment and what they could expect. They were told to indicate their feeling of dyspnoea using a self-report rating scale, of which the labels were introduced to them. The participant was asked not to talk or move, except to turn the rating scale to indicate the experienced dyspnoea. The participant was also reminded that he could stop whenever he wanted. After the instructions, the breathing mask was installed on the mouth and nose of the participant. The breathing mask was attached to a two-way valve, connected to one tube for inhaling and one for exhaling. This was necessary to induce breathing resistance only when the participant inhaled, so the exhalation process was without resistance. The participant was told before putting on the mask that the face mask and the tubes could cause some resistance as well, and the best way to deal with this would be to just let his breathing spontaneously adjust. After the installation of the breathing mask, the instructions were shortly repeated and the experiment began.

2.4 Design

The experiment (Appendix E) consisted of four blocks, two acquisition blocks and two test blocks. Each block consisted of 16 trials. During the first phase of each trial, subjects were exposed to a breathing resistance for 40 seconds, the dyspnoea phase - cued for each subject by either a circle or a triangle. During the second phase of each trial, the breathing resistance was removed, leading to relief of dyspnoea - cued for each subject by the other symbol, i.e., a triangle or a circle. In the first two blocks, the acquisition blocks, sighing during the relief of dyspnoea phase was monitored online. Two different reinforcement symbols (a star or a square) were presented during the relief of dyspnoea phase, predicting whether a sigh during this phase would be rewarded by the prolonging of the relief phase with 20 seconds, or would be punished by the immediate switch to breathing resistance for 20 seconds after the sigh. Following the reward or punishment phase, the next trial started. One acquisition block consisted of reward symbols, while the other one consisted of punishment symbols. If no sigh occurred in the relief of dyspnoea phase, this phase lasted 20 seconds.

The order of the blocks and the symbols were counterbalanced between subjects. After the acquisition blocks, the same trials were repeated in two test blocks. Again, participants were exposed to 40 seconds breathing resistance (dyspnoea phase), which was followed by a 20 seconds period during which the resistance was removed (relief of dyspnoea phase) and the reinforcement symbol for the respective subject (either the star or the square) was shown. However, these sighs were not rewarded or punished. The next trial followed immediately after the relief of dyspnoea phase. The experiment was finished after the fourth block and the participant was thanked for his/her participation.

3. Data analysis & Results

The physiological signals and stimulus presentation events were synchronized using Matlab R2015a (The MathWorks). The respiratory signals were visualized, screened for artefacts and pre-processed using VivoSense software (Vivonoetics). First, a qualitative diagnostic calibration was performed to integrate ribcage and abdominal traces and calculate the contribution of both to a total respiratory volume. Next, respiratory time and volume of each breath was determined. Sighs were determined as deep breaths: breaths with a respiratory volume at least twice as large as the mean respiratory volume in each block (Wilhelm et al., 2001). Only sigh rates, rating scale responses and the questionnaires data will be reported here. All the results were analysed within subjects. A repeated measures ANOVA was used for these analyses (Appendix F). Participants with missing values of one or more variables were excluded in the analyses of these specific variables. This exclusion could lead to varying degrees of freedom in some tests. Statistica 64 (Dell Inc., 2015) was used to statistically analyse the data.

The following questions were investigated by the described analyses, and were significant at $\alpha < .05$.

3.1 Manipulation check: Were sighs accurately monitored online during the acquisition phase?

In order to check whether sighs were detected online in a correct way and thus to check whether sighs were consistently rewarded or punished, the sigh frequency during the relief of dyspnoea phase was compared between trials that were rewarded or punished vs. trials that were not. A repeated measures ANOVA was performed with on one hand the sigh frequency during the relief of dyspnoea phase as dependent variable, and on the other hand the sigh detection - and thus reinforcement (Yes or No) - as a first independent variable, and type of reinforcement (Reward or Punishment) as a second independent variable. The dependent variable sigh frequency can be defined as the mean sum of sighs in each phase of a trial. This unit of measure will be used during the whole experiment.

There was no significant interaction between the type of reinforcement (Punishment or Reward) and the reinforcement of a sigh (Yes or No) for sigh frequency in the relief of dyspnoea phase (F (1, 31) = 1.56, p = .22). There was however a significant main effect of reinforcement on sigh frequency (F (1, 31) = 86.13, p = .000). The sigh frequency was significantly higher when the experimenter detected a sigh online, and thus reinforced (punished or rewarded) a sigh (Figure 1).

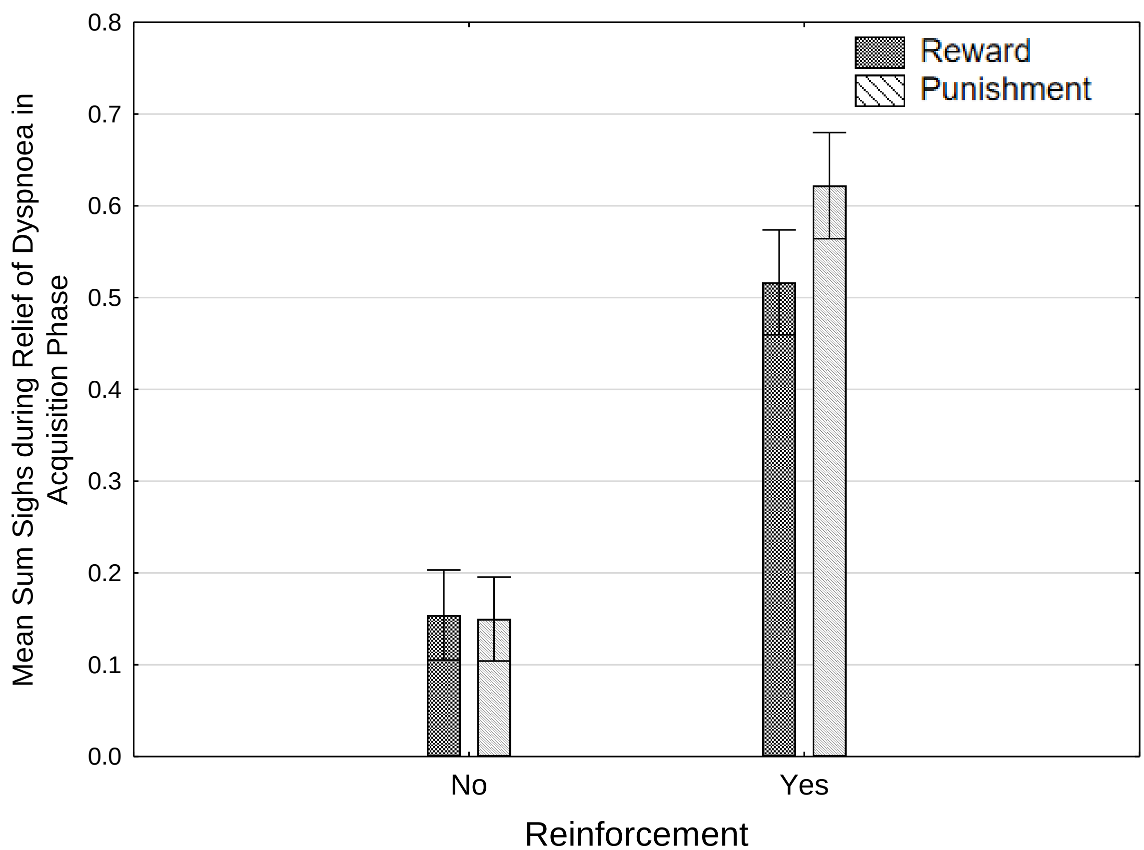

Figure 1. Sigh frequency during the relief of dyspnoea of the acquisition phase for the reinforcement of a sigh by type of reinforcement. The vertical lines denote the standard error.

3.2 Main research question: Are sighs conditioned responses?

To examine whether sighs are conditioned responses, we compared sigh frequencies in response to relief of dyspnoea in the test phase while presenting a cue that was coupled with reward in the acquisition phase, with sigh frequencies in response to relief of dyspnoea in the test phase while presenting a cue that was coupled with punishment during the acquisition phase. A repeated measures ANOVA was performed with sigh frequency during relief of dyspnoea in the test phase as dependent variable and the type of reinforcement (Reward vs. Punishment) as independent variable. We found that the sigh frequency in the relief of dyspnoea of the test phase was significantly higher during the reward condition in comparison to the punishment condition (F (1, 43) = 5.69, p = .022 (Figure 2)).

