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THE EFFECT OF VISUAL INFORMATION ON PAIN THRESHOLD

MASTER THESIS

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ANOTĀCIJA

Maģistra darbs ir uzrakstīts angļu valodā uz 47 lapam. Tas satur 17 attēlus, 4 tabulas u 82 atsauces.

Mērķis: Izpētīt, kā dažādas tematiskās fotogrāfijas modulē sāpju noteikšanas sliekšņus, un novērtētu emocionālās fotogrāfijas izmantojot pašnovērtējuma manekenu metodi (SAM).

Metodes: 21 sievietei sāpju noteikšanas sliekšņi tika izmērīti ar pakāpeniski pieaugoša sprieguma padevi dalībnieku apakšdelmiem.

Rezultāti: Sāpju noteikšanas sliekšņi tika samazināti ar negatīvām valences fotogrāfijām (attēlojot vardarbību, dzīvnieku un cilvēku uzbrukumus, zaudējumus). Skatoties neitrālās un pozitīvās fotogrāfijas, sāpju noteikšanas sliekšņi neatšķīrās. SAM pozitīvo fotogrāfiju vērtējumi atklāja augstus valences un satraukuma novērtējumus un vidējas ietekmes līmeņa vērtējumus; neitrālas fotogrāfijas - zems satraukums, vidēja valence un augsta ietekme; negatīvas fotogrāfijas - zema valence, liels satraukums un zems ietekmes vērtējums.

Atslēgvārdi: sāpju sliekšņis, sāpju mazināšana, (International Affective Picture System) IAPS, pašnovērtējuma manekens (SAM), emocionālu fotogrāfiju vērtējums.

ABSTRACT

The thesis is written in English on 47 pages. It contains 17 figures, 4 tables and 82 references.

Purpose: To examine how different themed photographs would modulate pain detection thresholds and use the Self-Assessment Manikin (SAM) to rate the emotional photographs.

Methods: 21 women had their pain detection thresholds measured with shocks of gradually increasing voltage administered onto the participants forearm.

Results: Pain detection thresholds diminished with negative valence photographs (depicting violence, animal and human attack, loss). There were no differences in pain detection thresholds while viewing neutral and positive photographs. SAM ratings for positive photographs revealed high valence and arousal ratings and medium dominance ratings; neutral photographs – low arousal, medium valence and high dominance ratings; negative photographs – low valence, high arousal and low dominance ratings.

Keywords: pain reduction, International Affective Picture System (IAPS), Self-Assessment Manikin (SAM), emotional photograph ratings, pain detection thresholds.

LIST OF ABBREVIATIONS

Affective stimulus – a stimulus that will elicit an affective response.

Appetitive stimulus – a positive stimulus that will elicit a positive affective response.

Aversive stimulus – a noxious stimulus that will elicit a negative affective response.

fEMG (facial electromyography) – technique to measure muscle activity in the two major muscle groups in the face. It is used to assess emotional reaction.

Spinal nociceptive responses – spinal electromagnetic responses to a noxious stimulus.

Startle probe reflex – a physiological blinking response to a threat, triggered by a loud auditory stimulus.

Valence – characterizes a stimulus as negative or positive in the context of affect and emotion.

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INTRODUCTION

The investigation of reducing pain with atypical analgesia has been a popular topic in the recent years. It is known that pain can be reduced by shifting ones' attention away from the noxious experience. The basis of multisensory integration between visual and somatosensory systems is not fully been understood but researchers believe it to be related to the evolutionary defensive or nurturing reflexes. A preparedness theory of noxious stimulus has been hypothesized: a noxious stimulus would negatively alter the perception of a foreground stimulus, as to preparing for a negative experience. If one views a photograph with a negative valence, for example an aggressive animal, while introduced with a noxious somatosensory stimulus, the negative emotional perception of the photograph is said to be increased and the noxious stimuli would be perceived more painful than without multisensory involvement. (*De Wied & Verbaten,* 2001) In addition to this, motional priming theory states that a positive valence foreground would reduce the negative perception of a noxious stimulus. If a visual positive foreground is added to a noxious somatosensory stimulus, the perception of noxious stimulus would reduce and the emotional perception to the visual stimulus would also lower. (*Lang* 1995) Both of these theories are conflicting in terms of positive foreground stimulus.

Multiple psychological, physical and social factors influence the pain detection and tolerance thresholds, such as: expectation of the pain and previous experience with similar pain, the interpretation of the painful stimulation, attention and distraction from the pain, beliefs and attitude towards a certain nociceptive stimulus, fear and anxiety, neurological diseases, chronic pain, skin temperature and thickness, electrical resistance of the skin, numerous skin conditions and scars, age and sex, mental illnesses as well as extreme stress and exhaustion and last but not least, habituation.

This study examined the impact of different valence photographs on the pain detection threshold with gradually growing voltage shocks administered onto the forearm. Participant was asked to note when they felt a painful sensation similar to a needle prick while viewing slideshows consisting of either positive, negative or neutral photographs, each block lasting for about 5 minutes and 10 measurements of Volts were derived. The pain detection threshold was defined as the current amplitude at which the participant began to feel pain. Emotional ratings from participants of each photograph were also gathered.

The aim of this study was to investigate what emotional visual stimulus will alter the perception of pain and how would the chosen photographs be rated by valence, arousal and dominance.

The hypothesis of current thesis is that negative photographs lower the pain detection threshold, neutral photographs would not alter the perception of pain and positive photographs would either reduce the perception of pain the most or have the same effect as neutral photographs. For emotional ratings for valence, the highest would be hypothesized to be positive photographs, followed by neutral and negative ones. For arousal ratings, highest ranked would be hypothesized to be negative and positive ones, and for dominance ratings, negative photographs would be rated the lowest.

1. LITERATURE REVIEW

Our everyday experiences are mostly multimodal: we get information from multiple modalities at the same time. The gathered information gets processed in multiple regions in the brain and turned into a combination of multimodal stimuli, enhancing a certain stimulus, diminishing another, ultimately choosing what kind of stimulus is the most important for a specific task. One of the less researched areas of multisensory integration is visual-somatosensory integration, namely rendering pain perception with visual stimuli. Experiencing pain is considered a multimodal experience that can be modified with attention: if a person is distracted from their painful experience, their perception of pain seems to decrease. *Hoffman et al.* (2000) conducted an experiment where they distracted children going through burn would care with visual stimulation, namely videogames. The children noted a decrease in pain levels during the care as well as less time thinking about the pain (*Hoffman et al., 2000*).

1.1. Theories of pain

IASP defines pain as: "An unpleasant sensory and emotional experience associated with actual or potential tissue damage or described in terms of such damage." (*The International Association of the Study of Pain,* 1994). *Eccelston* and *Crombez* (1999) concluded that this definition denotes three aspects of pain: pain is always a negative experience, that pain has sensory and emotional qualities that no other perception has, and that experiencing pain does not correlate with tissue damage. But the aspect that the definition does not include, is the relationship between pain and perceiving the environment: the alteration of attention while in pain or vice versa. (*Eccelston & Crombez,* 1999)

Two theories of the environmental influence of pain have been hypothesized: motivational priming theory and the preparedness theory.

1.1.1. Theory of motivational priming

The theory of motivational priming states that an experience of an affective foreground can be modified by an aversive stimulus. It hypothesizes that there are two opposing motive systems that give feedback about our surroundings: appetitive and aversive/defensive systems. The appetitive system is activated in the brain by stimuli that produce the feeling of nurture, procreation and elicits positive emotions. The aversive system is activated by stimuli that produces the feeling of genuine or potential threat and elicits negative emotions or the fight-or flight response and as well a protective response (a defensive reflex). (*Lang et al.,* 1990; *Lang* 1995)

The theory claims that:

1) if a noxious stimulus is added to an appetitive stimulus, there is a decrease in positive emotional response;

2) if an innocuous stimulus is added to an appetitive stimulus, the positive response to harmless stimulus increases;

3) if the noxious stimulus is added to an aversive stimulus, the negative emotional response to harmful stimulus increases;

4) if an innocuous stimulus is added to an aversive stimulus, the negative emotional response decreases. (*Bradley et al.,* 2001)

1.1.2. Theory of preparedness

The theory of preparedness states that a noxious stimulus will alter the perception of an aversive foreground into an even more emotionally negative experience, but a noxious stimulus will not alter the perception of an appetitive foreground with a positive emotional valence (*Seligman,* 1970). The theory postulates that visual stimuli that is related to fear has a greater impact on the perception of pain than any positive visual stimulus and the differences are thought to be due to cognitive mechanisms of the previous un-preparedness or preparedness (*Öhman & Soares,* 1993).

The theories suggest a multisensory integration between the visual and somatosensory systems in favor of either the visual system (negative photographs increase the perception of pain responses or pain ratings) or in favor of the somatosensory system (where the noxious stimulus changes the perception of photographs). (*Bradley et al.,* 2001; *De Wied & Verbaten,* 2001; *Meagher et al.,* 2001; *Tse et al.,* 2002a)

1.1.3. Motivational priming vs preparedness theory

The two theories are contradicting in the hypothesis of the relationship between noxious stimulus and positive visual stimulus: motivational priming theory states there is a decrease of positive emotional response to a noxious stimulus; (*Williams & Rhudy* 2007; *Williams & Rhudy* 2012;) while the preparedness theory states that the perception of positive photographs does not change with noxious stimulation (*Peterson et al.*, 1993; *Seligman,* 1970; *Seligman,* 1971).

Consistent with the priming theory were the results of a research conducted by *Meagher et al.* in 2001 where effects of positive and negative visual stimuli were viewed while participants held their right hand in a cold pressor. They concluded that while viewing photographs of both fear and disgust, the pain intensity thresholds reduced (participants noted that the sensation of the cold pressor felt more painful), but only photographs depicting fear

reduced the overall pain tolerance. They also found a difference in genders for arousing slides that did not elicit nurturing emotions: for men, viewing erotic photographs, the pain intensity thresholds increased (men rated the experience less painful). (*Meagher et al.,* 2001) *De Wied & Verbaten* (2001) tested the motivational priming theory by letting the participants submerge their arms in cold water similar to the former research and measuring the time how long a person could tolerate the pain. The results proved the hypothesis: participants viewing positive photographs could emerge their hand longer than participants viewing neutral photos (difference of 39 seconds) and participants who viewed negative photographs had the lowest pain tolerance levels (12 seconds less than for neutral photos). It was also revealed that for negative photographs, the lowest pain tolerance appeared to be for photos with pain cues (for example, sliced hands) while the highest pain tolerance was measured while viewing photos of sports and erotic undertones. (*De Wied & Verbaten,* 2001)

Roy and his colleagues showed the participants photographs of positive, negative and neutral undertones while administering small electrical stimulation to their biceps all the while monitoring their brain for spinal nociceptive responses to the stimulation. The research concluded that viewing photos with negative emotions increased the perception of pain (pain levels were rated higher by participants) and positive photos decreased the pain perception (pain levels were rated lower) when compared to neutral ones which prove the motivational priming theory; but for the spinal nociceptive responses, the results proved the preparedness theory: the reflex amplitudes increased with negatively charged photos, but for neutral and positive photographs, the amplitudes were similar: the brain did not note the decrease of reflex amplitudes. The authors noted that the difference could be due to the dangerous implications of the positive photographs, for example sports related photos like parachuting, that could portray dangerous activities and produce the feelings of fear instead of happiness (*Roy et al.,* 2009). The same conclusion had been made prior, by *Bernat et al.* in 2006, viewing photographs with adventurous themes (which are rated as positive photos by valence), the startle probe reflex of the participants increased which is a sign related to negative valence photographs, but viewing other positive photographs with arousing content, it decreased. The researchers proposed that for positive photos, there is a huge difference in themes of the photos and that photographs that have risky adventurous themes that would be rated pleasant would activate the defensive system instead because of the related risks, for example parachuting. (*Bernat et al.,* 2006)

Senkowsky et al. (2011) investigated how different facial expressions would subjectively change the perception of pain. The visual stimuli consisted of photographs of faces with four different emotions: happiness, neutral, fear and anger. For photos with neutral facial expressions, the participants rated the experience less painful than looking at faces with

expressions of sadness, fear and even happiness and thus proving the preparedness theory since it contradicted the findings of previous researches about positive photos. The authors suggested that with the combination of pain and a happy face could be interpreted as negative, for example laughing at the participants pain. (*Senkowsky et al.,* 2011; *Young et al.* 2002). The importance of themed photographs was also researched by *Godinho and colleagues* in 2006 who hypothesized and proved that negative photographs that depicted human physical pain would elicit a bigger emotional response to a noxious stimulus than other negative photos. For positive photographs, they did not find a difference in themes in accordance to neutral photographs as stated in the preparedness theory. (*Godinho et al.,* 2006)

1.1.4. Defensive motivation vs appetitive motivation systems

As mentioned previously, defensive motivation is activated by a noxious stimulus and will initiate a person to defend themselves. In addition to this, the intensity of a noxious stimulus can be linked to the degree of negative reaction: the more intense the stimulus, the bigger the reaction. It has been proven that photos of negative undertones (of animals attacking or violence, mutilation) represent an approaching threat and will always activate the defensive system. *(Bradley et al.,* 2001). The reactions include (but are not limited to): cardiac acceleration, pupil dilation, electrodermal increase, an increase of the probe startle reflex; in addition, participants noting higher pain ratings, low valence and dominance rankings and high arousal rankings to the photographs. (Lang *et al.,* 1995; *Bradley, et al.,* 2001; Meagher et al., 2001).

