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THE EFFECT OF WATCHING EYES ON PERCEPTION OF PAIN INTENSITY

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ABSTRACT

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Previous studies have shown how cognitive-emotional top-down processes can affect conscious pain perception. The experience of pain has been found to alter when, for example, attention direction or affective state are manipulated. Furthermore, interpersonal factors have also been found to have alleviating effects on pain. Because eye contact offers a fundamental connection between two people in all meetings, this study aimed to examine whether the mere perception of direct eye gaze of another person could have an effect on the perception of pain intensity. Following previous research on eye gaze and pain perception, we reasoned that there could be two possible effects of eye gaze direction: perception of direct eye gaze could heighten or lower pain intensity compared to averted eye gaze. These two hypothesized contradictory effects are explained through two different cognitive-affective processes. We also investigated whether the mere presence of another person could have a lowering effect on pain perception.

In this study, 98 female participants were asked to rate the amount of pain intensity they felt while they experienced mild to moderate pressure-pain in their finger caused by a flat-tipped stylus. During pain induction, the first experimental group received direct eye gaze, the second group received averted eye gaze and the third group experienced the pain induction alone. Affective state before and after pain induction and self-focused attention were measured by questionnaires. The results showed no differences in pain intensity between the experimental groups. Thus, no effect of gaze direction or another individual's presence on pain perception was found. In addition, no attentive or affective differences were found between experimental groups. It then seems, that eye contact is simply not a strong enough signal to affect this powerful physiological sensation. Finally, the limitations of the study and future directions are discussed.

Keywords: pain, eye gaze, gaze direction, social modulation, affect, attention

Table of Contents

1 Introduction

1.1 Nociceptive pain perception and experimental research of pain

Pain is an evolutionary designed feeling, created to aid the survival of an organism. According to International Association for the Study of Pain, pain is defined as "an unpleasant sensory and emotional experience associated with actual or potential tissue damage or described in terms of such damage" (IASP, 1994). It is a feeling that one cannot live without, but which also the humankind has been pursuing to control throughout the history. When in pain, the elimination of this distressing sensation usually becomes the first priority. As we seek relief, we often turn to other people for help. The link between social factors and pain has been gaining growing interest in pain research, because along with other cognitive-affective mechanisms, interpersonal factors have also been found to have their modulative effect on pain perception and related physiological arousal (Krahé et al.,2013). Research on social modulation of pain has been targeted on the effect of various social factors on pain, but one of the most fundamental ways for two individuals to meet, the eye contact, has still remained uninvestigated.

In nociception, a noxious stimulus meets with a part of a body containing pain receptors. This stimulus injures tissue cells which release chemicals which in turn bind to the receptors of nociceptors – the sensory nerve cells specialized for detecting painful events. These nociception-specific neurons send a message to the central nervous system – spinal cord and brain areas such as the thalamus and limbic areas notifying of a possibly threatening situation. Whether this potentially damaging signal is sufficient enough, a protective nociceptive withdrawal reflex is triggered. Conscious pain perception is a result of an activation of a wide array of different brain structures, such as somatosensory cortices, the insula and anterior cingulate cortex, often referred as the pain matrix (Garcia-Larrea & Peyron, 2013; Iannetti & Mouraux, 2010). Yet, this group of brain areas is not functionally nociception-specific and is rather harnessed in the processing of pain when necessary (Ploner et al., 2017). Focal activation or destruction of these specific brain areas do not always produce pain or induce analgesia and many other mental processes activate the same areas without any experience of pain or suffering (Garcia-Larrea & Peyron, 2013; Iannetti & Mouraux, 2010). Thus, the integration and more deeply, the dynamics of these interconnected areas are the actual creator of painful experiences.

Human pain perception is often measured via subjective assessment methods, because pain perception is not just a result of activation of the nociceptive system but the net result of complex physiological and psychological processes. In order to grasp the highly subjective experience of pain in whole, pain perception in scientific research is often divided into two dimensions: sensory pain or pain intensity and pain unpleasantness. Sensory pain includes spatial, temporal and intensity properties of pain whereas pain unpleasantness covers the emotional aspects of pain (Melzack & Casey, 1968). These two dimensions correlate with each other, but reflect different aspects of pain and can be measured separately (Prince et al.,1987). The most common methods used to measure pain perception are visual analogue scales (VAS) and verbal descriptor scales (VDS) (Staahl & Drewes, 2004). In psychophysical scales such as these, the magnitude of pain varies from no pain to unbearable pain from which participants select the best alternative to describe their experience. The main shortcoming of these methods lies naturally in their subjective nature and in the multiple cognitive-emotional factors which are hard to control in experimental research. Also video recordings of facial expressions (Gallant & Hadjistavropoulos, 2017), pain thresholds, electrophysiological methods such as measuring nociceptive withdrawal reflexes and evoked brain potentials can likewise be used to measure pain (Staahl & Drewes, 2004). However, these measures often evaluate only limited aspects of pain and do not capture the complex processes associated with conscious pain perception in whole.