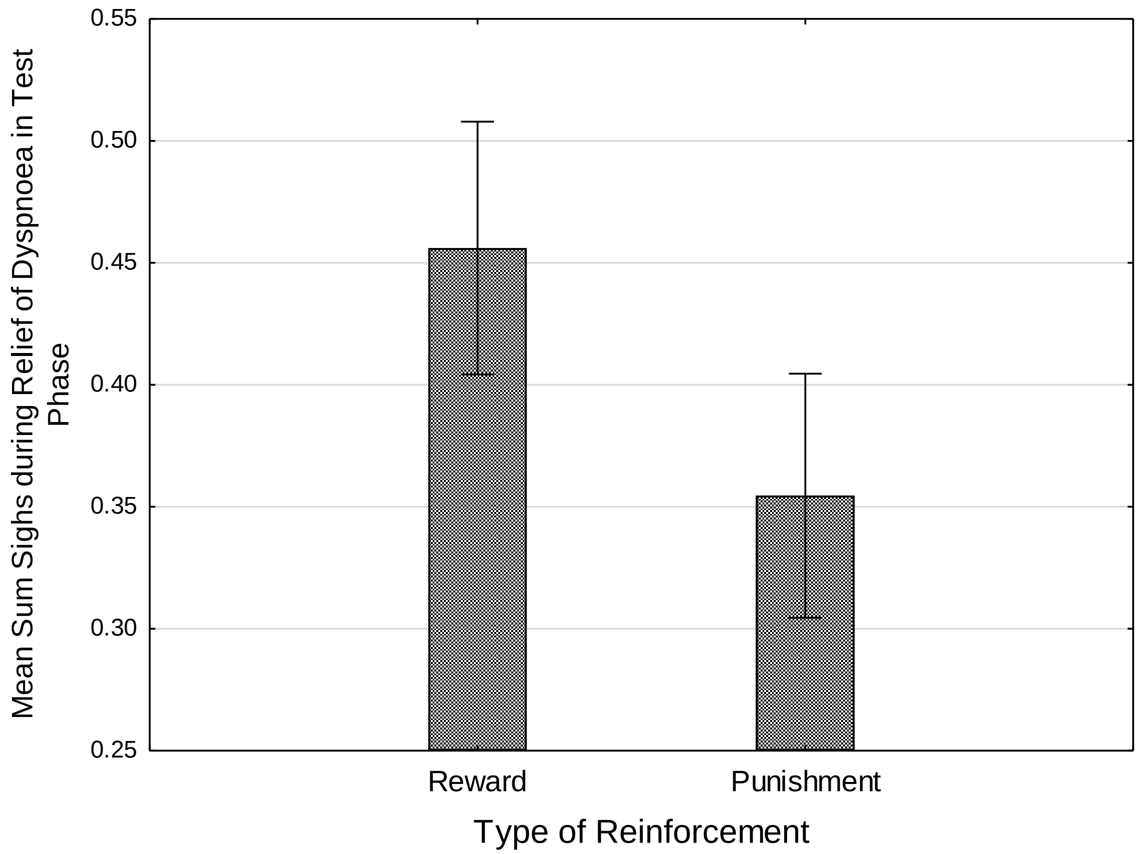

Figure 2. Sigh frequency during relief of dyspnoea of the test phase for the type of reinforcement (Reward and Punishment). The vertical lines denote the standard error.

3.3 Exploratory question 1: Is the conditioning of sighs dependent on anxiety sensitivity?

To examine if anxiety sensitivity influences the conditioning of sighs, we compared sigh frequency between the two types of reinforcement during the relief of dyspnoea of the test phase for high and low scores on ASI. A median split was used to divide the participants in a low ($X \leq 31$; $N = 21$) and high anxiety sensitivity group ($X > 31$; $N = 23$). A repeated measures ANOVA was performed with sigh frequency as dependent variable and the type of reinforcement and the anxiety sensitivity as independent variables.

There was no interaction between the type of reinforcement and a high or low ASI score (Figure 3). Although there was a significantly higher sigh frequency in the reward condition (F (1, 42) = 5.45, p = .024), people with a high ASI score did not sigh significantly more than people with a low ASI score (F (1, 42) = 2.07, p = .16).

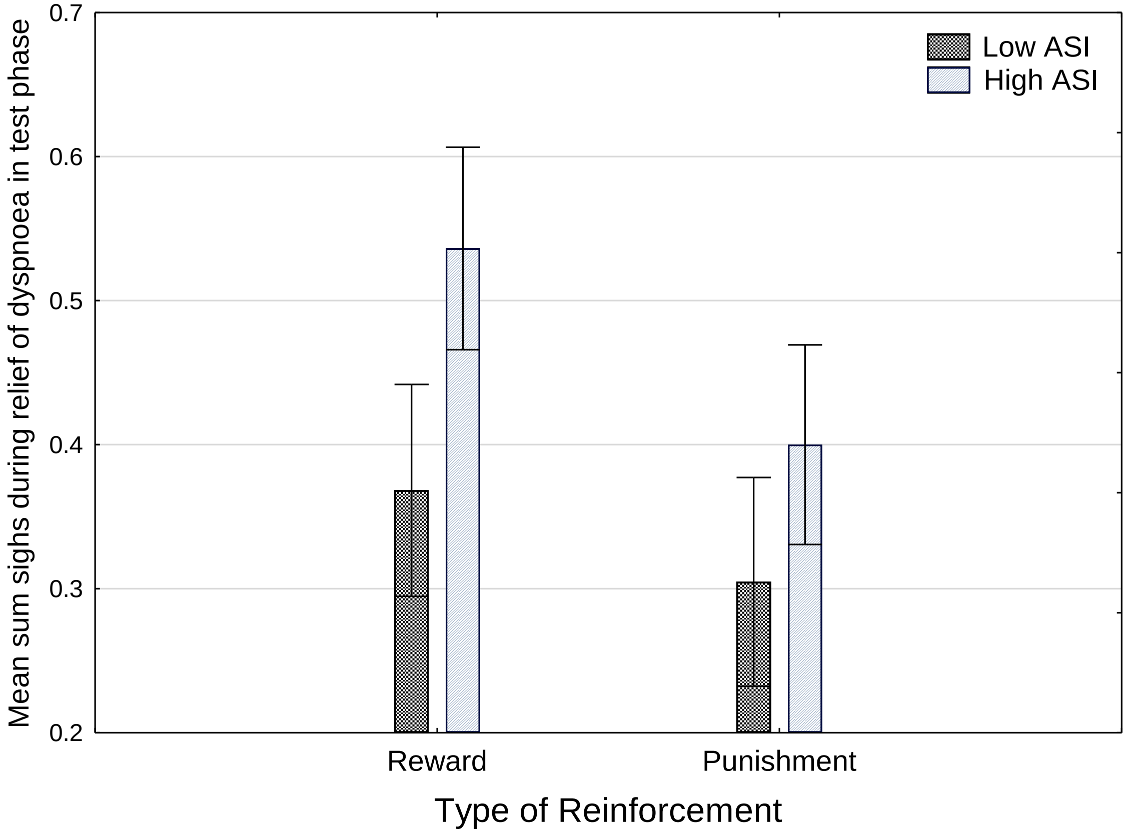

Figure 3. Sigh frequency during relief of dyspnoea of the test phase for the variable type of reinforcement (Reward and Punishment) by ASI-score. The vertical lines denote the standard error.

3.4 Exploratory question 2: Is the conditioning of sighs dependent on alexithymia?

In order to check if alexithymia has an influence on the conditioning of sighs, we compared the sigh frequency between the two types of reinforcement (Reward and Punishment) over different levels of alexithymia during the relief of dyspnoea of the test phase. The TAS divides the participants in three groups: No alexithymia ($X \leq 51$; N=30); possible alexithymia ($52 \leq X \leq 60$; N=10); and alexithymia ($X \geq 61$; N=4) (Bagby, Parker & Taylor, 1994). The same distribution was used in the repeated measures ANOVA, to evaluate the interaction and effects of the independent variables (type of reinforcement and alexithymia) on sigh frequency.

No significant interaction was found between TAS and the type of reinforcement for sigh frequency (F (2, 41) = 1.38, p = .26). There was also no significant effect of the TAS score on the sigh frequency (F (2, 41) = .33, p = .72).