The way the appetitive motivation system works is more complicated than defensive system because it strongly depends on the specificity of the attractiveness of the stimulus (for example, a certain food, one person would like a certain food more than the other and that would cause divided results) and is adjusted by a person's current state (for example, hunger and thirst; if a person is thirsty, seeing photographs of water would produce bigger results while a person who is not thirsty, would have smaller reactions or no reaction at all). (*Rolls,* 2000) One exception to this is arousing stimuli. It has been confirmed that viewing photographs of attractive people from the opposite sex and couples in intimate situations will always produce a reaction of the appetitive motivational system. (Bradley *et al.*, 2001) Reactions to these types of stimuli include (but are not limited to): increased heart rate, inhibition of the startle probe reflex, participants reporting both high pleasure and arousal rankings, and in some cases, lower pain ratings to noxious stimulus. (*Lang et al.,* 1999; *Meagher et al.,* 2001)

For neutral visual stimuli, that do not strongly evoke neither the defensive nor the appetitive motivation systems, there seems to be no significant reaction: pleasure and arousal

ratings are usually reported lower than positive by participants and pain levels are rated higher than for negative photographs and pain ratings are lower or similar to positive photographs. (*Senkowski et al.,* 2011; *Williams et al.,* 2012)

There is a biphasic view of the defensive and motivational systems: the valence and arousal systems. The valence (or pleasure) system dictates which motivational system is active (defensive or appetitive) and the arousal system dictates the intensity of the percept. Both of these systems are linear: if the appetitive motivation is increased, so are the arousal ratings together with the increase of attention and expected action to the stimulus. (See Figure 1.1.) The graph has a boomerang shape, the ascending vector shows the positive valence and arousal interaction, and descending arm – negative interaction. *(Bradley & Lang,* 2000 in *Mehrabian & Russell,* 1974; *Bradley et al.,* 2001).

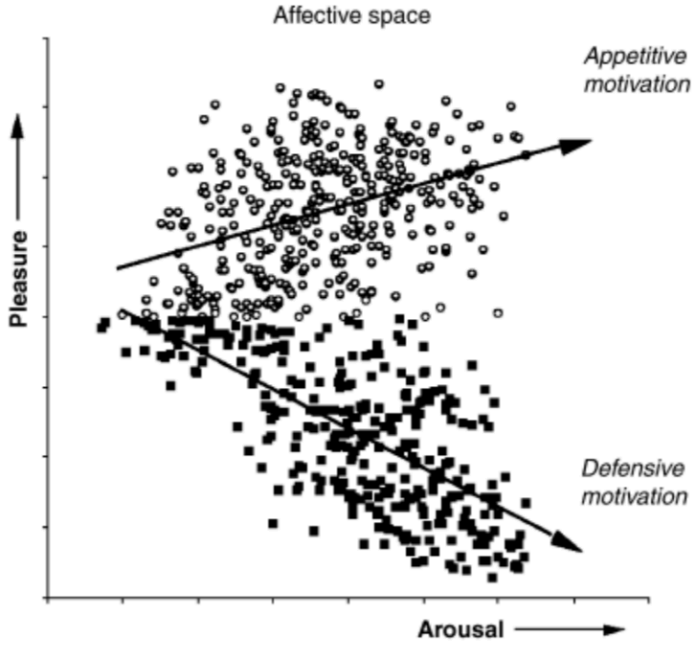


Fig.1.1. Natural selective attention: Orienting and Emotion. (*Bradley et al.,* 2001 in *Lang et al.,* 1993)

1.2. Stimulus

1.2.1. Visual stimulus for analgesia

There are numerous visual stimulus collections used as visual stimuli for pain reduction, for example: GAPED, NAPS, FEEST, IAPS systems.

The Facial Expressions of Emotion (or FEEST) is a visual stimulus battery consisted of 60 photographs of faces with four different emotions: happiness, neutral, fear and anger that were derived from *Ekman & Friesen* (1976) series of Pictures of Facial Affect. (see Figure 1.2) It has been successfully used in multiple studies (*Ekman & Friesen,* 1976; *Young et al.* 2002; *Senkowsky et al.,* 2011). Although it has proven that facial expressions elicit a much weaker

emotional reaction in a participant than for emotionally charged photos of different scenes. (*Britton et al.,* 2006)

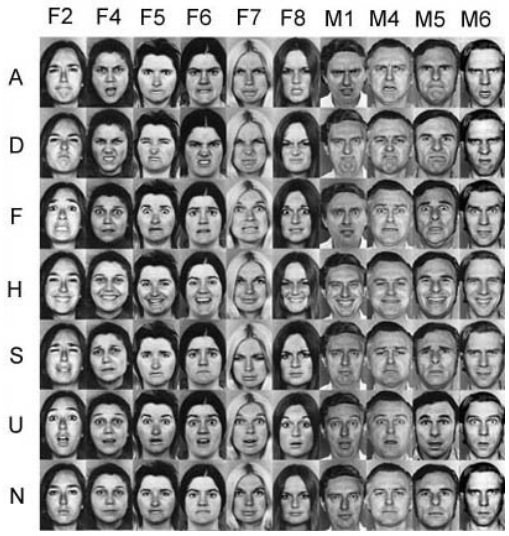


Fig.1.2. Photographs of facial expressions from the Ekman and Friesen (1976) Pictures of Facial Affect used in FEEST. There are emotional expressions of anger (A), disgust (D), fear (F), happiness (H), sadness (S) and surprise (U), and a neutral (N) pose. (*Young et al.,* 2002).

Similar collection as the FEEST photographs, is the IAPS collection. In 1995, *Lang et al.* developed the International Affective Picture System, that is a collection of 500 photographs of numerous variances (not only faces). The photographs have been rated by men, women and children in terms of arousal (calm to arousing/exciting), pleasantness or valence (pleasant to unpleasant) and dominance (low to high). (*CSEA-NIMH,* 1995; *Lang et al.,* 1995; *De Wied & Verbaten* 2001) The photographs have been successfully used in numerous studies because of the self-evaluative nature of arousal, pleasantness, dominance and valence (*Lang et al.,* 1993; *De Wied & Verbaten,* 2001; *Kenntner-Mabiala & Pauli* 2005; *Rhudy et al.,* 2007; *Bradley et al.,* 2001; *Rhudy et al.,* 2010). A study conducted by *Britton* and colleagues in 2006 compared the FEEST and IAPS visual stimuli collections and concluded that participants' valence ratings for all three major categories (positive, negative and neutral photos) were rated higher for IAPS photographs, meaning it was easier to distinguish what kind of emotion the photographs portrayed. (*Britton et al.,* 2006)

In addition to these two, three more collections have been released:

The Geneva Affective Picture Database (or GAPED) consists of 730 photographs and was produced to add to the IAPS system because the latter lacks specific types of negative visual stimuli. The added negative photographs depicted spiders, snakes, immoral and illegal scenes; positive photographs of babies, nature scenes and neutral photographs of inanimate objects. (*Dan-Glauser &Scherer,* 2011) NAPS or The Necki Affective Picture System consists of 1356

photographs with themes of faces, animals, people, objects and landscapes. The valence and arousal ratings were gathered from different European countries. (*Marchewka et al.,* 2014) The Emotional Picture System (EmoPicS) which was developed also as an addition to IAPS system, consisting of 378 photographs depicting different social situations, animals and plants. (*Marchewka et al.,* 2014 in *Wessa et al.,* 2010). All three of these of these databases are relatively new and there are not yet any researches using these collections to tackle the subject of pain analgesia.

In addition to official collections of emotional photographs, researchers have developed their own visual stimuli, (*Höfle* and colleagues in two separate researches who used a videoclip of a hand that was either pricked with a needle or a q-tip) (*Höfle et al.,* 2012; *Höfle et al.,* 2013); used a non-specific visual stimulus (*Tse et al.*, 2002a, *Tse et al.*, 2002b) or a video game (*Hoffman et al.,* 2000; *Rutter et al.,* 2009)

1.2.2. Noxious stimulus

Noxious stimuli of acute pain research could be produced by various machinery: a tourniquet to produce ischemia (*Magora et al.* 2006; *Tse et al.*, 2002a, *Tse et al.*, 2002b), cold water emersion (*Dahlquist et al.,* 2009; *DeWied & Verbaten,* 2001), electrical manipulation (*Roy et al.,* 2009; *Senkowski et al.,* 2011), laser and thermal manipulation (*Spence et al.,* 2002). All of the pain perception of aforementioned noxious stimuli has been successfully altered with in the past.

Tse et al. (2002a) and *Tse et al.* (2002b) used a tourniquet to cause ischemic pain to the participants upper limb while showing them either a video of a waterfall or a static blank screen through specialized eyeglasses, blocking the outside world (as would a virtual reality headset). The goal of the research was to see if there was a significant difference in the perception of pain and the pain tolerance with and without visual stimulation. It was found that when viewing the video, pain perception threshold and pain tolerance threshold both increased significantly. The changes in threshold and tolerance are shown in Figure 1.3. In two researches conducted by *Höfle* and colleagues (2012) and Höfle colleagues (2013) where the participants focused on videoclips of the view of a left hand that was either picked by a q-tip (innocuous stimulus) or a needle (noxious visual stimulus) while either painful or nonpainful surge of electricity was applied to the tip of their corresponding finger. They concluded in both researches that watching the needle touch the finger on a screen increased the perception of pain and enhanced the pupillary dilation response. (*Höfle et al.,* 2012; *Höfle et al.,* 2013)

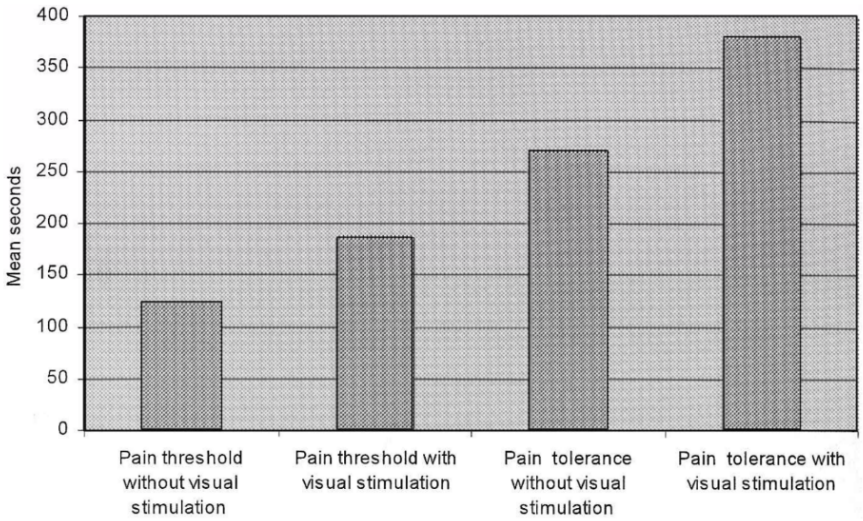


Fig.1.3. The effect of visual stimuli generated by eyeglass display on pain threshold and pain tolerance (*Tse et al., 2002a*).

1.3. Reducing chronic pain

Using visual stimuli to reduce chronic pain has become a popular subject of investigation in recent years. There have been multiple researches conducted in hopes to reduce the painful experience of cleaning the wounds during a hospital visit for burn victims. The feeling of immersion to the virtual reality experience has been reported to be stronger in kids rather than in adults and has produced positive results in patient reports on reducing the painful experience. (*Maani et al.,* 2008; *Faber et al.,* 2013) Virtual reality has been proven to reduce the fear of the procedure and pain for patients undergoing dental procedures (*Hoffman et al.,* 2001b, *Furman et al.,* 2009) as well as reduce anxiety in relation to claustrophobia (*Garcia-Palacios et al.,* 2007), patients with chronic migraines noted the inhibition of laser pain when viewing a virtual reality room with a sea view (*Tommaso et al.,* 2013).

1.4. Virtual reality in pain management

A widely used tool to manage pain and anxiety in recent years is virtual reality. It has been successfully used in both laboratory settings and in hospital settings (as noted in previous chapter). Virtual reality is using multisensory integration to modulate the perception of pain, using visual and auditory stimuli to draw the attention away from the noxious somatosensory perception and reduce the painful experience. Researchers suggest that virtual reality works as an analgesia using affective stimuli to change the pain perception. (*Li et al.* 2011) In behavioral science, virtual reality is described as a state-of-the-art interaction between a computer and a human where we can become immersed in and get the feeling of actually being in the virtual world (*Schultheis & Rizzo,* 2001).