In experimental research, pain is often induced to the skin by mechanical, electrical, thermal, laser or chemical methods (Staahl & Drewes, 2004). These painful stimulation methods include, for example: application of heat stimuli with various devices such as contact thermodes or lasers (Goldstein et al., 2016; Krahé et al., 2016; Miron et al., 1989; Pelaez et al., 2016), immersing a hand to a cold water (de Wied & Verbaten, 2001), and producing pressure (Kenntner-Mabiala et al., 2007) or electric shocks to the skin (Seidman et al., 1957). In addition, muscle pain caused by ischemic stimulation (Staahl & Drewes, 2004) or by physical exercise (Johnson & Dunbar, 2016) have also been used in pain research.

1.2 Modulatory effect of cognition and affective state on pain

Pain is a highly salient experience and its function is to secure the survival of an organism (Van Damme et al., 2010). It is automatically associated with distinct unpleasant sensory and emotional experience that draws attention and interrupts ongoing tasks, so that the required protective measures can be made quickly. However, higher-order cognitive-affective processes can have a significant role in the perception of pain, too. In other words, top-down processes are able to modify bottom-up pain-related sensory processing. Extensive amount of research has shown that different psychological mechanisms can alter, either by mitigating or strengthening, the perception of pain (Krahé et al., 2013; Villemure & Bushnell, 2002; for a review, Wiech et al., 2008). Factors such as attention, affective state, meditation, attitudes, experiences of control over pain stimulus, beliefs and learned anticipatory cognitions towards upcoming pain have been shown to have their impact on the subjective experience of pain.

It has been largely admitted that attention plays a pivotal role in modulating pain perception. Pain demands our attention in order to prevent further tissue damage and it can rarely be ignored (Eccleston & Crombez, 1999). Unless we are intentionally attending away from a painful stimulus, a novel noxious stimulus attracts our attention (Miron et al., 1989). When attention is targeted to the noxious stimulus, pain is then perceived faster and more intense (for a review, see Crombez et al., 2005). For example, attending to a noxious heat stimulus has been shown to increase the perception of pain intensity and unpleasantness (Quevedo & Coghill, 2007) and viewing one's own hand prior to a painful stimulus has been shown to cause higher pain evaluations compared to looking at an object (Beck et al., 2016). Similarly, when attention is directed elsewhere, for example to an attention-demanding task or another sensory modality, the perception of pain intensity and pain unpleasantness has been shown to decrease (Bantick et al., 2002; Miron et al., 1989; Terkelsen et al., 2004). It also seems, that the bigger the attentive load is, the more it reduces the experienced pain intensity (Romero et al., 2013).

In addition to attention, modulation of one's emotional state has also been shown to alter pain perception (Rhudy & Meager, 2001; Villemure & Bushnell, 2002). If a noxious stimulus is presented concurrently with an affective stimulus, negatively valenced pictures have been shown to decrease pain tolerance whereas positive pictures have been shown to increase it (de Wied & Vertaben, 2001). Also improving mood by presenting mood-lifting stimuli, such as odors or laughter, has been found to have a lowering effect on pain ratings (Cogan et al., 1987; Marchand & Arsenault, 2002), while negative emotions evoked by a hypnotic relaxation task have been shown to heighten pain unpleasantness compared to positive and neutral conditions (Rainville et al., 2005). Mood states induced by asking participants to immerse themselves to affective statements have showed similar effects on cold water tolerance, but not on pain ratings (Zelman et al., 1991). In this study, depressive statements reduced cold water tolerance, while statements expressing optimism and self-efficacy improved pain tolerance.

The effects of attention and affective states on pain are hard to separate, since they cannot be studied completely apart from each other. It has been suggested that the effect of emotional states on the perception of pain could be caused partly by attentive processes, and the impact of these two factors on pain has not yet been established to the fullest. Because emotional cues have attention-grabbing qualities, it is possible that the stronger the emotional stimulus is, the more it directs attention away from pain (de Wied & Verbaten, 2001; Villemure & Bushnell, 2002). This question has been of interest in scientific literature and there is some evidence that emotions and attention alter pain perception differently, since they invoke at least partially separate neural modulatory circuits (de Wied & Verbaten, 2001; Villemure et al., 2003; Villemure & Bushnell, 2002; Villemure & Bushnell, 2009). It is also suggested, that attentional and emotional manipulations could affect different types of pain (i.e. pain intensity and pain unpleasantness) differently. Attentive manipulations, for example distracting attention away from a painful stimulus, have been found to influence mainly sensory pain ratings, whereas emotional manipulations have been found to influence mostly the aspect of pain unpleasantness (Loggia et al., 2008; Rainville et al., 2005; Villemure et al., 2003; Villemure & Bushnell, 2009). It thus seems that cognitive and affective mechanisms both have an effect on pain perception, but their effects are realized by at least partially separate underlying mechanisms.