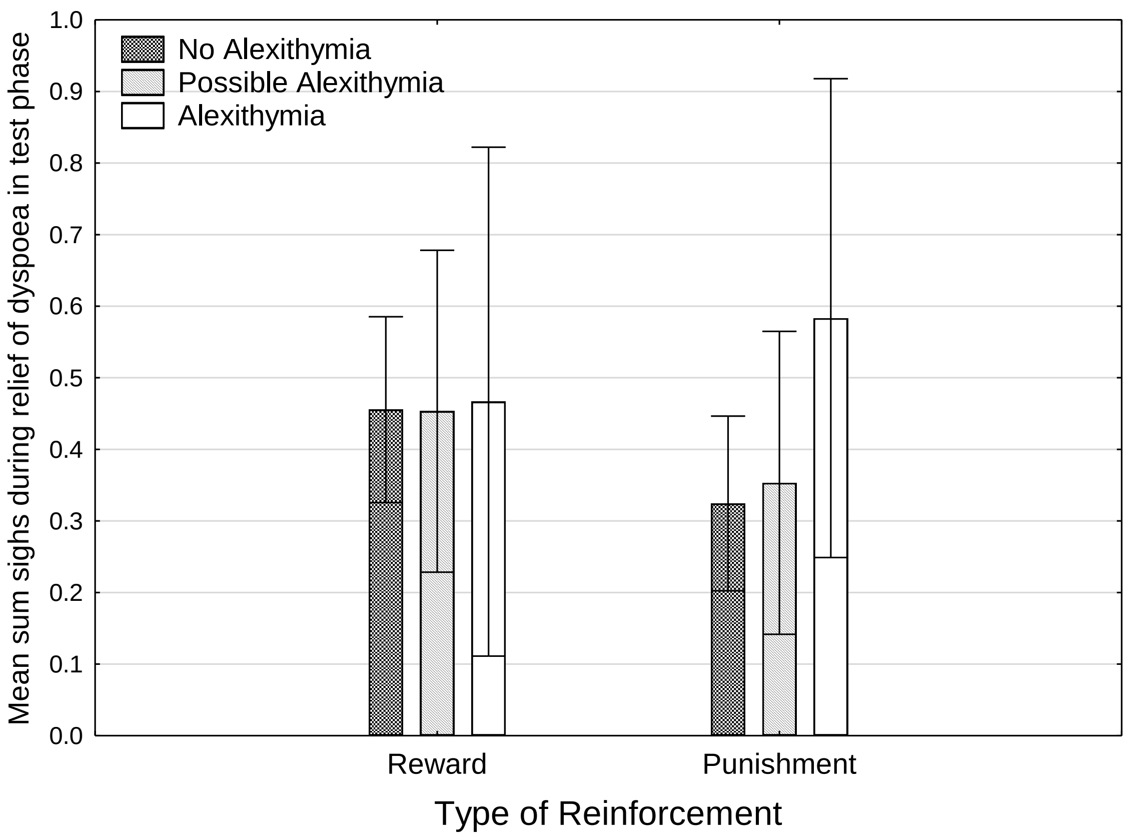

Figure 4. Sigh frequency during relief of dyspnoea in test phase for the two conditions of the variable reinforcement (Reward and Punishment) by the TAS score. Vertical bars denote the 0.95 confidence interval.

3.5 Exploratory question 3: Does learned sighing reduce subjective dyspnoea?

To investigate if conditioning of sighs influences the subjective dyspnoea feeling, we compared the subjective feeling of dyspnoea as dependent variable in the reward condition with the subjective feeling during the punishment trials during the test blocks. A repeated measures ANOVA was performed with subjective dyspnoea during the dyspnoea phase and the relief of dyspnoea phase as dependent variables, and type of reinforcement (reward or punishment) as independent variable.

During the dyspnoea of the test phase, there is no significant difference between the reward and punishment conditions (F (1, 43) = .04, p = .83). This effect is also not significant during the relief of dyspnoea phase (F (1, 43) = .05, p = .82).

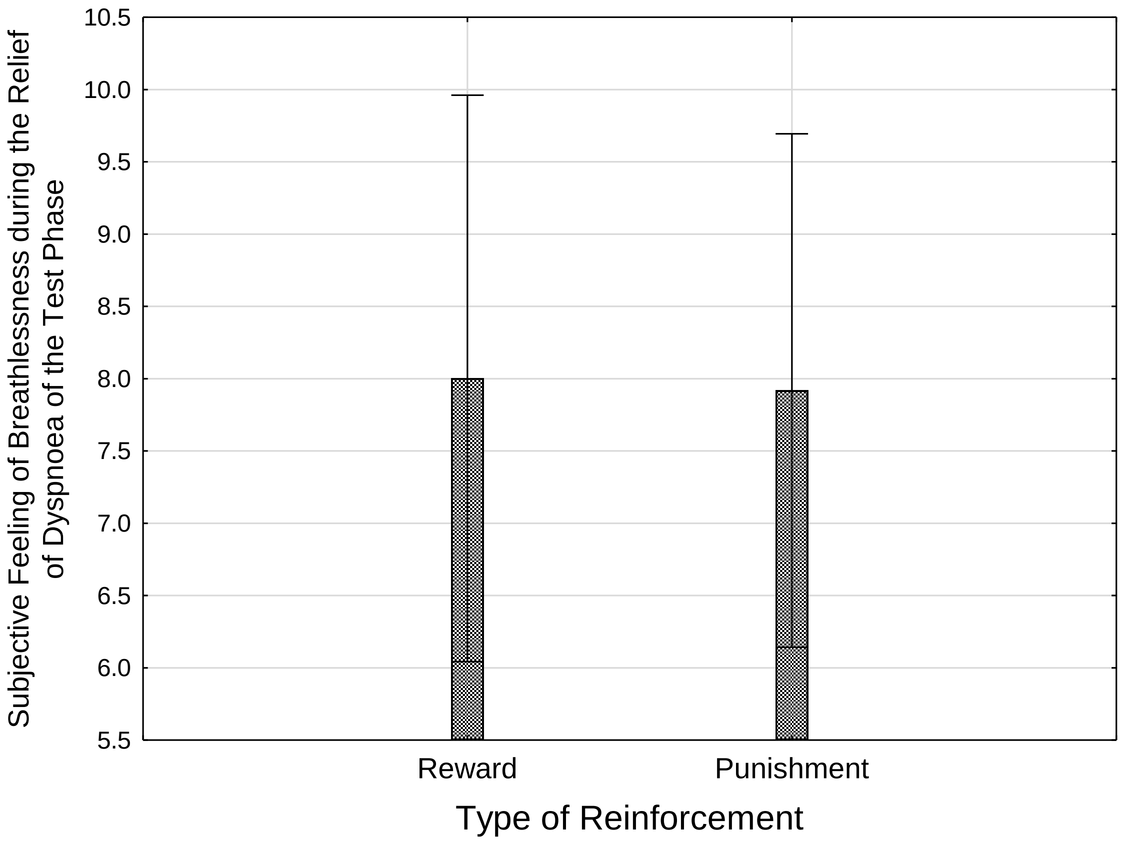

Figure 5. Subjective feeling of breathlessness during the relief of dyspnoea of the test phase for the two conditions of the variable type of reinforcement (Reward vs. Punishment). The vertical lines denote the standard error.

4. Discussion

We conducted an experiment to investigate whether participants sigh more during cues that were previously coupled with a reward, consisting of relief of dyspnoea, compared to cues that were previously coupled with a punishment, consisting of a breathing resistance. Based on the literature review, we also explored if behavioural traits and personality, such as anxiety sensitivity and alexithymia, could influence the conditioning of sighing. We used anxiety sensitivity and alexithymia because they have been linked with panic disorder patients (Cucchi et al., 2012), who have been found to have different sighing patterns (Wilhelm et al., 2001). Lastly, in order to know whether the applied breathing resistance was experienced as such in contrast with the relief of breathing resistance, their subjective feeling of dyspnoea was investigated.

We hypothesized that participants would sigh more when a reward would be expected, than when a punishment would be expected. The experiment confirmed that participants sighed more during the reward condition than during the punishment condition in the test trials. We could say that people learned to sigh, due to the expected reward or punishment. As manipulation check, we investigated if the experimenter monitored the sighs correctly during the relief of dyspnoea in the acquisition phase. The significant higher sigh rate of the participants in the conditions where the experimenter detected a sigh, suggests that the sighs were correctly identified and rewarded or punished. Besides the main research question, we had several exploratory questions.

First, we found no significant evidence that people with a higher anxiety sensitivity responded differently to the conditioning of a sigh. Secondly, alexithymia had no significant influence on the conditioning of sighs either. Lastly, we explored whether the subjective feeling of breathlessness was lower during conditions in which sighs were increased due to conditioning. This was not the case in this study.