Only recently have researches began to investigate exactly how indulging in Virtual Reality modulates the pain but three main theories have been suggested that include *Melzak's* and *Wall's* Gate Control theory and *McCaul's* and *Malott's* updated version of the previous theory (*Li et al.* 2011). *Melzack* and *Wall* suggested when humans feel a painful stimulus, the perception is affected by the past experience of the same pain and the emotion and in addition, that the painful perception signals have to go through a so-called gate before they reach the brain. They called it the gate control theory. When the gate is closed, the signal will be perceived as less painful. (*Melzak & Wall,* 1965). Adding to the original theory, *McCaul* and *Malott* theorized that a human beings' capacity of attention is restricted. In order to feel pain, one has to pay attention to it and if one does not pay attention to the pain, there is a facilitation in the perception of pain (as the previous theory stated, attention being able to close the gate). Modalities closing and opening the gate could be phycological, behavioral, emotional and sensory. They noted that the intensity of the noxious stimulus is also an important factor: if the painful stimulus surpasses a certain level of pain intensity, it will start to pull the attention from the stimulus that was used as a distraction. Both of these theories state that there should be a reduction of pain regardless of the emotions of the visual stimuli, whether it be positive or negative. But the actual mechanisms of pain reduction are still not known. (*McCaul & Malott,* 1984; *Li et al.,* 2011; *Triberti et al.,* 2014) The gate control theory has been the most wide-spread theories of pain reduction, but it comes with some shortcomings, especially in the simple descriptions of the neural pathways of the original theories. The newest multimodal aspect of pain still relies on the grounds of gate control, while stating that there are three dimensions to pain:

1. Cognitive-evaluative dimension – cognitive state, context of the stimulus, cultural background, appraisal,
2. Affective-motivational dimension – unpleasantness and the fight-or-flight response,
3. Sensory-discriminative dimension – the quality, location, intensity and duration of the pain. (*Moayedi & Davis,* 2013)

These dimensions are constantly interacting with one another. This is where the gate theory and newest pain theories agree, the more intense the nociceptive stimulus, the more unpleasant it is, but not always. (*Moayedi & Davis,* 2013) According to *Rainville*, while undergoing hypnosis, people have reported decreased pain thresholds while the intensity of the pain did not change (*Rainville,* 2002).

In order to investigate the pain modulation further, the researchers have moved the virtual reality experiments into laboratory settings. Immersion with Virtual Reality by *Magora*

et al. tackled the subject of pain tolerance with and without a VR headset. The participants were instructed to play an interactive game in a virtual reality world while one of their arms was suffering from ischemic pain. The pain variance was measured by a self-rated rating system and the absolute pain tolerance was timed. The results showed that while the participants were immersed in the video game, the time of pain tolerance grew significantly and as expected, the pain ratings by the subjects decreased, noting a reduction in the perception of pain, which are in agreement with the research conducted by *Tse* and his colleagues with similar machinery: virtual reality headset and a tourniquet but with the difference in that the specialized eyeglasses did not produce a 3D view and could not be interacted in real time. In addition to that, Tse and his coworkers found a difference in gender in pain thresholds and pain tolerance. Data describing their results are shown in Table 1.1. Both pain tolerance and the pain threshold were lower in women. (*Magora et al.* 2006, *Tse et al.* 2002a)

Table 1.1. Effect of gender on pain threshold and pain tolerance (*Tse et al,* 2002a)

	Female ($n = 32$) Mean ± SD	Male ($n = 14$) Mean ± SD	*P*-value
Pain threshold (seconds)			
With video	124 ± 117	193 ± 115	0.08
Without video	96 ± 90	139 ± 62	0.07
Pain tolerance (seconds)			
With video	370 ± 141	444 ± 140	0.11
Without video	312 ± 135	306 ± 87	0.84

Independent samples *t*-test. A *P*-value <0.05 was considered statistically significant.

A patient report by *Hoffman and colleagues* compared the experience of playing a video game on a screen to a virtual reality immersion during burn victim's wound care. The subjective ratings showed a vast difference between the reported pain ratings: the feeling of worst pain, average pain, unpleasantness, feeling bothersome and anxiety were drastically decreased as well as the overall time thinking about the pain between the two distraction conditions. Figure1.4 shows the patient reports. The researchers noted that the fact that the virtual reality headset restricts the view to the wound cleaning could play a part in reducing the pain. In addition to this, another group of researchers led by Hoffman found that higher-quality virtual

reality headsets tend to have better results in reducing the pain. (*Hoffman et al.,* 2000; *Hoffman et al.,* 2006)

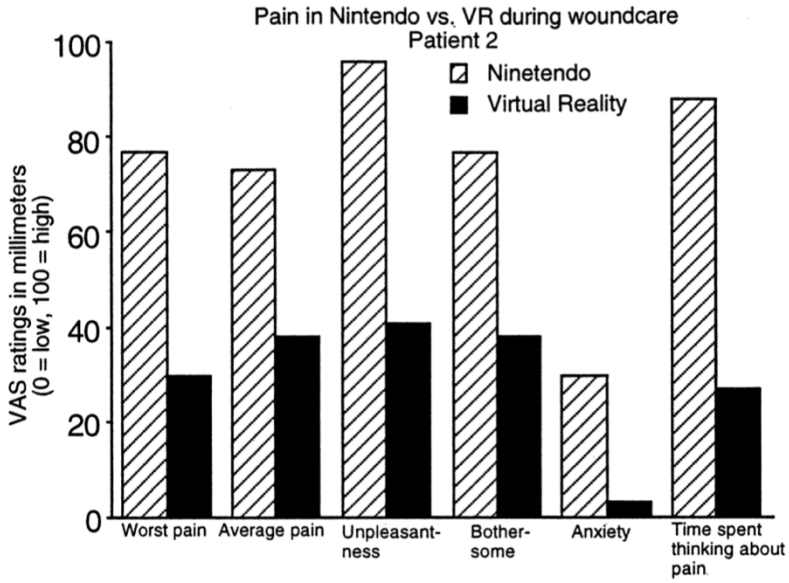


Fig. 1.4. Drops in pain ratings in VR compared to Nintendo64 (patient 2) (*Hoffman et al.,* 2000)

But there have been researchers who concluded that using a virtual reality helmet did not alter the pain thresholds. One of these studies have been conducted by *Dahlquist* and colleagues that compared children's pain tolerance and immersion in a video game during a cold pressor test and concluded that there was no significant difference between using a Virtual Reality headset or a screen showing the environment in reducing pain tolerance, although compared to the baseline pain thresholds, the distracted sessions showed a facilitation in pain thresholds. (*Dahlquist et al.,* 2009).

1.5. Pain processing from the skin to brain

There are three types of nerve fibers that transmit pain stimuli in the body: 1) A-beta fibers that react to touch and the sensation travels fast to the brain 2) A-delta fibers that react to a mechanical or thermal stimulus 3) C-fibers or the slow fibers that produce dull pain that appears after the initial perception of pain. From these nerve fibers, information gets transmitted into the brain. (*Parhizgar & Ekhtiari;* 2009) For electrical stimulation, first, myelinated A-beta fibers activate and cause a localized sensation on the skin, then nociceptive A-delta fibers activate a noxious stimulus causes a pricking or shocking painful sensation (*Hird,* 2017).

The sensation of pain is carried from the peripheral parts of the body (e.g the epidermis) to the spinal cord through the dorsal horn and then to the sensory nerve fibers in thalamus. (*Atlas et al.,* 2010) Lateral and medial thalamus project the information to lateral and medial areas of the cortex, which are the sensory and affective areas, respectively. (*Hird,* 2017) According to *Brooks and Tracey* (2005), predominant parts of the brain processing pain include: insula, anterior cingulate cortex, thalamus, prefrontal cortex as well as the primary and secondary somatosensory areas. Depending on certain conditions, additional areas of the brain activate during a painful experience: amygdala, cerebellum, basal ganglia, hippocampus, areas in temporal and parietal cortices. (*Brooks & Tracey*, 2005; *Tracey et al.,* 2007; *Wise et al.,* 2002) Areas of the brain in pain processes are depicted in Figure 1.5. The descending activation system of reacting to pain includes the frontal lobe, insula, amygdala, hypothalamus, anterior cingulate cortex, nucleus cuneiformis, rostral ventromedial medulla and periaqueductal gray (*Tracey, et al.,* 2007). The descending system in in charge of mediating the emotional modulation of pain: the insula generates interoceptive feelings and is involved with the process of emotional awareness (*Craig,* 2009); anterior cingulate cortex is involved in the affective component of pain (*Brooks & Tracey,* 2005); the periaqueductal gray is active in the modulation of pain perception and attentional control of pain (*Tracey et al.,* 2002).

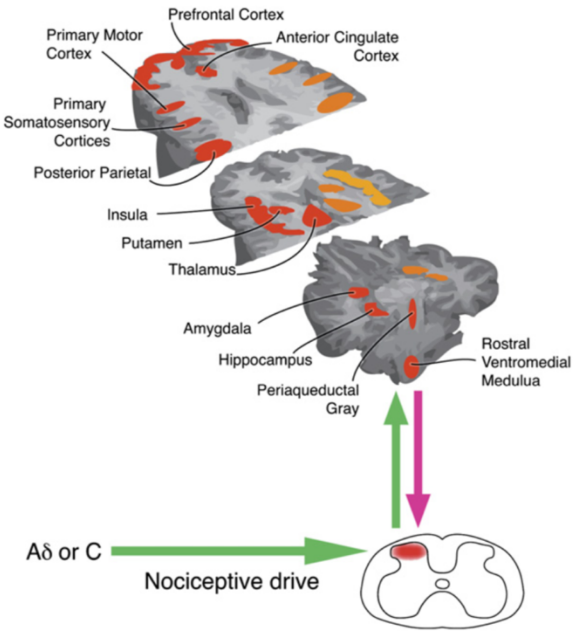


Fig. 1.5. Neuroanatomy of Pain Processing. Main brain regions that activate during a painful experience, highlighted as bilaterally active but with increased activation on the contralateral hemisphere (orange). (*Tracey & Mantyh,* 2007)

1.6. Factors influencing pain perception

Pain is influenced by many psychological, physiological and social factors. When we react to a noxious stimulus, and perceive it as painful, psychological processes have already begun in our brains.

One of the most important psychological factors to influence pain is expectation. The feeling and experience of pain is very subjective and is highly influenced by the past experiences and future prognosis of a situation. If the expectation and noxious stimulus are contradictory, it could lead to the modulation of the perception of the painful experience. (*Koyama et al.,* 2005) *Dannecker and colleagues* (2003) concluded that negative expectations can lead to increased sensations of pain as well as positive expectations to diminishing the painful sensation by conducting an experiment about post-exercising muscle soreness and expected pain values. (*Dannecker et al.,* 2003) This hypothesis was also proven by *Höfle and colleagues* in 2012 and 2013. The researchers noted an increase in the perception of pain as well as an increased pupillary response while they viewed a video of a needle approaching their hand while administering a noxious or innocuous stimulus onto the participants correlating finger (*Höfle et al.,* 2012; *Höfle et al.*, 2013). The expectational reaction to a painful stimulus and learning from the painful experience (to cope and to defend ourselves) is an important part of survival. Unfortunately, the psychological factors of pain perception are not completely understood. (*Linton & Shaw,* 2011)

Closely related to expectation is the interpretation of the painful situation and noxious stimulus. When the information about a noxious stimulus travels to the brain, the process of interpretation of the nociceptive stimulus is activated. (*Eccelston,* 1999) How we perceive a noxious stimulus is dependent on our previous experience with it. (*Linton & Shaw,* 2011)

Another major factor influencing pain perception is attention. The psychological function of attention is to motivate a certain behavior: if the noxious stimulus experienced is considered dangerous, more attention is placed towards it in hopes to eliminate it. (*Linton & Shaw,* 2011) While some experiments show that shifting attention away from a painful experience or the noxious stimulus can reduce the painful sensation (*Tse et al.,* 2002a; Hoffman, et al., 2001a), but the distraction technique does not always work (*Hodes et al.,* 1990). *De Wied and colleagues* hypothesize that is has less to do with attention and more about the valence of the distraction: the effective outcomes of distraction are related to positive emotional components. (*De Wied & Verbaten*, 2001).

Attitude and beliefs towards a nociceptive stimulus should be also taken into account. Ones beliefs about noxious stimulus are thought to be different from the feelings of coping with pain although believed to influence the emotional processing of pain and the coping (G*eisser*

et al., 1999). Attitude and beliefs are influenced by our surrounding and are very important for rapid interpretation of a noxious stimulus. (*Linton & Shaw,* 2011)

Emotional well-being is also a huge part of pain processing and perception. A usual emotional reaction to pain is sadness, fear, anxiety, guilt and frustration. (*Linton & Shaw,* 2011 *Hoffman et al.,* 2000, *Rolls,* 2000) When considering the negative emotions, fear and anxiety tend to have the greatest impact on pain. In 2000, *Rhudy and colleagues* conducted an experiment where they introduced a noxious stimulus and produced three emotional states: fear, anxiety and neutral. The research concluded that fear resulted in decreased pain thresholds while anxiety increased them. It is hypothesized that fear is an immediate reaction to a threat, forces the person to take action; while anxiety is a future-oriented emotional feeling and is associated to the anticipation of a negative situation. (*Rhudy & Meagher,* 2000)

Multiple physical factors influence the perception of pain, such as: neurological diseases (*Kunz et al.,* 2012), chronic pain (*Shaygan et al.,* 2017), skin temperature and thickness (*Arendt-Nielsen & Bjerring,* 1987), skin's electrical resistance (*Kramer et al.,* 2009), numerous skin conditions and scarring (*Isoardo et al.,* 2012), age and sex (*Craft et al*., 2004), mental illnesses as well as extreme stress and exhaustion (*Dufton et al.,* 2007). In addition, habituation plays a huge part of acute pain.