1.3 Psychosocial factors and pain

Interaction with other people has a vast influence on our psychological processes and on physiology, too. Close relationships with others are beneficial for our physical health, whereas social isolation can have debilitating effects on it (for a review, Cohen, 2004; Uchino et al., 1996). It has been shown that people with stronger social support use less analgesics in their daily lives, experience less pain when having cancer, and suffer less from chest pain after coronary artery bypass surgery compared to people with less social support (Eisenberger & Lieberman, 2005). Interestingly, pain tolerance has also been shown to correlate positively with human network size (Johnson & Dunbar, 2016).

When experiencing pain, having another person in the same space has been shown to have a relieving effect on pain perception. The presence of a peer has been shown to elevate the tolerance of self-administered electric shocks, cold-water tolerance, and pressure pain (Edwards et al., 2017; Seidman et al., 1957). Also, participants in both active and passive social support groups have been found to report less pain compared to participants experiencing pain alone and this effect has been observed regardless of whether the person in the situation is a friend or a stranger (Brown et al., 2003). The effect another person's presence on pain has also been found with older adults (Gallant & Hadjistavropoulos, 2017).

Even the loosest social connection, belief of another person watching through a one-way window, has been found to lower pain-related facial expressions, pain ratings, and skin conductance responses (Kleck et al., 1976). Pain unpleasantness has also been shown to decrease by asking participants to watch photographs of a loved one (Master et al., 2009).

However, the effect of another person's presence on pain perception is not yet established to the fullest, since not all studies show similar results. Some studies have not witnessed any pain alleviating effects by another person's presence (Modić Stanke & Ivanec, 2010; Roberts, et al., 2015). Instead, another individual's verbal support, i.e. comforting and encouraging talk prior to pain induction, has been found to alleviate pain more than the presence of another person (Roberts et al., 2015). Surprisingly, one study has even found, that the presence of a close one produces even more pain-related facial expressions with males and females, whereas the presence of a stranger reduces these same expressions with females compared to experiencing pain alone (Karmann et al., 2014).

Seeing other individual's faces has been shown to have a modifying effect on people's acute pain ratings. When receiving a painful thermal stimulus, showing pictures of faces (with joyful, fearful, and neutral expressions) compared to control pictures (fixation crosses) have been shown to decrease participants' subjective pain ratings (Reicherts et al., 2013). However, in the same study, watching faces communicating to be in pain resulted in higher pain ratings to painful stimulus compared to watching other facial expressions. Brain imaging studies are also compatible with this result: seeing others in pain has been shown to activate similar brain areas as in genuine pain experience (Jackson et al., 2004). When comparing different emotional expressions, seeing pictures of sad facial expressions has been shown to increase the intensity and unpleasantness of subjective pain to a noxious stimulus compared to seeing happy and neutral faces (Bayet et al., 2014). In the same study, seeing sad facial expressions decreased participants' mood, which modulated felt pain intensity, thus demonstrating the importance of affect in relieving pain.

Even a touch of another person has been shown to have a lowering effect on pain perception. It has been suggested that a touch of a parent lowers distress associated with pain during minimal medical procedures in healthy newborns (Gray et al., 2000), and it has been shown that a therapeutic touch lowers subjective pain ratings of cancer patients (Post-White et al., 2003). Goldstein and colleagues (2016) examined the analgesic effect of social touch and the moderative effects of a toucher's empathy on analgesia. In their experimental study, female participants received a constant heat stimulus to their left forearm in four different social conditions, where either the partner or a stranger touched them, the partner sat beside them, or they experienced the pain alone. Touch of a partner was found to alleviate women's pain compared to the other three groups (partner no-touch, stranger touch and alone). In addition, the researchers found that the partners' level of empathy, evaluated by the women themselves, interacted negatively with women's pain ratings only when the partners hold their hands. In other words, the more the women experienced their partner being empathetic, the more the partner's touch lowered the felt pain intensity.

1.4 Watching eyes and the perception of pain

It seems that when in pain, we are sensitive to social signals around us. What if even the most basic social signal – a mere eye contact - could have a similar modifying effect on our pain perception as touch has? According to John Heron (1970), a real reciprocal encounter between two people takes place only either when two people touch each other or look at each other in the eyes. In these two types of situations of human connection, both people meet one another by concurrently receiving and giving in the same act, which can never be the case in verbal interaction. As social animals, humans have a fundamental need to seek for the sense of togetherness. When in pain, we often turn to other people to ask for help and this happens naturally by seeking eye contact. In fact, eyes are a central factor in messaging empathy (Cowan et al., 2014). Since mutual eye contact offers a fundamental connection between two people in all meetings, it would be interesting to examine what kind of an effect direct eye gaze of another person would have on pain perception.