The study confirms that sighing can act as a conditioned response. Following the principles of the behavioural therapy (Hermans, Eelen & Orlemans, 2007), operant conditioning states that a behaviour will be repeated if followed by a positive reinforcement or a negative reinforcement. Vlemincx, Van Diest and Van den Bergh (submitted) found that a sigh was followed by relief. The positive reinforcement of a sigh through relief, as well as the negative reinforcement through the avoidance of a stressful situation, could explain the contingency between sighing and relief, found in several studies (Soltysik & Jelen, 2005; Vlemincx, Taelman, Van Diest, & Van den Bergh, 2010; Vlemincx et al., 2009). Relief would act as a natural (or intrinsical) reward. Moreover, the finding that sighing can be a learned behaviour could also explain several experiments where sighing related to negative emotions (Vlemincx, Taelman, De Peuter, Van Diest, & Van Den Bergh, 2011; Vlemincx et al., 2015). If relief is a natural positive reinforcement of sighing, the participant can learn that sighing could lead to feelings of relief when overwhelmed by negative emotions. This learning process could operate both consciously and unconsciously, as noticed in the experiment of Greenspoon (1962).

The finding that people learn to sigh can explain the different sighing patterns found in panic disorder patients (Wilhelm et al., 2001). An important characteristic of these patients is the higher score on alexithymia and anxiety sensitivity (Cucchi et al., 2012). Therefore, we hypothesised that participants with a higher score on anxiety sensitivity and alexithymia would have a higher sigh frequency. Our results are in line with the findings that panic disorder patients sigh more. Although not significant, the participants with a higher anxiety sensitivity showed a higher sigh frequency than participants with a lower anxiety sensitivity.

More specifically, based on earlier research (Wilhelm et al., 2001), we expected that participants with a higher score on these characteristics would sigh more in the punishment condition. This happens because the carbon dioxide level with panic disorder patients does not recover following a sigh as well as in healthy controls. This would imply that panic disorder patients paradoxically create dyspnoea by sighing, as they sigh often and do not restore carbon dioxide following a sigh. Nevertheless, they maintain high sigh rates. Since we did not find differences in sigh frequencies during punishment between persons with high vs. low anxiety sensitivity or alexithymia, we could not provide evidence to confirm these findings. Participants who scored higher on alexithymia sighed slightly more during the punishment conditions. Due to a lack of sufficient participants with high alexithymia, we cannot draw any conclusions on these effects. However, the direction of these non-significant effects is in line with our hypothesis, and worth exploring in the future.

Recent findings may suggest why the reinforcement effects of relief in response to sighing in panic disorder patients may be higher than in controls. Participants with a high anxiety sensitivity experienced, in addition to psychological relief (as did participants with low anxiety sensitivity), also physiological relief in response to sighs. Whereas both persons with low and high anxiety sensitivity experience subjective relief following a sigh, only high anxiety sensitive persons show a decline in muscle tension in response to sighs (Vlemincx, Van Diest & Van den Bergh, submitted).

This effect could function as an extra reinforcement of the sighing behaviour of high anxiety sensitive persons, and maybe panic disorder patients. Further research with panic disorder patients is required to investigate the special characteristics regarding learning effects of sighing in this group for valid statements on this topic. If there is an effect of alexithymia on learned sighing behaviour, this mechanism could explain several mechanisms in alexithymia related disorders where sighing is not a homeostatic response (Finesinger, J.E., 1943).

There are certain limitations to this study that should be taken into account. First, the study was conducted on 44 participants. This population was sufficient for the evaluation of the general research questions. However, when further dividing in smaller groups of, for example, alexithymia participants, these groups became too small to make statements about the observed effects. To increase the clinical validity, further studies should target these specific populations. Next, because participants consisted mainly of university students, generalising the results to older populations is not yet possible. A third limitation can be found in the manipulation of the breathing resistance. All the participants received the same amount of breathing resistance. Although we see that all the participants experienced the breathing resistance, the subjective feeling of the resistance was different for all the participants. In further research this could be eliminated by letting the participant choose the resistance which results in the same subjective breathlessness for all the participants at the beginning of the experiment. A fourth limitation implies that operant conditioning can proceed consiously and unconsciously (Greenspoon, 1965). The participants were not asked if they knew the purpose of the study, as a result, we could not tell if the participants consciously experienced the learning effect or that this happened unconsciously. No further statements can be made on this subject. As a fifth limitation we argue that although a learning effect was found, we can not assign the effect to a higher frequency of sighs in the reward condition, or to a lower frequency of sighs in the punishment condition. We can only say that the difference during the test phase was significant. Finally, in the punishment trials, the participant would experience an extra long breathing resistance between the sigh in the recovery phase and the recovery phase of the next trial in the acquisition. This happens because the breathing resistance of the first phase followed immediately on the punishment by breathing resistance of the third phase of the previous trial. For the participant, it was not possible to distinguish the two phases. This could mean that some of the participants did sigh during the punishment conditions in the acquisition as a homeostatic response. Further research could use another punishment method, for example one not linked with breathing.

5. Conclusion

As conclusion, we can say that sighing, besides being a natural response with an important homeostatic function (Vlemincx, Van Diest, et al., 2010), can be a conditioned behaviour as well. We investigated if participants could learn to sigh by inducing breathing resistance when they sighed during the punishment signal, and by rewarding them when they sighed during the reward signal. We concluded that they did sigh more during the reward condition than during the punishment condition. Moreover, we observed some natural sighs as well. When they had long periods of breathing resistance in de punishment condition, the particpants sighed more than expected. We did not find any significant effects of alexithymia and anxiety on the sighing behaviour. But the results show promising outcomes, if investigated with more alexithymia and high anxiety sensitivity participants. Further research is also needed to investigate these sighing learning processes with panic disorder patients.

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Are Sighs Conditioned Responses? Can we learn to sigh?

Appendices

Appendix A. Self-Report scale for the perceived dyspnoea

Figure A. Illustration of self-report scale used to measure the perceived dyspnoea.

Appendix B: Informed consent

'Geïnformeerde toestemming'

Titel van het onderzoek:
'Catch your breath 2'

Naam + contactgegevens onderzoeker:
Elke Vlemincx
Elke.Vlemincx@ppw.kuleuven.be

Methodologie van het onderzoek:
Het onderzoek betreft een experiment waarin de invloed van bepaalde ademweerstanden en de opluchting van deze ademweerstanden wordt onderzocht op zowel fysiologische en psychologische parameters. De deelnemer zal in-en uitademen via weerstanden van verschillende niveau's en veranderingen in zijn subjectieve beleving aangeven. Ondertussen worden ademhaling, hartritme, spierspanning en huidgeleiding nauwkeuring opgevolgd.

Duur van het experiment:
120 min

Gelieve aan te kruisen indien akkoord:

☐ Ik begrijp wat het doel van dit onderzoek is:

Hart- en vaatziekten, ademhalingsziekten, en psychologische condities zoals stress, angst en andere emoties kunnen gepaard gaan met ademhalingssymptomen. Een veel gerapporteerd symptoom is ademnood. In dit onderzoek zal nagegaan worden welke gevolgen ademnood en opluchting van ademnood hebben op jouw lichamelijke signalen en beleving.

☐ Ik weet dat ik zal deelnemen aan volgende proeven of testen:

☐ Tijdens dit onderzoek zullen eerst enkele vragenlijsten afgenomen worden die peilen naar jouw gezondheid en emotiegevoeligheid.

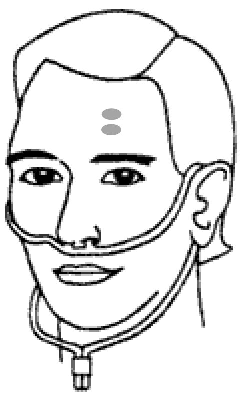
☐ Voor het experiment start, zal alle apparatuur geinstalleerd worden om de volgende fysiologische signalen te meten: ademhaling, hartritme, spierspanning en huidgeleiding.

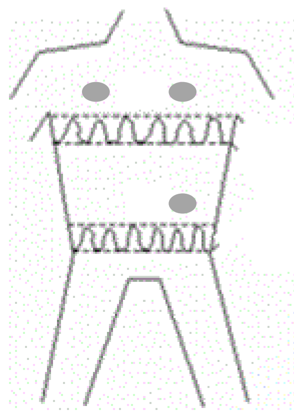
Je ademhaling zal gemeten worden d.m.v.:

- twee banden: een ter hoogte van de borstkas, een ter hoogte van het middenrif
- een neusbuisje

Electrodes zullen aangebracht worden

- op je borstkas om je hartritme te meten,
- op je voorhoofd om je spierspanning te meten,
- op je vingers om je huidgeleiding te meten.