1.6.1 Habituation

When using similar stimuli to modulate pain perception, there is always a risk of habituation. Habituation is the diminishing of an innate response to a frequently repeated stimulus. *Hoffman* and colleagues (2001a) wrote an article of a case report of a man who had deep burn wounds covering almost half of his body, who was emerged into virtual reality sessions five times during a period of one month while undergoing his wound care. The participant noted decreased pain ratings, as well a reduction in the time he was thinking about his pain. Figure 1.6. shows some of the results of the study. (*Hoffman et al.,* 2001a) The question remains, is five sessions of Virtual Reality distraction usage too little of a timespan to cause habituation and can we generalize the result of this study with only one subject. A research with a longer duration of time and multiple participants was conducted in 2009. *Rutter* and his colleagues studied the effects of repeated exposure to virtual reality distraction from pain produced by a cold pressor, with the study course lasting for eight weeks, one test per week. Time spent on thinking about the pain, pain threshold, intensity and tolerance were measured and as previous researches have concluded, there was an increase in pain tolerance and a significant decrease in pain intensity and the time spent thinking of the noxious stimulus throughout the 8 week session. The surprising result found was that the pain threshold results

and the level of enjoyment of the VR headset were graded low. For the conclusion, the authors noted that there was no significant increase in pain perception after eight weeks of virtual reality distraction with a marginally bigger sample size. (*Rutter et al.,* 2009)

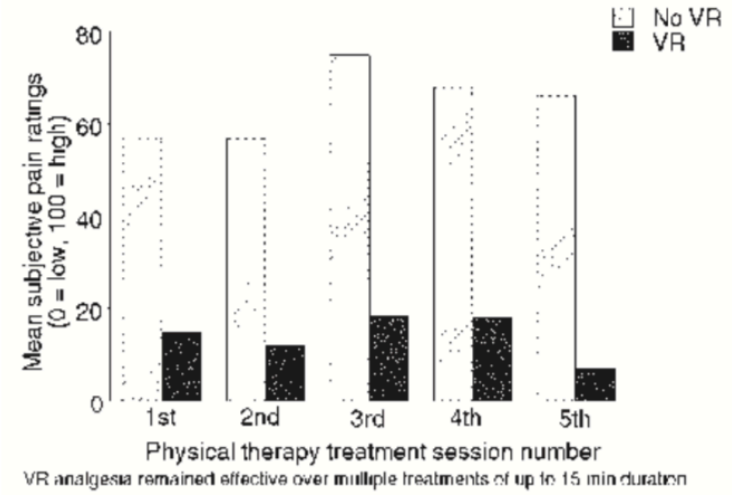


Fig.1.6. Subjective pain ratings in 5 different wound care sessions (*Hoffman et al.,* 2001b).

An older study by *Bradley* and his colleagues show the opposite results by hypothesizing that if the same stimulus is presented in a short enough timespan, there is a tendency for habituation. They used nine different photographs (positive, negative and neutral) where each photoset of 3 photos was presented to the participant 12 different times. The researchers collected data for startle reflex magnitude, skin conductance, heart rate and fEMG as well as participants' ratings for the photographs. It turned out that across almost all of the trials and data, there was a clear inclination to habituation: the startle reflex had a clear habituation for all the photographs, as well as skin conductance. For EMG, only the negative photographs produced a large response and led to a habituation in the second and third block (the positive and neutral photographs did not show habituation, shown in Figure 1.7). No habituation for heart rate nor participants ratings was noted. (*Bradley et al.,* 1993) *Rhudy* and colleagues came to the same conclusion in a research conducted in 2010, that after 52 electrical shocks, skin conductance and nociceptive flexion reflex habituated. This agreed with the former scientists that physiological-emotional reactions to repeated visual stimulus (for example, skin conductance, EMG) and startle blink magnitude have a tendency to habituate while emotional valence (valence ratings for the photographs) does not. They concluded that emotional modulation circuit is less sensitive to habituation than the autonomic and somatic systems. (*Rhudy et al.,* 2010)

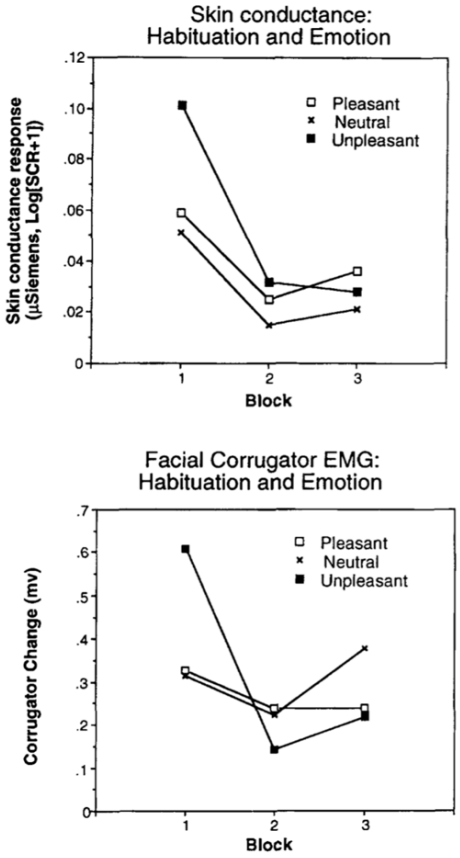


Fig. 1.7. Top panel: Skin conductance responses and bottom panel: facial corrugator muscle responses elicited while viewing pleasant, neutral and unpleasant pictures at each of the three blocks during the habituation phase demonstrate affective modulation only in the first block of trials. (*Bradley et al.* 1993)

2. DATA AND METHODS

2.1. Subjects

The participants were twenty-one females aged 19-42 (average 25±6.46) who were recruited from optometry students and teachers from Tallinn Healthcare College. The participants were screened for general health: participants were removed from consideration if they were not in ages 18-45, were pregnant, had health problems that would affect the tolerance of pain on the epidermis (diabetic neuropathy, nerve damage), had diseases that cause chronic pain (rheumatoid diseases, migraine), had skin conditions on the right forearm (burns, eczema, psoriasis), had psychiatric history (usage of antidepressants, anxiety medication), wore a pacemaker or had a circulatory disease (Raynaud's disease), did not have corrected-to-normal vision for near, currently used pain medications, had a phobia of snakes, experienced extreme exhaustion on the day of the testing. The subjects were enrolled in the study after reading the signing a written consent document and received both written and verbal instructions about the details of the experiment.

2.2. Methods

2.2.1. Visual stimulus

The visual stimuli were derived from IAPS, the International Picture System, consisting of 30 photographs with three emotional valences: 10 positive, 10 neutral and 10 negative ones. The IAPS numbers used as visual stimuli were as follows: positive – *4525, 4597, 4640, 4660, 8001, 8030, 8190, 8200, 8370, 8501* which consisted of photographs of sports and couples in intimate scenarios*;* neutral – *2320, 2580, 5500, 7000, 7004, 7009, 7050, 7100, 7205, 7217* which consisted of photographs of household objects and people in neutral situations; negative – *1052, 1300, 2811, 3030, 5971, 6211, 6212, 6540, 9050, 9810* which consisted of photographs of loss, attack, and pain.

The photographs were chosen by their ratings on valence, arousal and dominance by *Lang & colleagues* in the IAPS technical manual and affective ratings (*Lang et al.,* 2001; *Lang et al.,* 2008). The valence ratings for IAPS are categorized in a 9-point scale as: clearly pleasant with a rating of >6,5, neutral with a rating of 4-6 and clearly unpleasant <3,5 which correlate to the chosen photographs. The mean valence ratings with standard deviations for the photographs used in the research were as follows: pleasant – 7,61 ±0,29, neutral – 5,41 ±0,59, and negative – 2,31 ±0,69 and are portrayed in Figure 2.1 along with arousal and dominance ratings. For photographs rated for arousal, the ratings are as follows: positive – 6,45 ±0,46, neutral – 2,77±0,44, and negative photographs – 6,82 ±0,33. As for dominance (rated by the

perspective of the participant), for positive – 5,72 ±0,58, neutral – 6,23 ±0,392, and negative photographs – 3,06 ±0,49.

Fig.2.1. Average valence, arousal and dominance ratings for chosen photographs from IAPS (*Lang et al.,* 2008).

The visual stimulus was viewed through a virtual reality headset to block the surroundings situated approximately 80 millimeters away from the outer curvature of the cornea. The visual stimulus size varied with photographs and were made to fit the screen, 58 x 105 millimeters or 1334x750 pixels.

2.2.2. SAM rating scale

The emotional ratings for photographs were rated with a SAM (Self-Assessment Manikin by *Lang & colleagues* 1985; *Bradley & Lang,* 1994) rating system that assesses the participants arousal, pleasure and dominance. The SAM system is a 9-point rating scale. For valence ratings, 1 point corresponds to sadness/unpleasantness 9 points to happiness, pleasantness. For arousal ratings, 1 point corresponds to being emotionally calm, 9 points to being excited/aroused. For dominance ratings, 1 point corresponds to the participant being controlled/submissive and 9 points to being in control/dominating. The participants rated the stimulus with a figure in the box with the corresponding number underneath it or the space between two boxes, the medium rating being 5. Figure 2.2 portrays the rating scale for emotional ratings.

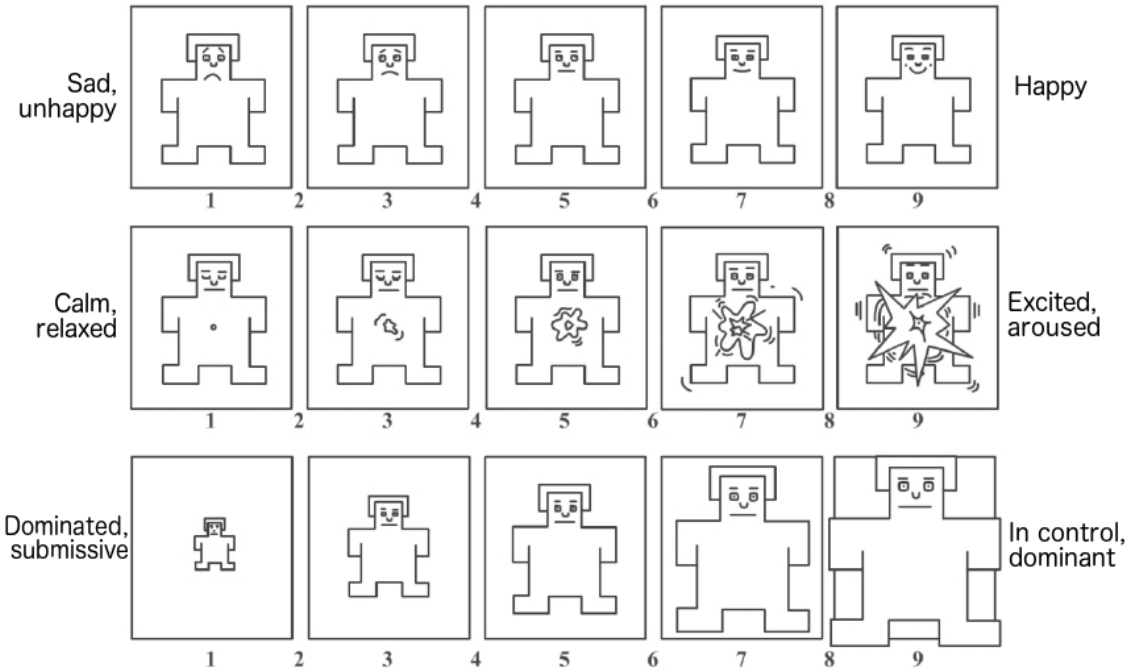


Fig.2.2. SAM and pain rating scales for participant. First block – valence ratings, second block – arousal rating, third block – dominance rating.

2.2.3. Noxious stimulus

The noxious stimulus comprises of an electrical shocker connected to an Arduino UNO machine that had been altered suitable for the testing with the highest voltage level of 200V delivered that corresponds to 230 microamperes for safety. The amperes and volts in the electrical device were growing linearly as depicted in Figure 2.3.