Perception of another person's direct eye gaze has been shown to modulate individuals' affective responses. In his review, Hietanen (2018), describes different types of evidence suggesting that perception of direct eye gaze automatically evokes positively valenced affective reactions. For example, in affective priming studies, perceiving direct eye gaze has been found to elicit a more positive affect as compared to perceiving closed eyes (Chen et al., 2017) and frontal EEG asymmetry measurements have shown that direct eye gaze evokes greater brain activity associated with approach motivation as compared to perceiving another's averted gaze when facing a real person (Hietanen et al. 2008). Also when watching neutral or even angry facial expressions, people tend to prefer faces with direct eye gaze compared to averted eye gaze (Lawson, 2015). Since there is evidence that the perception of direct eye gaze triggers automatically a positively valenced affect, eye contact could therefore be expected to alleviate pain perception via affective mechanisms.

Perceiving another individual's direct eye gaze has also attention-grabbing qualities. Human neonates look longer at face-like pictures compared to pictures of disarranged facial features or blank pictures (Johnson et al., 1991) and they spend significantly more time looking at pictures of faces with direct gaze than averted gaze or eyes closed (Batki et al., 2000; Farroni et al., 2002). During demanding cognitive tasks, perception of direct eye gaze has been shown to load cognitive resources more compared to perceiving averted eye gaze, while performing a Stroop task or a visual detection task (Conty et al., 2010; Senju & Hasegawa, 2005). Given that attending away from a painful stimulus alleviates pain perception and that perception of direct eye gaze attracts attention, gaze of another person could also have a mitigative power on the experience of pain via attentive mechanisms.

However, direct eye gaze of another person could also have a heightening effect on pain. As attending to a painful stimulus has been shown to strengthen the experience of pain, perception of direct eye gaze has also been theorized to increase a perceiver's self-awareness (Conty et al., 2016; Reddy, 2003). Direct eye gaze of another person has been shown to raise one's public self-awareness (Hietanen et al., 2008). Also in a more recent study, it has been found to bolster participant's self-referential processing (i.e. information processing directed to one's self) (Hietanen & Hietanen, 2017). Interestingly, Baltazar and colleagues (2014) discovered that after showing pictures of faces with direct eye gaze, participants were better at rating their own physiological reactions engendered by emotional stimuli. In their study, direct eye gaze, averted eye gaze or a fixation cross stimuli were presented shortly before emotional stimuli, after which the participants would rate their emotional reactions. These ratings were compared to the participants' skin conductance responses (SCR). After direct eye gaze the correlation between SCRs and subjective ratings of emotion was significantly higher as compared to after seeing an averted eye gaze or a mere fixation cross. Furthermore, the same effect was discovered when the participants believed to be watched by another person (Hazem et al., 2017). These results suggest that direct eye gaze corroborates our bodily self-awareness and body-focused attention. Therefore, perception of direct eye gaze of another person could strengthen the intensity of pain experience, because it draws perceiver's attention towards one's own body.

These described cognitive-affective processes when perceiving another's direct eye gaze have been proposed to be triggered by the realization that the self is under someone else's attention. These so called "watching eyes effects" do not demand the visual perception of eyes in the environment per se, they rather require the sense of being watched (Conty et al., 2016). Indeed, the perception of direct eye gaze from the corner of the eye or even the mere belief to be watched has been found to elicit similar brain and autonomic responses as genuine direct eye gaze elicits (Hietanen et al., 2018; Myllyneva & Hietanen, 2015; Myllyneva & Hietanen, 2016). Kleck and colleagues (1976) studied the effect of sense of being observed on subjective, expressive and physiological responses on pain. In their study, participants experienced electric shocks while they either believed to be watched through a one-way window by a stranger (who they never saw) or they were alone. The belief to be watched was found to inhibit facial expressions and lower subjective pain ratings and physiological arousal during pain induction compared to being alone. In other words, being observed attenuated participant's pain perception. This result raises further interest to examine whether similar, or even stronger, effects on pain perception would be found when perceiving another person's direct gaze.

1.5 The present study

The objective of this study was to investigate whether another individual's eye gaze direction has a modifying effect on a perceiver's perception of pain intensity. In addition, the effect of another person's presence on pain experience was investigated. In this study, participants received mild to moderate tonic pain to their middle phalanx of a finger caused with a flat-tipped stylus. Participants were divided into three experimental groups: the first group received direct eye gaze, the second group received averted eye gaze and the third group experienced the pain induction alone. During pain induction, the experimenter varied her eye gaze and presence between experimental groups, either by looking directly at the participant, looking down to a laptop or by leaving the research space. The participants were asked to report the amount of sensory pain they experienced with the help of a numeral pain rating scale. In addition, positive and negative affects before and after pain induction, participants' self-awareness, social desirability and impressions towards the experimenter were measured by questionnaires.