☐ Tijdens het experiment zelf, zal je in-en uitademen via een masker dat we over je neus en mond plaatsen, en dat geconnecteerd is met een buis. Je zal dus in-en uitademen via deze buis. Vervolgens zal de diameter aan het uiteinde van deze buis systematisch verkleind en vergroot worden, waardoor de ademweerstand vergroot en verkleint. Wanneer de ademweerstand toeneemt, zal je ademnood ervaren. Dit betekent dat in-en uitademen moeilijker wordt en dat je meer moeite zal hebben om volledig in- en uit te ademen. Signalen op een beeldscherm voor je zullen aangeven of de ademweerstand aanwezig of afwezig is. Tijdens het observeren van de signalen en het ervaren van de ademnood, zal je gevraagd worden aan te geven hoe je je voelt.

☐ Ik begrijp wat van mij verwacht wordt tijdens dit onderzoek.

☐ Ik weet dat er risico's of ongemakken kunnen verbonden zijn aan mijn deelname:

☐ Tijdens dit onderzoek zal ademnood veroorzaakt worden. Ademnood is een negatieve ervaring. De maximale intensiteit van de ademnood die in dit onderzoek toegepast zal worden, zal echter niet erger zijn dan de ademnood die je ervaart bij intens sporten. De ademweerstanden die gebruikt zullen worden, zullen geen schadelijke gevolgen hebben.

☐ Ikzelf of anderen kunnen baat bij dit onderzoek vinden op volgende wijze:

☐ Ik leer bij over klachten en symptomen die eigen zijn aan hart- en vaatziekten, ademhalingsziekten en psychologische condities zoals stress en angst.

☐ Door deel te nemen aan een studie die de invloed van ademnood en opluchting van ademnood nagaat op de lichamelijke beleving, kan meer duidelijkheid geschept worden omtrent de rol van lichamelijke signalen in therapieën voor stress, angst, relaxatie, ademhalingsziekten en hart- en vaatziekten.
Indien je op de hoogte gebracht wilt worden van de resultaten van het onderzoek, kan je onderaan dit formulier je e-mailadres vermelden.

☐ Ik neem uit vrije wil deel aan dit onderzoek.

☐ De resultaten van dit onderzoek kunnen gebruikt worden voor wetenschappelijke doeleinden en mogen gepubliceerd worden.

☐ Mijn naam wordt daarbij niet gepubliceerd, anonimiteit en de vertrouwelijkheid van de gegevens is in elk stadium van het onderzoek gewaarborgd.

☐ Ik behoud het recht om op elk moment mijn deelname aan het onderzoek stop te zetten en ik weet dat daaruit geen nadeel voor mij mag ontstaan.

☐ In overeenkomst met art 29 van de Belgische wet van 7/5/2004 inzake experimenten op de menselijke persoon heeft het UZ Leuven een verzekering afgesloten die mogelijke schade ten gevolge van het onderzoek dekt.

☐ Voor eventuele vragen, klachten, verdere opvolging, weet ik dat ik na mijn deelname terecht kan bij:

☐ de Sociaal-Maatschappelijke Ethische Commissie: smec@kuleuven.be

☐ de onderzoeker: Elke.Vlemincx@ppw.kuleuven.be

☐ Indien je geen contact wenst op te nemen de Sociaal-Maatschappelijke Ethische Commissie of de onderzoeker, kan je terecht bij de vertrouwenspersoon van de Onderzoeksgroep Gezondheidspyshologie: Katleen.Bogaerts@ppw.kuleuven.be

Ik heb bovenstaande informatie gelezen en begrepen en heb antwoord gekregen op al mijn vragen betreffende deze studie. Ik stem toe om deel te nemen.

Datum:

Naam en handtekening proefpersoon

Naam en handtekening onderzoeker

Appendix C: Questionaires

A. Subject information

Antwoordmogelijkheden: Ja/Nee

1. Ben je zwanger?
2. Geef je borstvoeding?
3. Heb je een hartaandoening?
4. Heb je een ademhalingsziekte of ademhalingsproblemen?
5. Heb je andere medische aandoeningen?
6. Heb je een medische ingreep ondergaan in de afgelopen drie maanden?
7. Heb je andere medische klachten die je wilt meedelen?
8. Heb je ooit een diagnose gekregen voor een psychiatrische aandoening?
9. Ben je ooit in behandeling of counseling geweest voor een psychiatrische aandoening?
10. Neem je medicatie op dit moment?

B. Dutch translation of the Anxiety Sensitivity Index (ASI; Reiss & Peterson, 1986)

Anxiety Sensitivity Index - 3 *(Steven Taylor et al., 2007)*

Geautoriseerde Nederlandse Vertaling (Peter J. de Jong, 2008)

Omcirkel a.u.b. het getal dat het beste weergeeft in hoeverre u het met iedere uitspraak eens bent. Als een uitspraak gaat over iets dat u nog nooit heeft meegemaakt (zoals flauwvallen in het openbaar) antwoord dan zoals u denkt dat u zich zou voelen *als u zoiets zou meemaken*. Beantwoord verder alle uitspraken op grond van uw eigen ervaring. Omcirkel a.u.b. slechts één getal per uitspraak en beantwoord alle uitspraken.

	Heel weinig	**Een beetje**	**Behoorlijk**	**Erg**	**Heel erg**
1. Het is belangrijk voor me om niet nerveus over te komen.	0	1	2	3	4
2. Als ik mijn aandacht niet bij een taak kan houden, dan maak ik me zorgen dat ik misschien wel gek word.	0	1	2	3	4
3. Ik word angstig als mijn hart snel klopt.	0	1	2	3	4
4. Als mijn maag van streek is, maak ik me zorgen dat ik misschien wel ernstig ziek ben.	0	1	2	3	4
5. Ik vind het eng als ik niet in staat ben om mijn aandacht bij een taak te houden.	0	1	2	3	4
6. Als ik tril waar anderen bij zijn, dan maak ik me zorgen wat ze wel niet over me zullen denken.	0	1	2	3	4
7. Als ik een benauwd gevoel op de borst heb, ben ik bang dat ik niet normaal kan ademhalen.	0	1	2	3	4
8. Als ik pijn op de borst voel, maak ik me zorgen dat ik een hartaanval zal krijgen.	0	1	2	3	4
9. Ik maak me zorgen dat andere mensen zullen zien dat ik bang ben.	0	1	2	3	4
10. Als ik me versuft of verdwaasd voel, maak ik me zorgen dat ik een psychische aandoening heb.	0	1	2	3	4
11. Ik vind het eng om te blozen waar andere mensen bij zijn.	0	1	2	3	4
12. Als ik merk dat mijn hart een slag overslaat, maak ik me zorgen dat er iets ernstigs met me aan de hand is.	0	1	2	3	4
13. Als ik in gezelschap begin te zweten, maak ik me zorgen dat mensen negatief over me zullen denken.	0	1	2	3	4
14. Als mijn gedachten steeds sneller lijken te gaan, ben ik bang dat ik wellicht gek aan het worden ben.	0	1	2	3	4
15. Als mijn keel dichtzit, maak ik me zorgen dat ik zou kunnen stikken.	0	1	2	3	4
16. Als ik niet in staat ben om helder te denken, maak ik me zorgen dat er iets mis met me is.	0	1	2	3	4
17. Het lijkt me afschuwelijk om in het openbaar flauw te vallen.	0	1	2	3	4
18. Als ik het allemaal niet meer weet, maak ik me zorgen dat er iets ernstig mis is met me.	0	1	2	3	4

Scores: Lichamelijke zorgen = optellen items 3, 4, 7, 8, 12, 15. Geestelijke zorgen = optellen items 2, 5, 10, 14, 16, 18. Sociale zorgen = optellen items 1, 6, 9, 11, 13, 17.
Bron: Taylor, S. et al. (2007). Robust dimensions of anxiety sensitivity: Development and initial validation of the Anxiety Sensitivity Index-3. *Psychological Assessment, 19.*
Geautoriseerde vertaling: Peter J. de Jong (2008). Rijksuniversiteit Groningen.