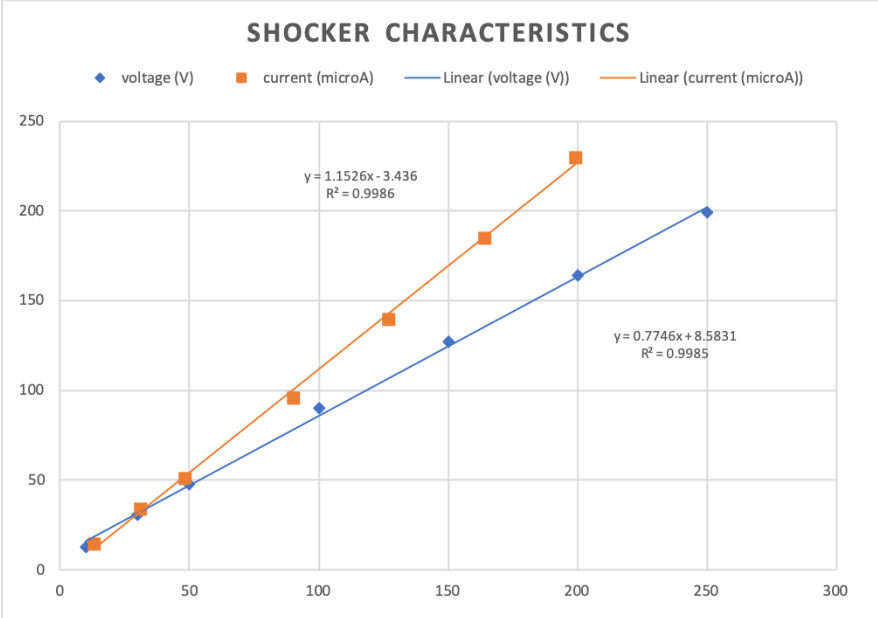


Fig. 2.3. Shocker characteristics.

Each shock from the machine lasted for 0,5 seconds and the Table underneath (Table 2.1. shows the energy and power of the electrical system.

Table 2.1. Watts and corresponding Joules of the Arduino machine.

Watts	time(s)	Joules
0,000189	0,5	0,0001
0,001054	0,5	0,0005
0,002448	0,5	0,0012
0,00864	0,5	0,0043
0,01778	0,5	0,0089
0,03034	0,5	0,0152
0,04577	0,5	0,0229

2.3. Study Design

After filling the questionnaire for health-related questions, scanned for near vision (with Hoya reading test for 40 cm distance), reading the participant information sheet and signing the agreement contract, the participant was sat comfortably in complete silence on a chair with their left arm on the table in front of them. The process of the experiment was described.

Two pins 8 millimeters apart were fixed on the left forearm, in the middle of the medial and lateral cutaneous nerves on the forearm and the virtual reality headset over the eyes, no auditory distraction was used. At the start of the experiment, shocks of 50 Volts (each shock lasting 0,5 seconds) were directed to the epidermis in high-charge every 2-4 seconds and gradually increased until the participant noted the first initial painful sensation (the pain detection threshold that felt like needle pricks or small shocks). The pain detection threshold was defined as the current amplitude at which the participant began to feel pain; at which time they pressed a button on the computer and the voltage was automatically lowered by 20V and started increasing again by 5 volts gradually. The Arduino machine is depicted in Figure 2.4.

The visual stimulus comprised of loops of 10 photographs with the same valence (three different blocks in total: positive, negative and neutral) with the photographs changing every 4 seconds. All three loops were played until the participant noted pain 10 times. The loops were presented in a randomized order. After every loop was a 5-minute pause. Throughout the pause, participant was asked to rate the previously viewed photographs on a Self-Assessment Manikin 9-point scale, rating the valence, arousal and dominance of the photos. The Self-Assessment Manikin and photographs were portrayed on a computer screen for the participant to fill. For every participant, 30 values of pain detection thresholds measured in Volts and 30 emotional ratings were obtained.

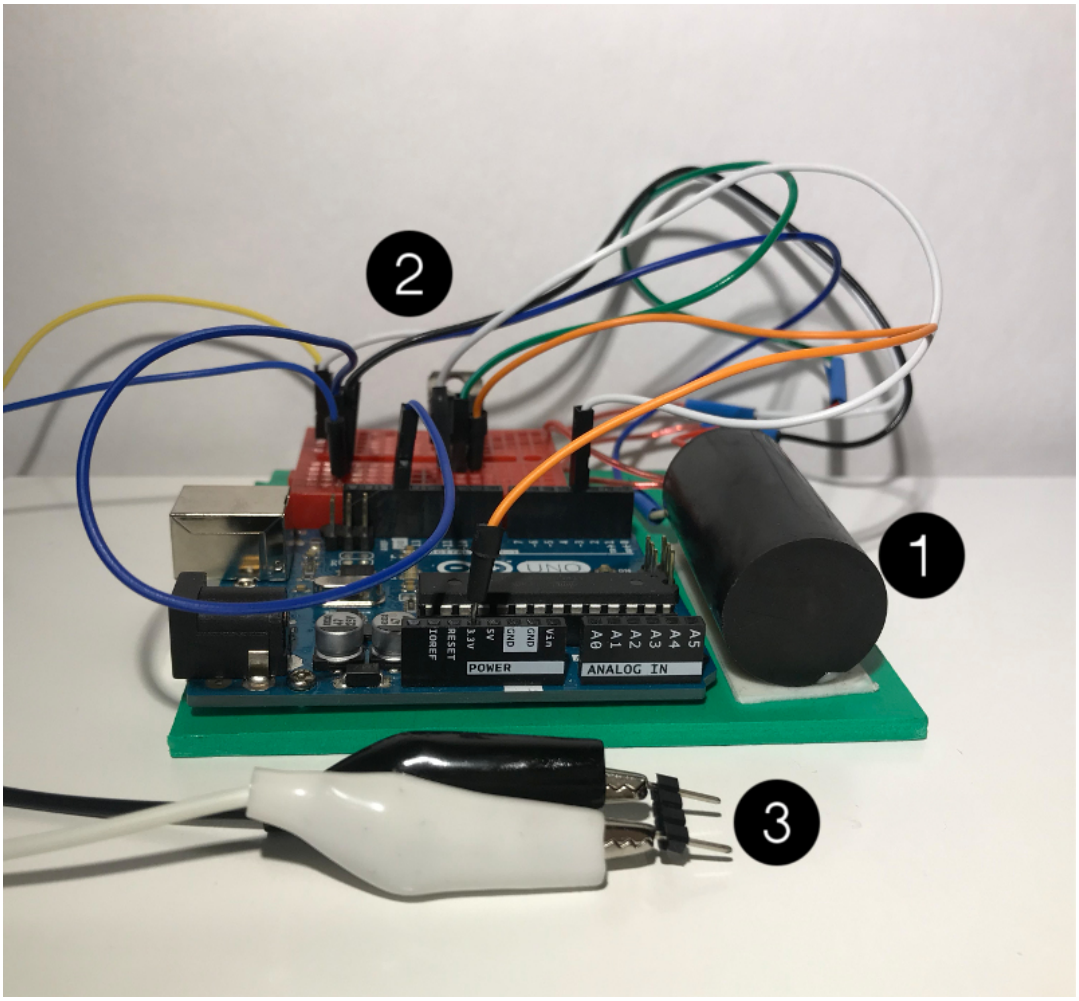


Figure 2.4. Electrical device setup. 1 – shocker, 2 – Arduino UNO, 3 – pins that connect to the epidermis.

2.4. Statistical analysis

Prior to statistical analyses, the results of two participants were excluded due to their pain detection thresholds being more than 200 Volts (high skin resistance) and one due to the reason of their pain resistance threshold being just about 200 Volts: for 1/3 of the trials they sensed pain just under the maximum threshold of the machine (185-195V), for the other 2/3 of shocks they did not feel pain at 200V.

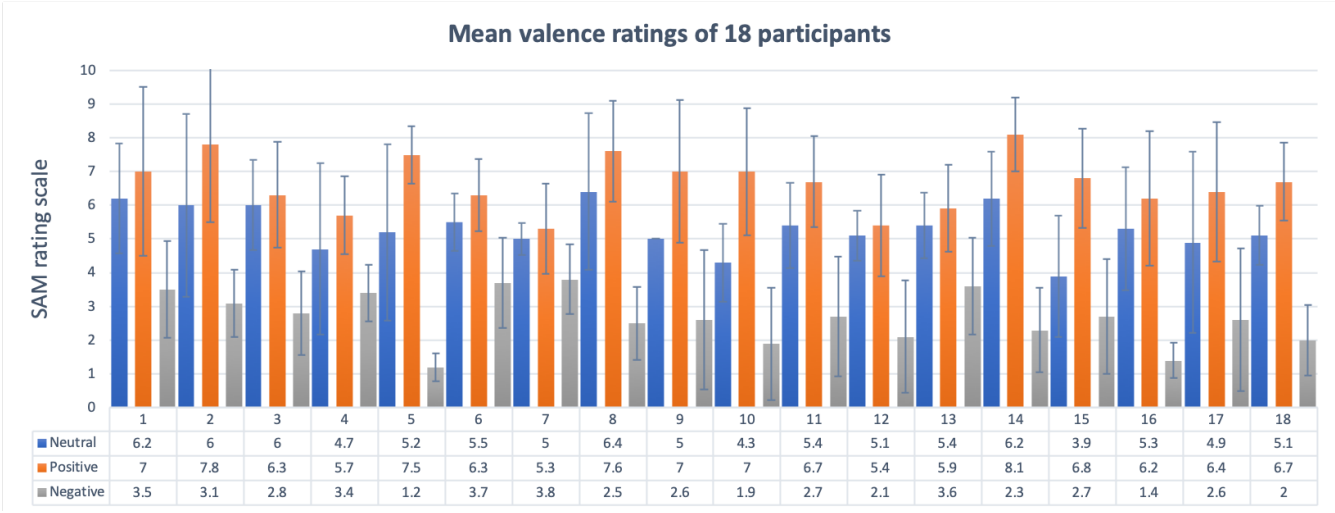
Statistical analyses for ratings of the emotional photographs was conducted separately (for valence, arousal and dominance) using a two-tailed ANOVA with Replication to see if there was a difference between Positive, Neutral or Negative control groups; then Paired T-Test was used for further analyses. Correlation and regression between valence and arousal were also calculated for all three blocks of photographs.

For pain detection threshold ratings, Two-Tailed ANOVA with Replication and Paired T-Tests were used, as well as difference from baseline measurements. Correlation was used to find if there was a linear relationship between pain detection thresholds. Interactions of pain detection thresholds-valence, pain detection thresholds-arousal and pain detection thresholds-dominance in three different blocks was calculated using Spearman's correlation.

3. RESULTS

3.1. Emotional photograph ratings

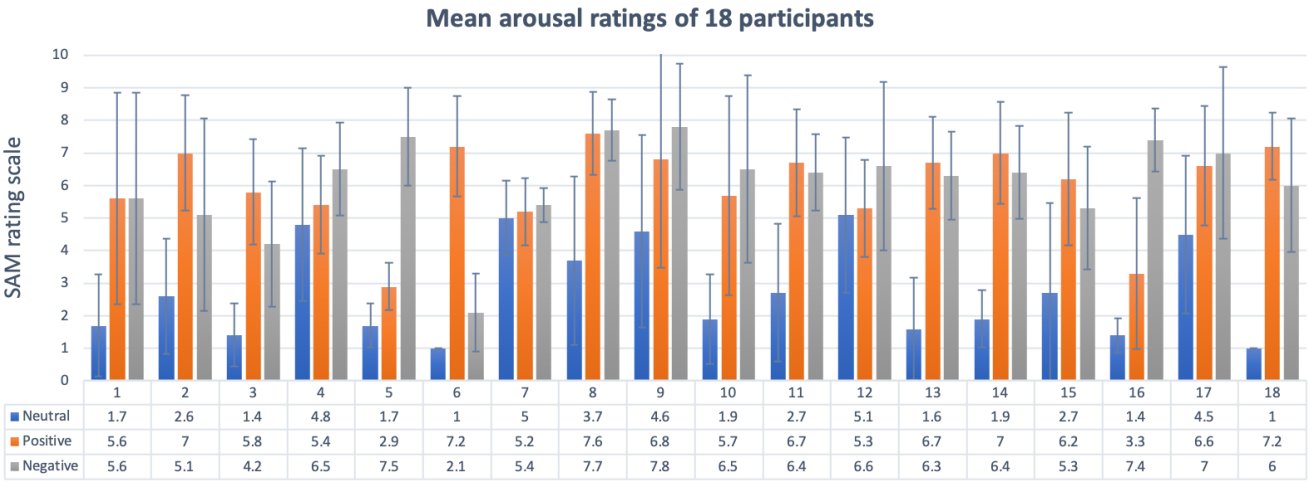
Data analyses for the Self-Assessment Manikin ratings showed to be consistent with the former work with International Affective picture system data and is shown in Figure 3.1. Valence was rated by the participants the highest for positive photographs (mean=6,65; Sd=1,74), medium ratings for neutral photos (mean=5,31; Sd=1,75) and lowest for negative (mean=2,66; Sd=1,52). ANOVA demonstrated a significant difference between the three groups, $p < 0{,}001$, F (2,17) = 269,91. For further analyses, Paired T-Test was used and it showed there was a significant difference between the ratings of neutral and positive photographs, t (179) = -7,71, $p < 0{,}001$, and ratings between neutral and negative photographs, t (179) = 14,79, $p < 0{,}001$, rejecting the null hypothesis for both tests.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Neutral	6.2	6	6	4.7	5.2	5.5	5	6.4	5	4.3	5.4	5.1	5.4	6.2	3.9	5.3	4.9	5.1
Positive	7	7.8	6.3	5.7	7.5	6.3	5.3	7.6	7	7	6.7	5.4	5.9	8.1	6.8	6.2	6.4	6.7
Negative	3.5	3.1	2.8	3.4	1.2	3.7	3.8	2.5	2.6	1.9	2.7	2.1	3.6	2.3	2.7	1.4	2.6	2

Fig 3.1. 18 participants ratings for valence.