Given the social modulation of pain (Krahé et al., 2013) and various cognitive-affective effects when perceiving another individual's watching eyes (Conty et al., 2016), we hypothesized that the perception of direct eye gaze can either have heightening or lowering effect on pain intensity compared to perceiving another's averted eye gaze. Direct eye gaze of another individual has been shown to evoke positive emotions (Hietanen, 2018) and positive affect in turn has been found to lower pain perception (Rhudy & Meager, 2001). In addition, direct eye gaze has been shown to distract from an ongoing task (Conty et al., 2010) and attending away from pain has been shown to lower pain perception (Terkelsen et al., 2004). Because of these aspects, we expected that perception of direct eye gaze would lower the perception of sensory pain compared to averted eye gaze. On the other hand, previous research also indicate, that direct eye gaze bolsters perceiver's bodily self-awareness (Baltazar et al., 2014; Hazem et al., 2017), and self-directed attention has been shown to heighten pain perception (Bantick et al., 2002; Crombez et al., 2005; Eccleston & Crombez, 1999). With this in mind, instead of lowering pain experience, it was possible that perception of direct eye gaze could heighten a perceiver's sensory pain compared to averted eye gaze. In addition, because the presence of another person has been shown to alleviate pain perception (Edwards et al., 2017; Seidman et al., 1957), we also expected that when experiencing pain in solitude, the perceived pain intensity would be higher compared to when experiencing pain in company.

2 Method

2.1 Participants

The study was approved by the local ethical committee. 98 female students were recruited during daytime in the main lobby of University of Tampere (mean age = 25,15; standard deviation = 5,41; range = 19–49). Since the experimenter was a woman, only women participants were recruited as participants because of the possible influence of opposite genders of the participant-experimenter dyad on the pain ratings. The participants were free of chronic pain disease, any sort of acute pain or skin condition that included damaged skin on fingers. In addition, participants had not consumed any alcohol or analgesics in the past 12 hours. Because of the unclear effect of handedness on pain perception (Murray & Safferstone, 1970; Pud et al., 2009), we chose to include only right-handed participants to the experiment to ensure the consistency of pain experience between all the subjects. Psychology students were not allowed to participate in this study, since they could have had more foreknowledge of the area of this research. The experimenter had not met the participants before.

2.2 Algesimetry

Nociceptive stimulus was delivered by an in-house designed and built device consisting of a blunt metallic rod (diameter 4 mm) attached to a lever. The weight of the lever could be adjusted by adding weights on top of the lever from 160 g up. Because of between subject design, the required reliable adjustment of pain stimulus to the same pain level for each participant was challenging, we chose to use the same amount of weight for every participant. Based on Kenntner-Mabiala and colleagues (2007) we used a 550 g weight resulting in a pressure of approximately 500 +/- 100 kPa. This amount of weight results in a moderately painful sensation, depending on the pain tolerance and circumference of participant's finger. In this study, the middle finger and ring finger of the left hand were used.

Figure 1. Research setting.

2.3 Procedure

The participants were recruited during the day-time in the main building of University of Tampere. First, the participants were given an information sheet about the experimental procedure. They were falsely informed that the study investigated the effects of analgesic drugs and that they were recruited in a control group without having to take analgesics. Next, they read and signed a consent form. It was made sure that the participants were aware that they could discontinue the procedure at any time.

Following recruitment, the participants were led to the research space, situated in a remote corner in the main lobby of the main building of University of Tampere. The space included two chairs, a table and the visual analog pain rating scale in A3 size on the wall behind the experimenter's seat. The scale was set just above the experimenter's head in a way that the participants could easily perceive the experimenter's eye gaze from the corner of their eye while looking at the pain rating scale. On the table, there was a laptop and the nociceptive pain device. For an illustration of the research setting, see Figure 1. Before the experiment, the experimenter inquired the participant's age and field of study. Field of study was asked to ensure the participants were not psychology students. After this, the experimenter turned the laptop around for the participant and asked them to fill out a computerized questionnaire related to their mood at the moment (PANAS, see "Self-ratings"). Then, the laptop was turned facing the experimenter and the pain device. VAS, and the following experimental procedure was introduced to the participant in detail. Before starting the experiment, the participant put on headphones and placed the specified finger's middle phalanx underneath the stylus of the pain induction device. The order of starting finger was randomized.

Because the amount of weight was the same for every participant, it was possible that there would be a large variance in pain intensity values. To examine the trajectory of change of sensory pain as a function of time, the sensation of painless pressure preceding pain perception was also included in the measurement. Participants were asked to rate the amount of sensory pain they felt using a numerical pain rating scale ranging from 0 to 200, anchored by 0 = no pressure, 100 = just noticeable pain, 120 = slight pain, 150 = moderate pain, 180 = strong pain and 200 = worst pain imaginable. The participants were asked to focus their attention on the physical aspect of pressure pain stimulation (i.e. pain intensity).