C. Dutch translation of the Toronto Alexithymia Scale (TAS)

Instructies. *Volgende vragenlijst gaat over hoeveel u bezig bent met uw gevoelens. Lees elke stelling en beslis of u het er eens mee bent. Omcirkel het nummer naast elke stelling, gebruik makend van de volgende schaal:*

1 helemaal oneens	2 oneens	3 noch eens noch oneens	4 eens	5 helemaal eens

Ik ben vaak in verwarring over wat ik voel.	1	2	3	4	5
Ik vind het moeilijk de juiste woorden voor mijn gevoelens te vinden.	1	2	3	4	5
Ik heb lichamelijke gewaarwordingen die zelfs artsen niet begrijpen .	1	2	3	4	5
Ik kan mijn gevoelens gemakkelijk beschrijven.	1	2	3	4	5
Ik vind het prettiger problemen te analyseren dan ze alleen maar te beschrijven.	1	2	3	4	5
Wanneer ik van streek ben, weet ik niet of ik verdrietig, bang of boos ben.	1	2	3	4	5
Mijn lichamelijke gewaarwordingen stellen me vaak voor raadsels.	1	2	3	4	5
Ik vind het prettiger dingen gewoon te laten gebeuren dan te begrijpen waarom ze zo gebeuren.	1	2	3	4	5
Ik heb gevoelens die ik niet helemaal kan thuisbrengen.	1	2	3	4	5
Het gaat erom dat je je bewust bent van je gevoelens.	1	2	3	4	5
Ik vind het moeilijk te beschrijven wat ik van andere mensen vind.	1	2	3	4	5
Men zegt mij dat ik mijn gevoelens meer moet beschrijven.	1	2	3	4	5
Ik weet niet wat zich binnenin mij afspeelt.	1	2	3	4	5
Ik weet vaak niet waarom ik boos ben.	1	2	3	4	5
Ik praat met anderen liever over hun dagelijkse bezigheden dan over hun gevoelens.	1	2	3	4	5
Ik kijk liever naar amusementsprogramma's dan naar psychologische drama's.	1	2	3	4	5
Ik vind het moeilijk mijn diepste gevoelens prijs te geven, zelfs aan goede vrienden.	1	2	3	4	5
Ik kan mij dichtbij iemand voelen, zelfs tijdens ogenblikken van stilte.	1	2	3	4	5
Ik vind het onderzoeken van mijn gevoelens nuttig voor het oplossen van persoonlijke problemen.	1	2	3	4	5
Zoeken naar de bedoeling achter films of toneelstukken leid je af van het genieten ervan.	1	2	3	4	5

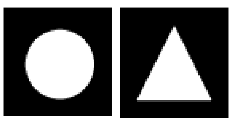
Appendix D. Instructions for the experiment.

Catch your breath

Dit onderzoek heeft als doel
de invloed van bepaalde ademweerstanden, en opluchting van deze ademweerstanden,
te onderzoeken
op jouw ervaren gevoel van ademnood,
en op verscheide fysiologische parameters,
zoals ademhaling, hartritme, spierspanning en huidgeleiding.

Tijdens het experiment zal je via een ademweerstand ademen
die je een gevoel van ademnood zal geven.
Je zal ademnood ervaren,
wat betekent dat het moeilijker zal worden om in te ademen
en dat inademen meer moeite zal vergen.

De vorm van de gepresenteerde figuren op het scherm zal aangeven
of de ademweerstand aanwezig is, of afwezig is.



Wanneer de ademweerstand ophoudt,
kunnen er twee verschillende symbolen gepresenteerd worden.

Tijdens de presentatie van deze symbolen,
zal je ademgedrag bepalen of er een ademweerstand volgt of niet.

Bij een diepe inademing tijdens een van beide symbolen,
zal er gedurende 20s geen weerstand volgen,
en zal je dus vrij kunnen ademen en geen ademnood voelen.

Bij een diepe inademing tijdens het andere symbool,
zal gedurende 20s een ademweerstand volgen
en zal je dus onmiddellijk weer ademnood ervaren.

Het experiment bestaat uit 4 blokken van 20 minuten,
met een korte pauze tussen de blokken.
Tijdens 2 blokken zal de ster verschijnen,
tijdens de 2 andere blokken zal het vierkant verschijnen.

Tijdens het hele experiment zal je ademen via een masker
dat we over je neus en mond plaatsen.

De mondopening in het masker wordt verbonden met een buis
die langs de andere zijde verbonden is met een weerstand.
De studieleider kan de grootte van de weerstand controleren
en kan de weerstand dus systematisch vergroten of verkleinen.

Jouw taak tijdens het experiment is aan te geven hoe je je voelt,
en meerbepaald **hoe intens** de **ademnood** is die je ervaart.

Geef aan hoe intens de ademnood is
aan de hand van de volgende schaal:

Je kan aangeven hoe intens je ademnood ervaart door de knop te draaien van 0 tot 100,
en dit continu tijdens het hele experiment.
Op ieder moment tijdens het experiment, kan je je antwoord wijzigen op basis van
je gevoelens en ervaringen naar aanleiding van de signalen en de weerstanden.
Dus, gelieve te draaien telkens wanneer je een verandering voelt.

Duid je antwoorden aan in stilte.
Gelieve niet te praten tijdens het experiment,
tenzij je het experiment wil onderbreken!

Gelieve ook zo weinig mogelijk te bewegen tijdens het experiment!
Iedere beweging verstoort het signaal.

Gelieve de hand waarmee je de 'ademnood'-schaal bedient,
aan de knop van de schaal te houden om iedere ervaren verandering aan te geven.

Gelieve de hand waarmee je de schaal niet bedient,
stilletjes te laten liggen op de tafel.

Wanneer je de ademweerstand voelt, panikeer niet.
Je ademhalingsysteem zal zich spontaan aanpassen aan de weerstand,
dus laat je ademhaling langzaam wennen aan de weerstand.

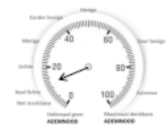
Heb je nog vragen?
Stel ze dan nu!

Ter herinnering

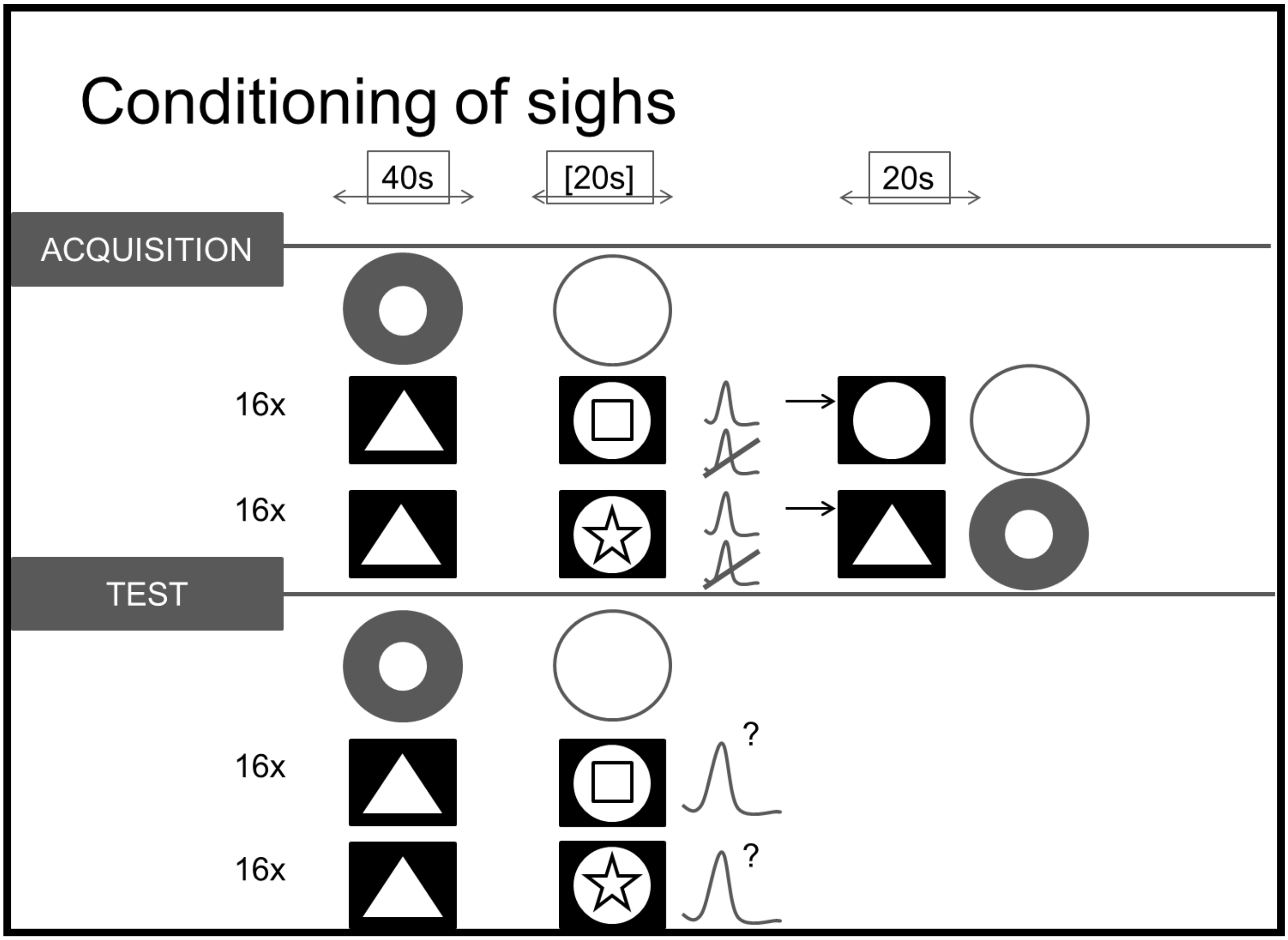
De vorm van de gepresenteerde figuren op het scherm zal aangeven
of de ademweerstand aanwezig of afwezig is.