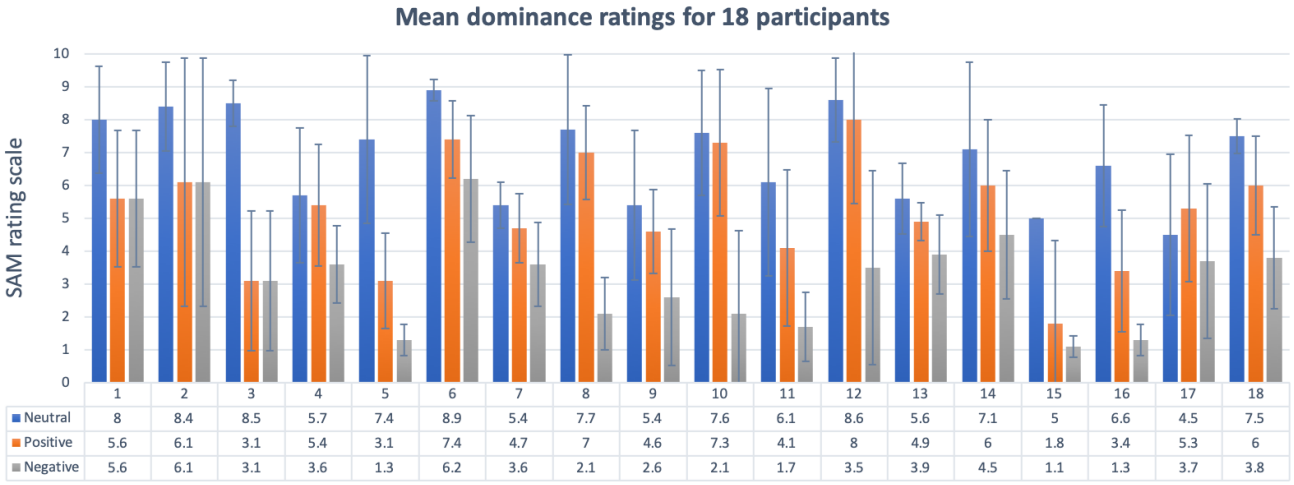
For arousal ratings, negative photographs received the highest rating (mean=6,10; Sd=2,31), followed by positive photographs (with mean=6,01; Sd=2,23) and lowest rated were neutral photographs (mean=2,74; Sd=2,23), shown in Figure 3.2. Two-Tailed ANOVA showed a significant difference between three groups, $p < 0{,}001$, F(2,17) = 182,44, for further testing, T-test was used and revealed that there was no significant difference between positive and negative photographs t (179) = -0,37, *t critical value* = 1,97, $p = 0{,}71$, but there seemed to be a statistically significant difference between positive and neutral arousal ratings, t (179) = 13,92, $p < 0{,}001$ as well as negative and neutral ratings t (179) = -14,97, $p < 0{,}001$.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Neutral	1.7	2.6	1.4	4.8	1.7	1	5	3.7	4.6	1.9	2.7	5.1	1.6	1.9	2.7	1.4	4.5	1
Positive	5.6	7	5.8	5.4	2.9	7.2	5.2	7.6	6.8	5.7	6.7	5.3	6.7	7	6.2	3.3	6.6	7.2
Negative	5.6	5.1	4.2	6.5	7.5	2.1	5.4	7.7	7.8	6.5	6.4	6.6	6.3	6.4	5.3	7.4	7	6

Fig. 3.2. Arousal ratings for 18 participants.

For dominance ratings, the lowest rated photographs were negative (mean=3,32; Sd=2,38), highest rated photographs were neutral ones (mean=6,86; Sd=2,17) followed by positive photos (mean=5,21; Sd=2,52). The data is shown in Figure 3.3. Two-Tailed ANOVA showed a significant difference between three groups, $p < 0.001$, $F(2,17) = 573,12$. T-test revealed significant differences between positive and neutral dominance ratings, $t\ (179) = -7,36$, $p < 0,001$, as well as between positive and negative photographs, $t\ (179) = 9,96$, $p < 0,001$.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Neutral	8	8.4	8.5	5.7	7.4	8.9	5.4	7.7	5.4	7.6	6.1	8.6	5.6	7.1	5	6.6	4.5	7.5
Positive	5.6	6.1	3.1	5.4	3.1	7.4	4.7	7	4.6	7.3	4.1	8	4.9	6	1.8	3.4	5.3	6
Negative	5.6	6.1	3.1	3.6	1.3	6.2	3.6	2.1	2.6	2.1	1.7	3.5	3.9	4.5	1.1	1.3	3.7	3.8

Fig 3.3. Dominance ratings for 18 participants

There was a significant negative relationship between the arousal and valence ratings of negative photographs, $r\ (8) = 0,79$, $p < 0,05$, the higher the arousal, the smaller the valence rating. There was no significant difference between those two variables for positive nor neutral photographs.

Table 3.1 shows the mean ratings and standard deviations of ratings per photograph. There was a noticeable and statistically significant difference between the dominance ratings in positive photographs, between sports and non-sports photos. The sport-themed photographs had an overall lower average than non-sports photographs, t (89) = 3,87, p < 0,001.

Table 3.1. Valence, arousal and dominance ratings for individual IAPS photographs (on a 9-point scale rated with Self-Assessment Manikin)

Neutral no	Photo	Valence rating	Arousal rating	Dominance rating
2320	Girl reading	5,27 ± 1,10	2,44 ± 2,10	6,81 ± 2,04
2580	Old men	5,08 ± 2,49	2,44 ± 1,97	5,50 ± 2,63
5500	Mushrooms	3,37 ± 3,71	2,63 ± 2,42	7,69 ± 1,62
7000	Rolling pin	5,09 ± 1,87	2,50 ± 2,13	7,06 ± 2,52
7004	Spoon	5,27 ± 1,68	2,00 ±1,90	7,44 ± 2,39
7009	Mug	6,00 ± 1,41	2,25 ± 2,08	7,44 ± 2,10
7050	Hair drier	3,80 ± 1,30	3,88 ± 2,75	6,56 ± 1,71
7100	Firehydrant	5,20 ± 1,48	3,00 ± 2,37	6,38 ± 1,93
7205	Scarf&mitten	6,20 ± 2,77	2,00 ± 1,59	7,06 ± 2,24
7217	Clothes	3,40 ± 2,19	2,06 ± 2,43	6,75 ± 2,11

Positive no	Photo	Valence rating	Arousal rating	Dominance rating
4525	Man in nature	6,20 ± 1,30	5,00 ± 2,45	5,31 ± 2,33
4597	Couple 1	6,00 ± 1,41	5,81 ± 1,87	5,19 ± 2,32
4640	Couple 2	6,60 ± 1,82	5,38 ± 2,36	5,38 ± 2,63
4660	Couple 3	6,60 ± 2,19	6,19 ± 2,17	5,13 ± 2,96
8001	Basketball	7,20 ± 084	5,75 ± 2,82	5,25 ± 2,54
8030	Skijump	6,60 ± 1,67	6,13 ± 2,09	4,38 ± 2,33
8190	Skiing	6,80 ± 2,86	6,50 ± 2,16	4,88 ± 2,28
8200	Waterskiing	4,15 ± 3,00	5,94 ± 2,29	4,88 ± 2,60
8370	Rafting	6,09 ± 3,21	7,19 ± 2,07	4,38 ± 2,13
8501	Money	7,56 ± 1,84	6,00 ± 2,37	6,69 ± 2,39

Negative no	Photo	Valence rating	Arousal rating	Dominance rating
1052	Snake	1,40 ± 0,55	6,06 ± 2,72	2,63 ± 2,00
1300	Attacking dog	2,40 ± 1,14	5,75 ± 2,18	3,69 ± 2,60
2811	Kid with gun	2,14 ± 1,15	6,50 ± 2,13	3,44 ± 2,22
3030	Mutilated face	1,05 ± 0,95	6,69 ± 2,09	3,81 ± 3,02
5971	Tornado	2,80 ± 0,84	5,94 ± 2,59	2,69 ± 2,02
6211	Gun attack	2,40 ± 1,67	5,31 ± 3,00	2,50 ± 1,83
6212	Soldier	2,80 ± 2,05	6,63 ± 1,93	2,75 ± 1,95
6504	Knife attack	2,00 ± 1,73	6,81 ± 2,14	2,50 ± 1,71
9050	Plane crash	2,00 ± 1,73	6,44 ± 2,03	3,19 ± 2,10
9810	KKK	2,80 ± 2,49	5,25 ± 1,98	4,13 ± 2,42

In the Figure 3.4 depicted below, average arousal and valence ratings can be seen again to show the distinct difference between different valences and their corresponding valence ratings. The graph shows general clusters of all three blocks of photographs but for positive photos, a photo of waterskiing has a remarkably low valence rating for a positive photograph.

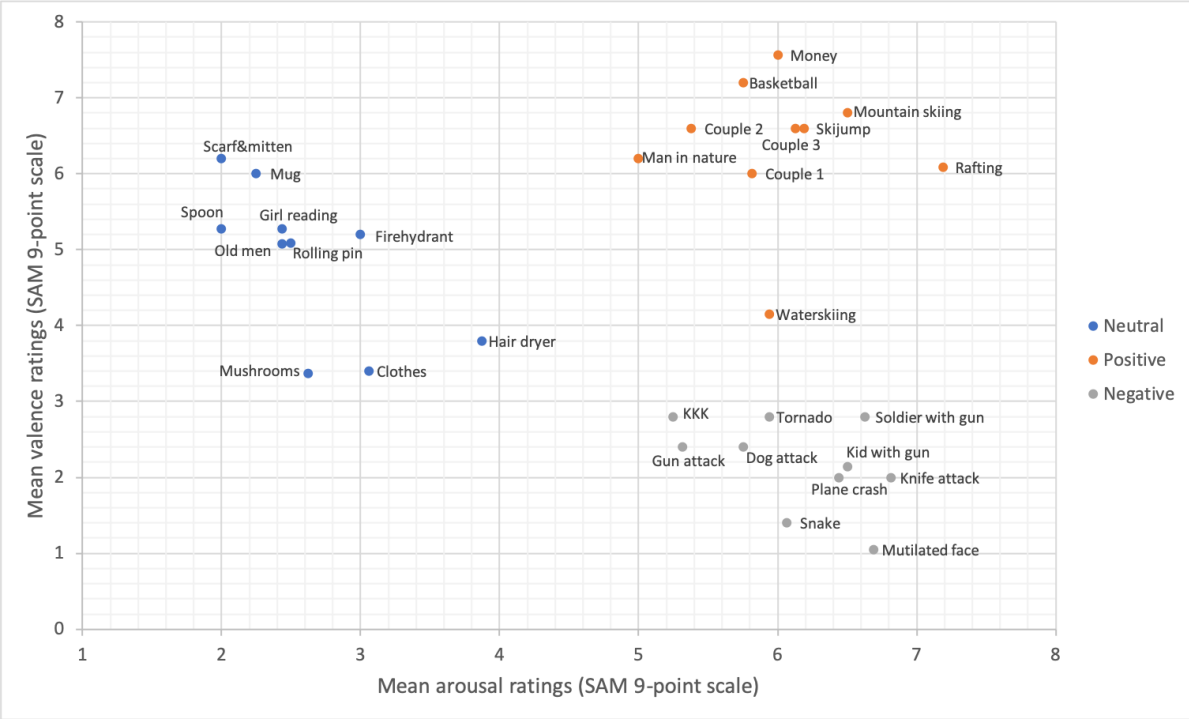
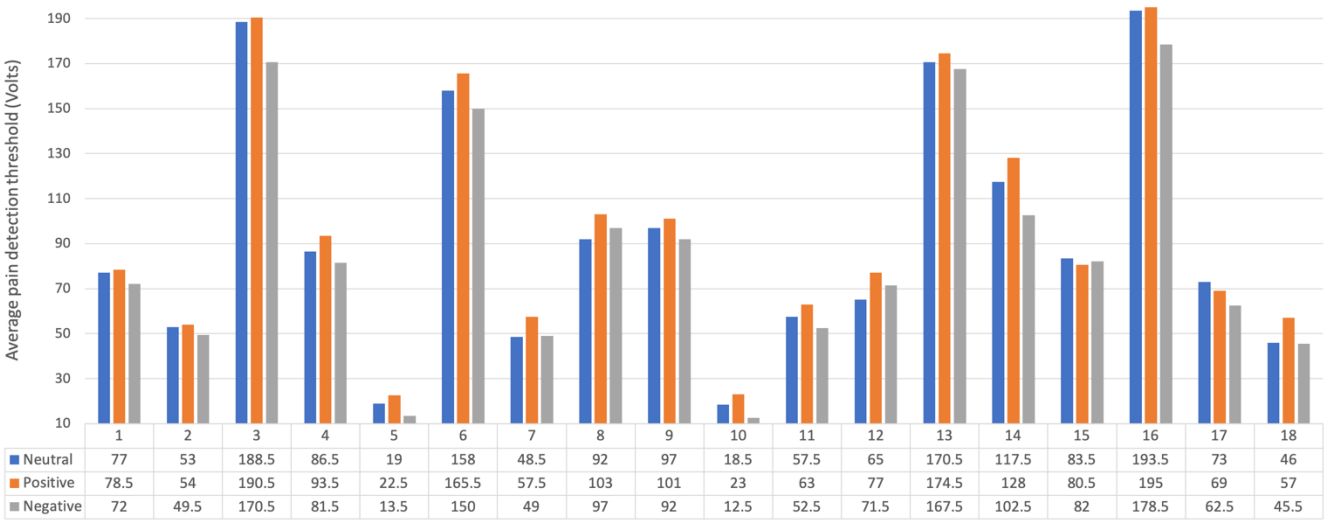


Fig 3.4. Mean valence and arousal ratings of IAPS photographs

3.2. Pain detection thresholds

ANOVA was conducted to investigate the influence of different emotional photographs on subjective ratings of pain showed a strong effect $p < 0.001$, F (2,17) = 22,59. Mean pain detection thresholds were as follows: neutral – 91,36; positive – 96,27; negative – 86,11 Volts.