The study was conducted as a randomized between-subject design with three experimental groups (direct gaze, gaze down, no experimenter) each of which included two identical pain blocks. Before starting the pain experiment, an E-prime script let the experimenter know which experimental manipulation (direct gaze, gaze down, no experimenter) she would carry out. Then, the experimenter began the experiment by concurrently starting the computer program instructing experimenter's eye gaze -direction and by starting the pressure stimulation by gently placing the stylus on the participant's finger. Once the program had started, the computer presented a sound signal to the participant every 10 seconds. After the sound signal the participants reported verbally the amount of pain they felt with the help of visual pain rating scale on the wall. The pain stimulation continued for 50 seconds with 5 signals. After the last signal and the participant reporting the fifth pain evaluation, the experimenter lifted the stylus from the participant's finger. To avoid carryover effect, after the first pain stimulation block, a short pause was held (a minimum of 1 minute). Then the procedure with same gaze direction was repeated to the participant's other finger.

In the "direct gaze" group the experimenter looked directly in the participants' eyes, while every seven seconds looking down to the laptop for three seconds. A cycle including a sound signal, direct eye gaze and writing down a pain rating proceeded in 10 second cycles. To avoid uncomfortable or unnatural staring, and in order to write down the participants' pain scores the experimenter looked down to the laptop periodically. To assist the timing and number of gazes away from the participant, the computer program presented visual signals to the experimenter on the screen. These signals were not visible to the participant. During the 60-second trial, approximately 70% of the time the participant received direct eye gaze from the experimenter and 30% of the time the experimenter looked down to the computer. When looking down to the laptop, the experimenter bowed her head in 45-degree angle. In the "averted gaze" group, the experimenter looked at the laptop screen for the whole pain stimulation period. During the pain stimulation, the experimenter adopted a neutral facial expression, however avoiding to look too negative.

In the "no experimenter" group the participants were informed that the experimenter would leave the research space for the time of pain stimulation and that the laptop would record their pain-scores automatically. Once the pain stimulation was started, the experimenter stepped outside the research space and wrote down the pain scores by listening behind the partition wall. After the pain stimulation, the experimenter returned to the space and lifted the stylus off from the participant's finger.

After both pain stimulation trials, the participants were asked to answer questionnaires described below. The participants filled out the questionnaires on the laptop. In the end of the procedure, the participants were asked for their impressions of the purpose of the research. Finally, the nature of the research was revealed to the participants and a small reward (a ticket for a lunch at the university cafeteria) was given to them. The whole procedure lasted approximately 20 minutes.

2.4 Self-ratings

Before and after the pain experiment the participants answered computerized questionnaires. Questionnaires were run by E-Prime-program (version 2.0). To examine whether there was a change of emotional state due to the pain induction, a questionnaire measuring the valence of affect was presented before and after the pain experiment. The Positive and Negative Affect Schedule (PANAS; Watson et al., 1988) consists of 10 positive and 10 negative terms such as “excited” or “distressed”. The terms were responded on a 5-point Likert scale, ranging from very slightly / not at all to extremely. The participants were instructed to mark the most appropriate answer describing how they felt at the moment.

To measure participants’ self-awareness, a modified version of a 9-item Situational Self-Awareness Scale (SSAS; Govern & Marsch, 2001) was used. The questionnaire includes three factors all of which are measured by three questions. The factors are public self-awareness (e.g. “Right now, I am concerned about the awareness for presenting myself”), private self-awareness (e.g. “Right now, I am conscious of my inner feelings”), and awareness for immediate surroundings (e.g. “Right now, I am keenly aware of everything in my environment”). In addition, to further measure bodily self-awareness we added three questions of bodily self-awareness. These added questions were based on the Private body items from Body Consciousness Questionnaire (Miller et al., 1981), and the items were embedded inside the Situational Self-Awareness Scale. The questions were: during the pain stimulation, I was very aware of changes in my body temperature; during the pain stimulation, I could feel my heart beating; during the pain stimulation, I recognized my state of arousal.

Since the study measured only subjective evaluations and because of a suspicion that the direct eye gaze could bolster socially desirable answering, a short version of Marlow-Crowne Social Desirability Scale (M-C 1(10); Crowne & Marlowe, 1960; Strahan & Carrese Gerbasi, 1972) was added to examine the social desirability of the responses between experimental groups. The measure includes 10 items concerning personal attitudes and traits (e.g. I like to gossip at times) and were responded using true or false response categories.

The participants were also presented with three items concerning the impression of the experimenter made upon them. The participants were asked how pleasant or unpleasant, empathic or unemphatic and dominative or submissive the experimenter was. These items were answered on a 9-point Likert scale from not at all to very much. Importantly, as a manipulation check, the participants were asked to rate on a 9-point Likert scale ranging from not at all to constantly of how much the experimenter was looking at them during the pain stimulation. Finally, as an explorative item, participants participating in both gaze-groups were asked to rate their own belief of how eye gaze of another person could affect pain perception. This question was answered on a 9-point Likert scale from descending to raising with number 1 with no at all, 9 very much and number 5 anchored with no effect.