De volgende symbolen 
zullen aangeven of een diepe inademing
ofwel beloond wordt met 20s vrij ademen (tijdens 2 blokken van de 4)
ofwel bestraft wordt met 20s ademen via de weerstand (tijdens de andere 2 blokken).

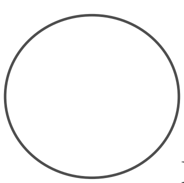
Geef tijdens het experiment continu aan hoe intens je ademnood ervaart:



Appendix E. Visualisation of the experimental design.




Participants receives breathing resistance


Participant can breathe freely

Appendix F. Tables and Figures

1. Manipulation check: Were sighs accurately monitored online during the acquisition phase?

Table I

Interaction and main effects on the sigh frequency with type of reinforcement (Reward vs. Punishment) and reinforcement (Yes vs. No) during the relief of dyspnea of the acquisition phase. Analysed with a repeated measures ANOVA.

Effect	SS	df	MS	F	P	Partial eta-squared	Non-centrality	Observed power (alpha=0,05)
Intercept	16.65	1	16.65	97.25	0.000*	0.76	97.25	1.00
Error	5.31	31	0.17					
Type of Reinforcement	0.08	1	0.08	1.42	0.24	0.04	1.42	0.21
Error	1.79	31	0.06					
Reinforcement	5.57	1	5.57	86.13	0.00*	0.73	86.13	1.00
Error	2.01	31	0.06					
Type of Reinforcement * Reinforcement	0.09	1	0.09	1.56	0.22	0.05	1.56	0.23
Error	1.91	31	0.06					

*p < .05

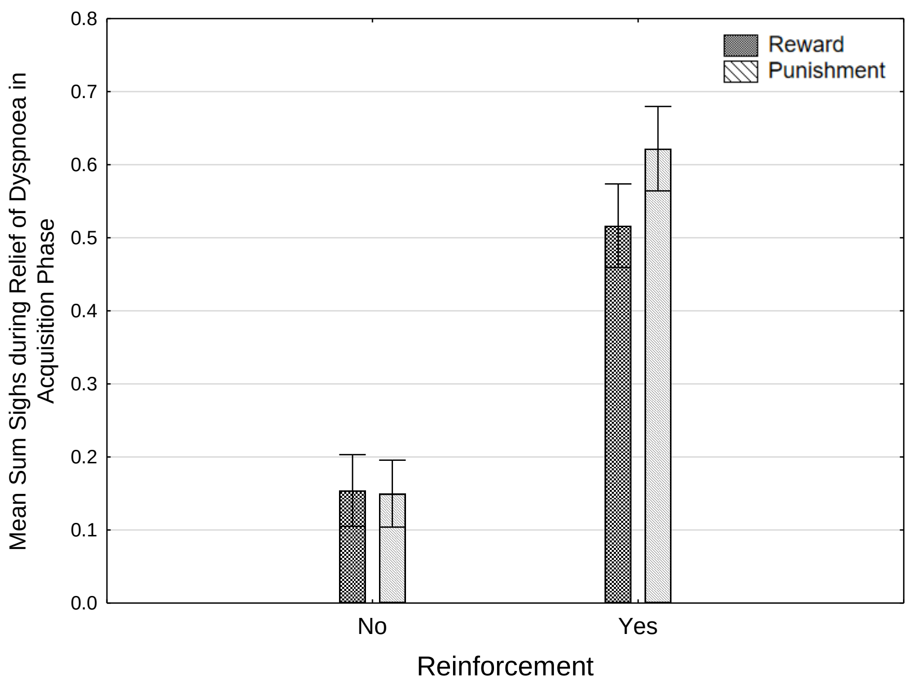


Figure 1. Sigh frequency during the relief of dyspnoea phase of the acquisition for the reinforcement of a sigh by type of reinforcement. The vertical lines denote the standard error.

2. Main research question: Are sighs conditioned responses?

Table II

Effects of type of reinforcement (Reward vs. Punishment) on the sigh frequency within participants during the relief of dyspnea of the test phase. Analysed with a repeated measures ANOVA.

Effect	SS	df	MS	F	p	Partial eta-squared	Non-centrality	Observed power (alpha=0,05)
Intercept	14.46	1	14.46	76.68	0.000*	0.64	76.68	1
Error	8.11	43	0.19					
Type of Reinforcement	0.23	1	0.23	5.69	0.02*	0.12	5.69	0.65
Error	1.71	43	0.04					

*p < .05

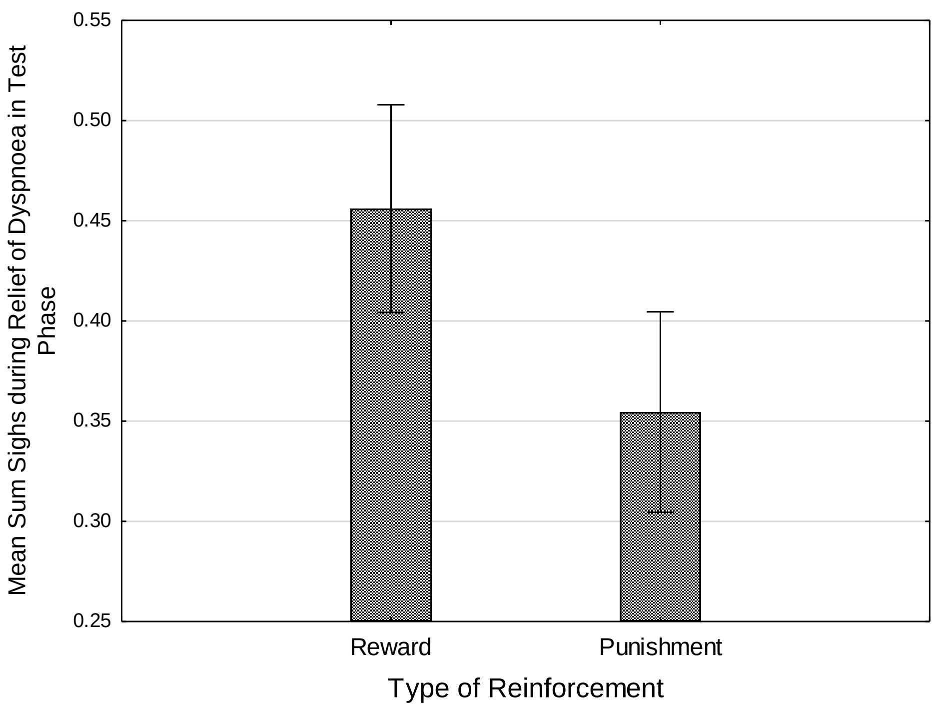


Figure 2. Sigh frequency during relief of dyspnoea of the test phase for the type of reinforcement (Reward and Punishment). The vertical lines denote the standard error.

3. Exploratory question 1: Is the conditioning of sighs dependent on anxiety sensitivity?

Table III

Interaction and main effects on the sigh frequency with type of reinforcement (Reward vs. Punishment) and ASI (High vs. Low) during the relief of dyspnea of the test phase. Analysed with a repeated measures ANOVA.