There was a significant difference in pain detection thresholds while viewing neutral and negative photographs t (179) = 3,47, $p < 0,001$ as well as viewing positive and negative photographs t (179) = 7,21, $p < 0,001$, but Neutral and Positive photographs did not show a significant difference in pain detection ratings t (179) = -3,10, p=0,0022. The ratings of all the participants are depicted in Figure 3.5.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Neutral	77	53	188.5	86.5	19	158	48.5	92	97	18.5	57.5	65	170.5	117.5	83.5	193.5	73	46
Positive	78.5	54	190.5	93.5	22.5	165.5	57.5	103	101	23	63	77	174.5	128	80.5	195	69	57
Negative	72	49.5	170.5	81.5	13.5	150	49	97	92	12.5	52.5	71.5	167.5	102.5	82	178.5	62.5	45.5

Fig. 3.5. Average pain detection thresholds of 18 participants

Differences from baseline responses were calculated, taking neutral photographs as the baseline measurement. The mean average difference of neutral-positive was -4,91V (standard error 1,11) and neutral-negative – 5,25V (standard error 1,52). Figure 3.6 shows the relationship between neutral-positive and neutral-negative baseline responses as well as Table 3.2 to see the correlation. The figure and table show that there was a weak (Pearson's correlation = 0,417) correlation between the baseline responses exised: the subjects who had a difference in neutral-positive responses (more than 10V) had negative responses almost the same as neutral (or even higher): participant 8, participant 12, participant 14 and participant 18.

Table 3.2. Correlation table of baseline responses to Neutral-Negative and Neutral-Positive photos

Participant	PT1	PT2	PT3	PT4	PT5	PT6	PT7	PT8	PT9	PT10	PT11	PT12	PT13	PT14	PT15	PT16	PT17	PT18
mean Natural Volts	77	53	189	86,5	19	158	48,5	92	97	18,5	57,5	65	171	118	83,5	194	73	46
mean Positive Volts	78,5	54	191	93,5	22,5	166	57,5	103	101	23	63	77	175	128	80,5	195	69	57
mean Negative Volts	72	49,5	171	81,5	13,5	150	49	97	92	12,5	52,5	71,5	168	103	82	179	62,5	45,5
difference Neutral-Positive	-1,5	-1	-2	-7	-3,5	-7,5	-9	-11	-4	-4,5	-5,5	-12	-4	-11	3	-1,5	4	-11
difference Neutral-Negative	5	3,5	18	5	5,5	8	-0,5	-5	5	6	5	-6,5	3	15	1,5	15	10,5	0,5
Pearson correlation = 0,417																		

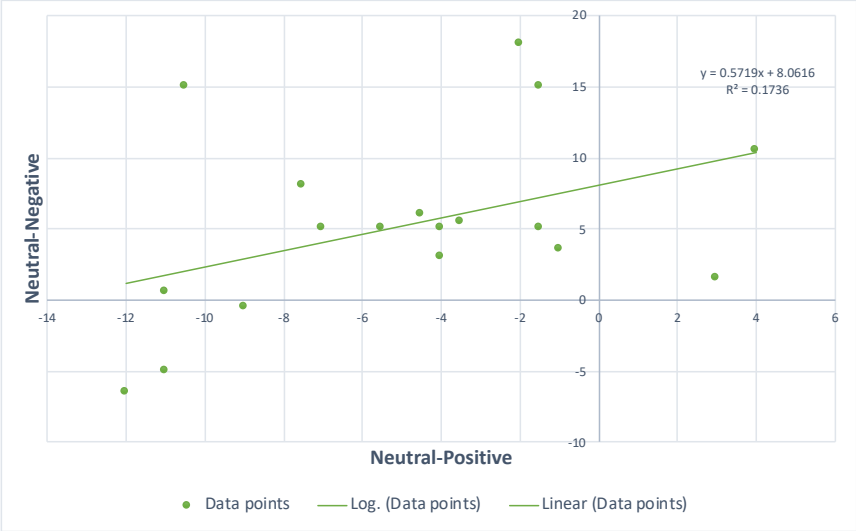


Fig. 3.6. Baseline responses for Neutral-Negative and Neutral-positive photographs (in Volts)

Spearman's Rho calculation showed a weak monotonic relationship between pain detection thresholds and arousal ratings while viewing neutral photographs: $r_s = -0{,}148$, $p < 0{,}05$ as well as between pain detection threshold and valence ratings while viewing negative photographs: $r_s = 0{,}14873$, $p < 0{,}05$.

4. DISCUSSION

This study examined the impact of different valence photographs on the pain detection threshold with gradually growing voltage shocks administered onto the forearm and the viewed photographs were rated on a 9-point scale Self-Assessment Manikin in terms of valence, arousal and dominance.

Valence ratings were analyzed for 18 participants. The current study concluded that for mean valence ratings, participants rated the photographs as hypothesized: positive photos had a mean of over 6,5, neutral photographs in the range of 4-6 and negative under 3,5 points on a 9-point Self-Assessment Manikin scale which is in agreement with multiple researches conducted prior. (*Williams & Rhudy,* 2012; *Rhudy et al.,* 2010) Surprisingly, a photograph depicting a handsome man waterskiing was rated low on valence but high on arousal ratings, (categorizing the photo as almost negative in valence) which could be explained by the content of the photograph: that photos of sports that involve a certain risk (for example, skydiving, waterskiing) would be rated lower in the valence rating because the photographs activate the defensive system instead of affective system due to the life-threatening implications. *(Bernat et al.,* 2006; *Roy et al.,* 2009) Surprisingly, three of the neutral photographs were rated low in valence as if they were emotionally negative for the participants: photos of mushrooms, clothes hanging on a clothes rack and a hairdryer.

The arousal ratings were ranked consistent with the hypothesis that positive and negative photographs have higher arousal ratings than neutral ones. This would lead to a hypothesis that the negative photographs would inhibit pain detection thresholds. (*Rhudy et al.,* 2008; *Williams & Rhudy,* 2012) Photographs depicting mutilation and attack were rated highest in arousal in the current research, which is in agreement with *Bradley and colleagues* who stated that photographs that represent attack and immediate threat activate the defensive system more rapidly than other unpleasant photographs. (*Bradley et al.,* 2001) The photograph of a mutilated face was rated lowest in valence and one of the highest in arousal scale, making it the most unpleasant photograph chosen in current research according to the participants. *Godinho and colleagues'* research agrees with current findings and in addition to the emotional ratings, came to a conclusion that seeing photographs of a human body in pain decreases the pain perception more than any other negative photograph. (*Godinho et al.,* 2006).

For dominance ratings, when a classically phobia-inducing photograph is presented, such as a snake or an aggressive dog, the participant would perceive the photograph as highly in control and themselves submissive in the situation. (*Bradley & Lang,* 1994) Dominance ratings for negative photos were lower than those of positive and neutral ones, in fact, the dominance ratings for positive and neutral photographs were similar with no significant

statistical difference. For positive photographs, all sport-related photographs were rated lower in dominance than other positive photographs, further giving information about their risky implications, that participants did not feel like they were in charge of the situation. (*Roy et al.,* 2009)

Pain detection thresholds of 18 participants were analyzed. The statistical analyses stated that negative photographs significantly lowered the pain detection thresholds compared to both neutral and positive photographs. Multiple researchers have come to the same conclusion: *Kenntner-Mabiala* and *Pauli* proved that negative photos lowered the perception of pain with noxious and even innocuous electrical stimulation of the skin; *De Wied* and *Verbaten* found a lower pain tolerance threshold for negative photographs; *Höfle and colleagues* concluded that watching a video of a needle pricking a finger led to an increased expectation of pain and lower pain detection thresholds compared to a video with a q-tip touching the finger. (*Kennetner-Mabiala & Pauli,* 2005; *De Wied & Verbaten,* 2001; *Höfle et al.,* 2012)

There was a difference in pain detection thresholds between positive and neutral photographs, but the difference was not statistically significant ($p = 0{,}0022$). In agreement with our current research, *Meagher and colleagues* in 2001 – analyzing the results of their research, noted that there were no significant differences between the unpleasantness and pain intensity thresholds while viewing positive and neutral photographs (*Meagher et al.,* 2001).
Theorists have thought of two reasons for this phenomenon:

1. One cannot rule out the contrary presumption of the multisensory integration involving a noxious stimulus: the constant painful or uncomfortable shocks may have altered the emotional perception of the photographs, especially inhibiting the valence ratings for positive and neutral photographs and facilitate arousal ratings for all three different blocks of photos, as it was found by *Williams and Rhudy* in their research in 2012 comparing the emotional rating results during a noxious and innocuous noise. (*Williams & Rhudy,* 2012) Surprisingly, *Senkowski* with his colleagues even found that presenting negative and even positive photographs while getting intracutaneous electric shocks on their skin would both lower the pain thresholds. (*Senkowski et al.,* 2011)

2. The low inhibition of pain detection thresholds while viewing positive photographs could be due to the chosen photos not being arousing or attractive enough for the participants. According to *Bradley and colleagues*, if the positive photographs are rated high in valence but lower in arousal, the modulation of perception of the noxious stimuli would be lower than those with a higher arousal rating (*Bradley et al.,* 2001) which is consistent with current research.

Due to the similarity of pain detection thresholds in positive and neutral photographs, current research is leaning towards the Preparedness theory which states that negative photographs would negatively alter the perception of pain while neutral and positive would not have a significant impact on pain detection thresholds. (*Seligman,* 1970)

CONCLUSIONS

Current thesis investigated the influence of different valence photographs on pain detection thresholds and the conclusions are as follows:

1. The results demonstrated that there was a significant difference in all of the participant's valence ratings: ratings of neutral and positive photographs, t (179) = -7,71, $p < 0,001$, and ratings between neutral and negative photographs, t (179) = 14,79, $p < 0,001$.
2. Participant's ratings for arousal showed a significant difference between neutral and positive t (179) = 13,92 ($p < 0,001$), as well as neutral and negative photographs with t (179) = -14,97 ($p < 0,001$) but no significant difference was found between negative and positive arousal ratings; both negative and positive photos were rated higher in arousal than neutral ones.
3. Participant's ratings for dominance differed significantly between all three conditions F (2,17) = 573,12, p < 0,001, with the highest dominance ratings were received from neutral photographs (mean 6,86), followed by positive (mean 5,21) and lowest for negative photographs (mean 3,23).
4. A significant difference was found in dominance ratings for positive photos depicting sports and non-sports, sport themed photographs had a lower mean for the ratings, t (89) = 3,87, $p < 0,001$.
5. The results demonstrated a difference significant in the pain detection thresholds between neutral and negative photograph viewing conditions t (179) = 3,47, $p < 0,001$; as well as between positive and negative photograph viewing conditions t (179) = 7,21, $p < 0,001$.
6. Although the mean pain detection thresholds were different for neutral and positive photo blocks (from baseline responses -4,91 Volts), the difference was not statistically highly significant t (179) = -3,10, $p = 0,0022$.

While viewing different valence photographs, investigating if there is a difference in pain detection thresholds by gradually increasing voltage shocks has yet to be investigate prior to this thesis.