2.5 Data analysis

The data analyses were performed using IBM SPSS Statistics -program (version 25). Due to some participants not following experimental instructions correctly and technical problems in the procedure, 6 participants had missing pain values. Two participants were missing only the first pain value. These values were replaced by subtracting the mean-difference of the second and the first pain values across all participants from the second pain value of the participants in question. Three participants were missing two or more pain values in one pain block, and due to loud background noise in the lobby, one participant was missing multiple values in both pain blocks. These missing values were not replaced, thus these participants were excluded from further analyses (final $n = 94$).

The Shapiro-Wilk test of normality showed that all pain variables were not normally distributed ($p < 0.05$). In addition, the assumption of sphericity was not met. However, because the sample size of each group was sufficient for carrying out parametric tests and the analysis of variance is considered a robust statistical test (Ghasemi & Zahediasl, 2012), both parametric and non-parametric tests were conducted and are reported here. With all analyses, significance level was set to $\alpha = 0.05$.

A three-way mixed analysis of variance (ANOVA) was conducted with experimental group ("direct gaze"/"averted gaze"/"no experimenter") as a between-subject factor, pain stimulation block (first/second) and time points (first – fifth) as within-subject factors. Greenhouse-Geisser corrections were applied. As a non-parametric counterpart, Kruskall-Wallis one-way analysis of variances were performed. In order to analyze the relative change of pain values across time with a one-way test, measures of change were calculated for both pain blocks. These values were achieved by calculating the difference between the last and the first pain value of a block, divided by the mean of all 5 pain values of the block. Also a mean value was created from these calculated change values. Thus, three Kruskall-Wallis H tests were performed: for change variables of block 1, block 2 and for the combined mean variable. In addition, since three participants reported not perceiving any pain during the pain stimulation, above analyses were also conducted without these data. However, the results were parallel to the main analysis and therefore are not reported in the results.

Positive and negative affects (PANAS) were analyzed with repeated measures ANOVA, with groups as a between subject factor. Greenhouse-Geisser corrections were applied. Self-awareness (SSAS) values, social desirability, impressions the experimenter made upon participants and participants' views how direct eye gaze affects pain perception were analyzed with one-way ANOVAs.

3 Results

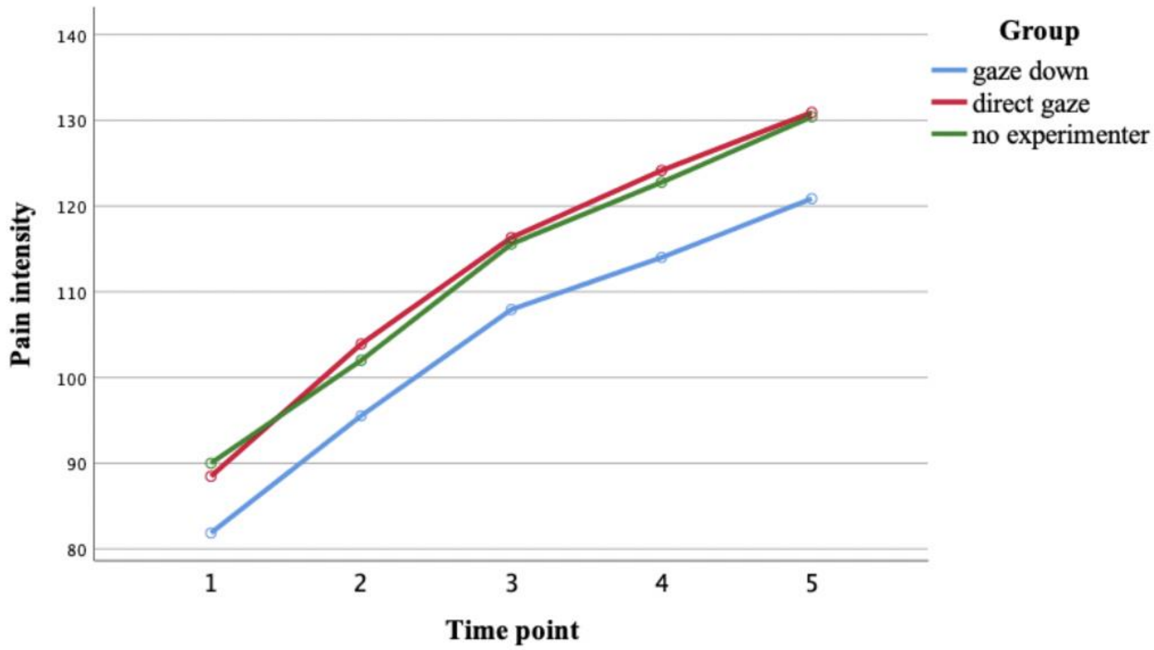
3.1 Manipulation checks

The two gaze-groups differed significantly in the ratings of how much they felt receiving direct eye gaze during the pain induction. In the "direct gaze" group, participants rated that the experimenter was looking at them significantly more (M = 7.41, SD = 0.373) compared to "averted gaze" group (M = 3.44, SD = 0.291, $t(64) = -8.331$, $p < .001$).