Effect	SS	df	MS	F	p	Partial eta-squared	Non-centrality	Observed power (alpha=0,05)
Intercept	14.21	1	14.21	77.27	0.000*	0.647850	77.27	1.00
ASI	0.38	1	0.38	2.07	0.15	0.046909	2.07	0.29
Error	7.73	42	0.18					
Type of Reinforcement	0.22	1	0.22	5.46	0.02*	0.115039	5.46	0.63
Type of Reinforcement * ASI	0.03	1	0.03	0.72	0.40	0.016950	0.72	0.13
Error	1.68	42	0.04					

*p < .05

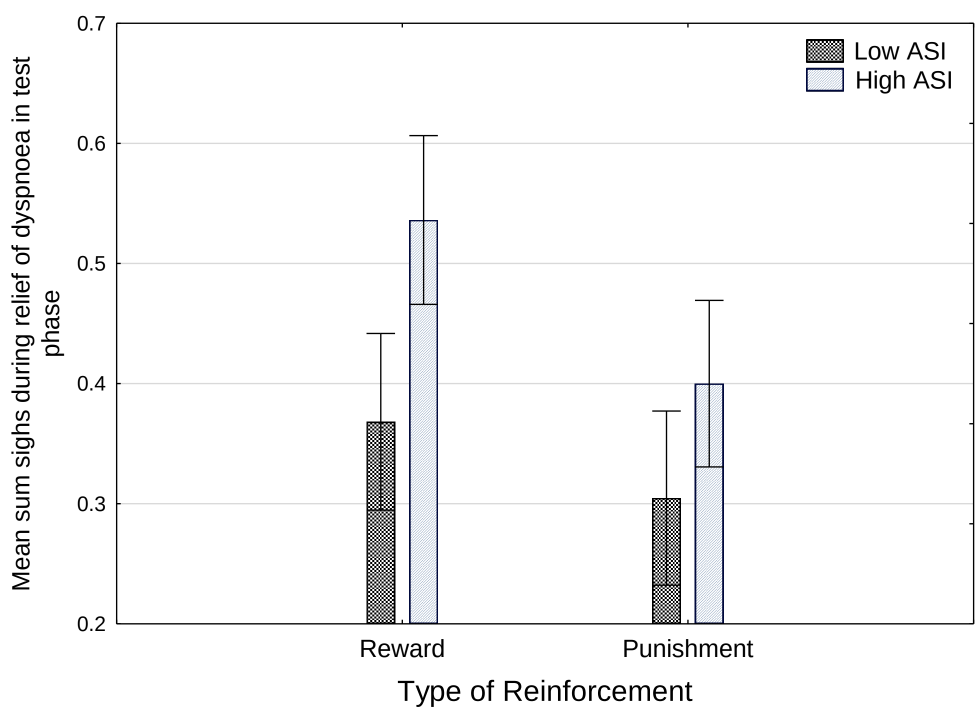


Figure 3. Sigh frequency during relief of dyspnoea of the test phase for the variable type of reinforcement (Reward vs. Punishment) by ASI-score. The vertical lines denote the standard error.

4. Exploratory question 2: Is the conditioning of sighs dependent on alexithymia?

Table IV

Interaction and main effects on the sigh frequency with type of reinforcement (Reward vs. Punishment) and TAS during the relief of dyspnea of the test phase. Analysed with a repeated measures ANOVA.

Effect	SS	df	MS	F	p
Intercept	9.07	1	9.07	46.60	0.000*
TAS	0.13	2	0.06	0.33	0.72
Error	7.98	41	0.19		
Type of Reinforcement	0.02	1	0.02	0.44	0.52
Type of Reinforcement * TAS	0.11	2	0.05	1.38	0.26
Error	1.60	41	0.04		

*p < .05

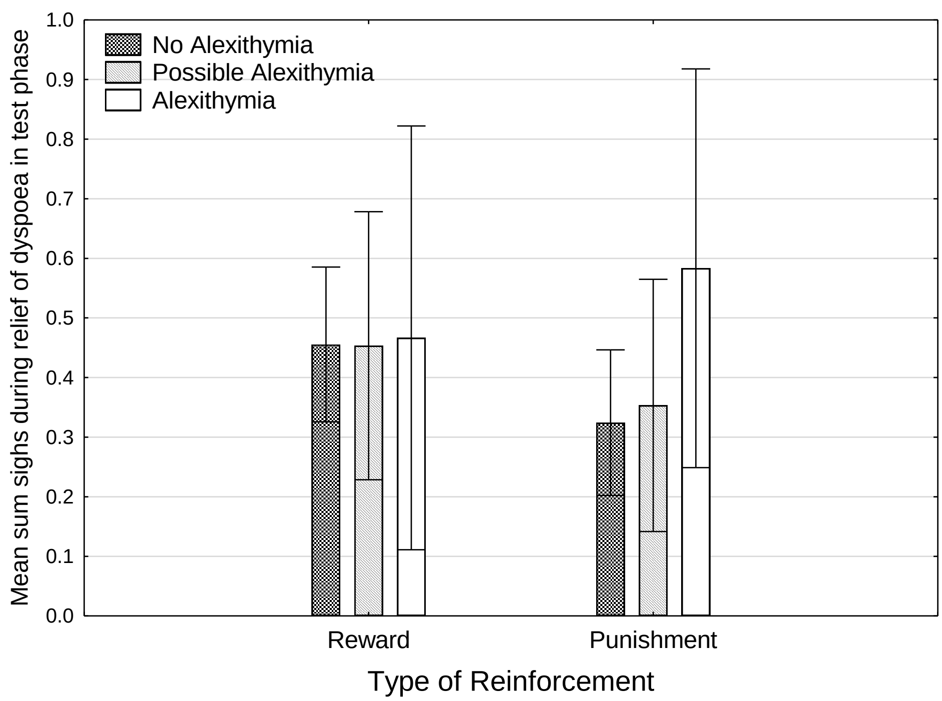


Figure 4. Sigh frequency during relief of dyspnoea in test phase for the two conditions of the variable reinforcement (Reward and Punishment) by TAS score. Vertical bars denote the 0.95 confidence interval.

5. Exploratory question 3: Does learned sighing reduce subjective dyspnoea?

Table V

Effects of type of reinforcement (Reward vs. Punishment) on the subjective feeling of breathlessness within participants during the relief of dyspnoea of the test phase. Analysed with a repeated measures ANOVA.

Effect	SS	df	MS	F	p	Partial eta-squared	Non-centrality	Observed power (alpha=0,05)
Intercept	5576.59	1	5576.58	18.29	0.000*	0.30	18.29	0.99
Error	13103.51	43	304.73					
Type of Reinforcement	0.15	1	0.15	0.05	0.82	0.00	0.05	0.06
Error	123.60	43	2.87					

*p < .05

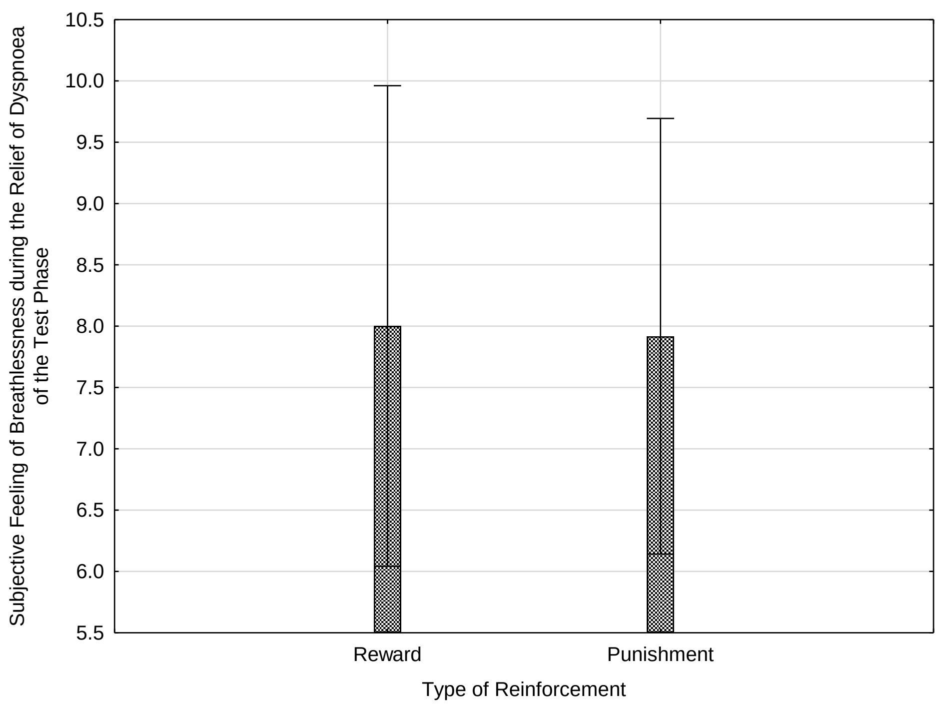


Figure 5. Subjective feeling of breathlessness during the relief of dyspnoea of the test phase for the two conditions of the variable type of reinforcement (Reward vs. Punishment). The vertical lines denote the standard error.