Current thesis results are in agreement with Preparedness theory of pain: negative photographs increase the pain perception thresholds, while neutral and positive photographs similarly decrease the pain perception.

ENDING

Gradually increasing voltage is an effective way to investigate the effect of neutral, positive and negative photographs on pain detection thresholds. For future research purposes, more themed photographs could be researched, in addition to Williams's & Rhudy's research (family, adventure photographs) or Bradley and colleagues' (attack, mutilation photographs) as well as a control group of participants to see if in fact, multisensory integration works the other way – the noxious stimulus changes the visual stimulus (*Williams & Rhudy,* 2012; *Bradley et al.,* 2001), as well as tackle the subject of habituation.

Current thesis helped tackle the subject of unusual pain analgesia that could be used in everyday pain management to help patients with pain, coping, stress, fear and nervousness about their clinical procedures.

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APPENDIX 1 – PAIN DETECTION THRESHOLDS

Pain detection thresholds	PT1	PT2	PT3	PT4	PT5	PT6	PT7	PT8	PT9	PT10	PT11	PT12	PT13	PT14	PT15	PT16	PT17	PT18
Neutral	110	85	185	85	15	130	50	105	90	20	55	55	155	105	95	190	75	50
	85	65	190	80	20	110	45	90	80	25	85	50	145	140	90	200	85	40
	60	40	200	75	20	140	20	75	85	15	75	80	150	115	95	190	65	45
	40	60	180	85	15	195	35	75	70	25	80	65	165	110	80	195	60	40
	40	60	185	100	20	170	40	70	90	20	60	60	190	85	65	195	80	45
	60	40	190	95	25	150	55	95	95	15	50	40	200	95	90	195	65	55
	95	30	180	90	15	160	55	115	110	20	45	90	190	75	90	195	70	45
	95	45	195	90	20	175	65	95	135	10	50	75	180	150	95	190	75	40
	85	50	200	80	20	180	60	105	115	15	40	70	175	145	70	200	75	45
	100	55	180	85	20	170	60	95	100	20	35	65	155	155	65	185	80	55
Positive	75	50	185	85	20	160	70	105	110	15	95	50	155	85	70	185	85	60
	80	55	200	105	15	155	45	105	95	35	75	60	160	60	85	200	100	55
	95	45	200	110	20	160	65	95	70	15	80	35	185	120	75	200	70	40
	90	60	190	100	15	190	65	115	105	15	55	95	190	125	70	195	75	75
	70	55	180	80	25	155	55	120	95	15	40	100	180	165	85	200	70	60
	75	50	185	105	20	175	60	105	105	30	35	95	170	170	75	195	70	50
	85	65	190	95	30	165	55	100	115	30	55	90	170	145	90	185	50	60
	65	50	200	95	30	165	60	100	110	20	45	80	200	150	85	200	55	65
	70	55	180	80	30	145	40	95	105	35	75	85	175	135	75	195	65	55
	80	55	195	80	20	185	60	90	100	20	75	80	160	125	95	195	50	50
Negative	85	65	165	85	10	135	55	135	105	10	75	65	175	100	75	190	70	50
	60	45	155	90	15	150	55	110	65	15	50	70	185	90	70	185	85	45
	85	30	170	75	15	145	55	90	100	10	30	75	175	85	85	195	35	35
	95	55	165	85	15	155	35	65	85	20	50	70	170	145	90	185	50	45
	70	45	155	90	10	165	60	75	125	15	50	60	165	120	95	185	55	55
	55	50	180	80	10	150	40	80	65	10	35	75	155	100	65	200	70	50
	75	65	195	75	15	160	25	75	90	10	65	65	165	75	75	175	65	45
	70	55	175	85	10	140	55	100	90	10	70	85	170	90	80	160	70	45
	65	45	175	80	15	155	45	115	80	15	55	80	160	115	90	155	75	40
	60	40	170	70	20	145	65	125	115	10	45	70	155	105	95	155	50	45

APPENDIX 2 – VALENCE THRESHOLDS

Valence ratings	PT1	PT2	PT3	PT4	PT5	PT6	PT7	PT8	PT9	PT10	PT11	PT12	PT13	PT14	PT15	PT16	PT17	PT18
Neutral	6	5	8	5	1	7	5	7	5	5	5	5	6	5	5	3	7	5
	9	5	8	8	5	5	5	3	5	5	5	5	5	5	5	6	8	4
	7	7	5	5	5	5	5	6	5	5	7	5	8	7	5	7	7	5
	5	5	5	3	9	7	6	8	5	5	5	5	5	7	1	6	3	6
	5	7	5	2	1	6	5	9	5	5	5	5	5	5	5	7	2	5
	5	9	5	9	8	5	5	8	5	5	7	5	5	7	5	5	8	5
	6	9	5	3	5	5	5	3	5	3	3	4	5	5	2	3	5	4
	9	9	5	5	6	5	5	7	5	5	7	5	5	7	5	3	6	5
	5	3	7	6	7	5	5	9	5	2	5	7	5	9	5	8	2	7
	5	1	7	1	5	5	4	4	5	3	5	5	5	5	1	5	1	5
Positive	9	9	7	6	7	7	7	8	9	5	5	5	7	7	5	8	5	6
	6	6	9	7	8	5	5	8	9	5	5	5	7	7	5	8	5	5
	8	9	8	6	7	6	4	9	9	9	5	5	7	9	5	8	5	6
	7	2	8	7	6	5	3	9	5	7	6	5	5	9	5	7	3	7
	9	9	5	5	7	7	7	8	9	5	8	6	5	6	5	7	8	8
	6	9	5	6	8	5	5	5	9	9	8	5	6	8	5	4	8	6
	9	9	5	4	8	6	5	5	5	5	8	5	8	9	5	2	9	7
	9	9	5	5	7	7	5	7	5	7	7	6	5	9	5	5	5	6
	1	7	6	4	8	7	5	8	5	9	8	3	4	8	9	6	9	7
	6	9	5	7	9	8	7	9	5	9	7	9	5	9	9	7	7	9
Negative	5	9	7	3	2	6	3	2	5	1	6	1	7	1	1	2	1	2
	3	6	9	3	2	5	3	3	5	5	3	3	2	2	1	2	3	4
	4	9	8	5	1	3	5	1	1	1	3	1	3	2	3	1	1	2
	4	2	8	3	1	2	3	1	1	1	1	5	2	3	2	1	1	1
	3	9	5	3	1	5	5	3	1	2	3	1	4	3	2	2	4	3
	4	9	5	4	1	4	5	2	1	1	1	5	4	2	5	1	1	3
	3	9	5	4	1	2	3	4	1	1	3	1	3	5	5	1	1	2
	2	9	5	3	1	3	3	4	5	1	1	1	3	1	5	1	2	1
	1	7	6	4	1	3	3	2	1	1	1	2	4	1	2	1	5	1
	6	9	5	2	1	4	5	3	5	5	5	1	4	3	1	2	7	1

APPENDIX 3 – AROUSAL RATINGS

Arousal ratings	PT1	PT2	PT3	PT4	PT5	PT6	PT7	PT8	PT9	PT10	PT11	PT12	PT13	PT14	PT15	PT16	PT17	PT18
Neutral	1	1	1	2	2	1	6	5	5	1	1	7	1	1	1	2	3	1
	6	3	1	1	3	1	5	2	1	2	1	7	1	3	1	1	3	1
	2	3	1	7	2	1	4	1	1	1	4	8	6	1	1	1	7	1
	1	2	1	5	1	1	4	7	5	1	3	1	2	2	7	2	1	1
	1	5	1	5	1	1	5	6	1	1	1	6	1	1	1	1	3	1
	1	1	1	7	1	1	3	2	5	1	3	5	1	1	1	1	8	1
	1	6	4	7	2	1	6	8	9	3	7	5	1	2	6	1	5	1
	2	1	1	5	2	1	5	3	9	1	5	5	1	3	1	2	6	1
	1	1	1	2	1	1	5	1	5	5	1	1	1	3	1	2	2	1
	1	3	2	7	2	1	7	2	5	3	1	6	1	2	7	1	7	1
Positive	3	1	6	3	2	1	6	6	9	1	1	2	7	4	1	2	4	7
	4	2	6	6	4	1	5	8	1	1	1	5	7	7	1	1	5	6
	7	5	7	5	2	1	5	9	1	5	1	5	5	5	1	2	5	8
	9	2	6	7	2	1	7	9	5	5	1	4	6	8	1	2	6	7
	1	7	2	5	4	1	6	9	9	1	3	6	5	6	1	2	8	8
	1	9	2	7	3	1	5	6	9	9	7	5	5	8	1	7	8	6
	8	6	2	6	3	1	5	6	1	5	6	1	3	9	1	7	9	8
	9	9	3	5	3	1	5	8	9	5	7	6	2	8	1	1	5	6
	9	7	4	7	3	1	5	8	9	9	9	7	5	8	7	4	9	7
	5	3	4	3	3	1	3	7	9	1	6	6	3	7	7	5	7	9
Negative	3	1	6	8	8	1	5	8	9	5	5	9	3	9	8	7	9	2
	4	2	6	7	5	1	6	8	9	3	7	5	8	6	7	8	6	3
	7	5	7	5	5	3	5	9	9	7	6	9	7	5	2	8	9	6
	9	2	6	5	8	2	6	9	5	9	8	5	7	5	4	8	9	7
	1	7	2	8	8	1	5	7	9	5	6	9	6	7	7	8	6	8
	1	9	2	8	9	2	5	8	9	8	8	1	7	7	5	7	1	5
	8	6	2	4	7	4	6	7	9	9	7	8	6	5	5	7	9	7
	9	9	3	7	9	4	6	6	9	9	5	7	7	8	3	8	9	7
	9	7	4	6	9	2	5	8	5	9	7	5	6	7	6	8	5	8
	5	3	4	7	7	1	5	7	5	1	5	8	6	5	6	5	7	7

APPENDIX 4 – DOMINANCE RATINGS

Dominance ratings	PT1	PT2	PT3	PT4	PT5	PT6	PT7	PT8	PT9	PT10	PT11	PT12	PT13	PT14	PT15	PT16	PT17	PT18
Neutral	9	5	8	6	5	9	5	8	5	9	9	9	7	3	5	5	5	8
	4	7	8	7	1	9	5	3	1	7	9	9	5	6	5	3	6	7
	7	9	9	3	9	9	6	9	9	9	5	9	5	9	5	8	7	8
	9	9	9	5	9	9	6	9	5	9	3	9	6	9	5	8	1	7
	9	9	9	5	8	9	7	9	9	9	2	9	8	9	5	8	2	7
	9	9	9	9	9	9	5	9	5	9	3	9	5	9	5	9	7	8
	7	9	8	4	9	9	5	4	5	5	7	9	5	7	5	5	7	8
	8	9	9	7	8	8	5	8	5	9	5	5	5	2	5	7	6	7
	9	9	9	8	8	9	5	9	5	5	9	9	5	9	5	7	2	8
	9	9	7	3	8	9	5	9	5	5	9	9	5	8	5	6	2	7
Positive	3	9	2	7	3	6	5	7	5	9	5	9	5	8	1	5	5	7
	5	9	4	7	5	8	5	8	5	9	3	9	5	4	1	3	3	6
	7	9	6	6	5	8	4	8	5	9	1	9	5	4	1	3	3	8
	9	9	7	7	4	8	2	7	5	9	1	9	5	4	1	1	3	7
	5	9	1	4	4	8	5	8	1	9	5	7	4	7	1	7	6	6
	3	2	1	4	3	7	5	4	5	5	2	9	4	7	1	2	7	5
	7	1	2	3	2	5	5	6	5	5	5	9	5	8	1	2	7	4
	5	1	1	5	1	9	5	7	5	5	4	9	5	7	1	2	7	5
	8	3	3	3	3	7	5	6	5	4	8	1	5	3	1	4	3	4
	4	9	4	8	1	8	6	9	5	9	7	9	6	8	9	5	9	8
Negative	3	9	2	2	2	8	3	1	1	2	1	1	5	1	1	2	5	4
	5	9	4	4	2	9	3	1	1	3	1	7	2	7	1	2	7	4
	7	9	6	4	2	5	5	1	5	1	2	1	2	5	2	1	7	3
	9	9	7	4	1	3	2	2	5	1	1	9	3	7	1	1	2	7
	5	9	1	2	1	8	5	4	1	1	2	1	4	2	1	2	3	2
	3	2	1	4	1	5	5	1	1	1	1	4	4	5	1	1	1	5
	7	1	2	6	1	5	3	3	1	1	4	1	5	5	1	1	1	3
	5	1	1	3	1	5	2	3	1	1	1	5	4	5	1	1	2	2
	8	3	3	4	1	6	3	2	5	1	3	1	5	3	1	1	3	5
	4	9	4	3	1	8	5	3	5	9	1	5	5	5	1	1	6	3

The Master Thesis “The effect of visual information on pain thresholds” has been developed in Estonia.

I certify with my signature, that the research has been conducted independently, all information sources used in the Master Thesis have been mentioned in the reference list, and the submitted electronic copy of the Master Thesis corresponds to the printed version.

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