3.2 Sensory pain ratings

Mean pain values as a function of time are presented in Figure 1. For group sizes, numerical means and standard deviations, see Appendix 1. The three-way mixed analysis of variance showed no significant differences between experimental groups in participants' pain ratings ($F(2,91) = 0.948$, $p = .391$). As expected, a main effect of time was detected ($F(4,364) = 243.696$, $p < .001$), with pain values increasing in the course of time. A main effect of experimental block was not found ($F(1,91) = 1.134$, $p = .290$). Neither interactions for Block × Experimental Group ($F(2,91) = .092$ $p = .913$), Block × Time (F(4,364) = 2.499, $p = .075$), Time × Experimental Group ($F(8,364) = 0.378$, $p = .762$) or Block × Time × Experimental group ($F(8,364) = 1.657$, $p = .151$) were found. In Table 1, the calculated change scores of pain ratings and test values of non-parametric Kruskall Wallis h test are shown. Compatible with the ANOVA results, the Kruskall-Wallis one-way analysis of variance showed no significant differences in the change scores between the groups.

a) Block 1



b) Block 2

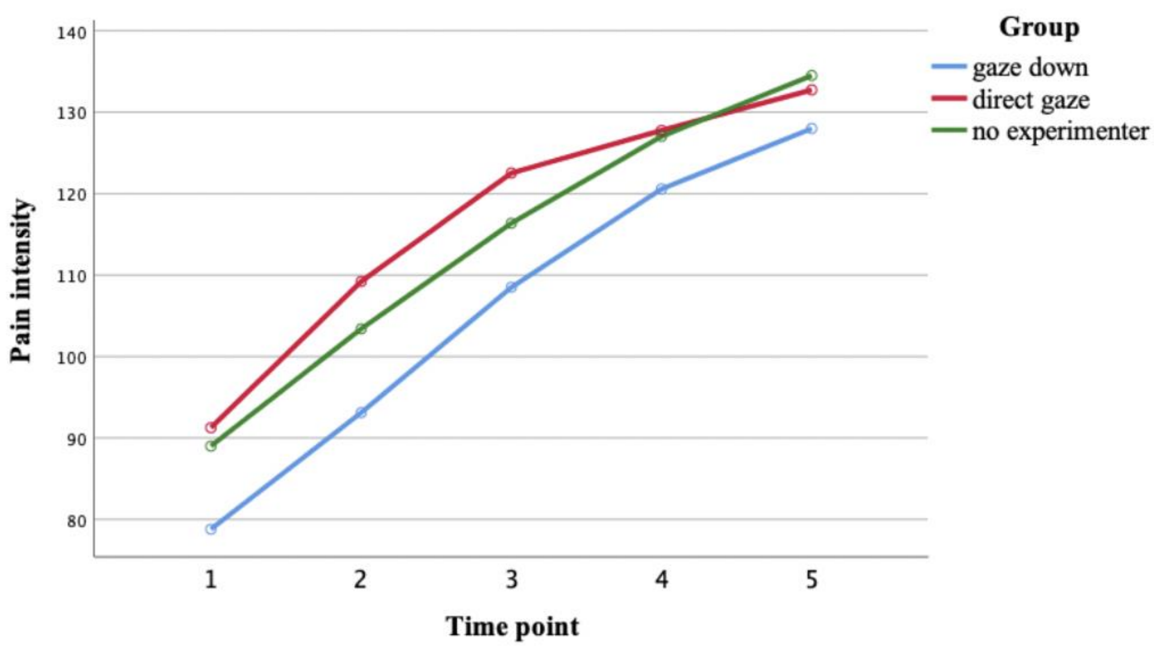


Figure 1. Mean values of pain ratings in different groups as a function of time. The trajectories of pain of the first block (a) and the trajectories of pain of the second block (b) are shown separately.

Table 1. The means and standard deviations of calculated change scores in different experimental groups. The table also shows the test values of Kruskall-Wallis one-way analysis of variance.

	Gaze down		Direct gaze		No experimenter		$\chi^2(2)$	*p*
	M	*SD*	*M*	*SD*	*M*	*SD*		
Block 1	.47	.35	.44	.44	.43	.38	0.510	.775
Block 2	.56	.41	.40	.32	.43	.26	2.661	.264
Mean	.52	.36	.42	.34	.43	.30	1.012	.603

3.3 Self-ratings

Figure 2 shows mean values of positive and negative affect before and after the pain induction. No significant changes in positive affect (F(2,91) = 0.243, *p* = .785) or negative affect (F(2,91) = 0.135, *p* = .874) between the groups were found. However, a significant main effect of time in negative affect was found. The negative affect decreased as a function of time in the whole sample (F(1,91) = 31.650, *p* = .001). No similar changes were detected for positive affect (F(1,91) = 1.716, *p* = .194). In Table 3, means, standard deviations and test values for self-awareness are shown. No significant differences in self-awareness between the groups were found.

The groups did not differ in social desirability (*F*(2,91) = 0.906, *p* = .408) nor in impressions the experimenter made upon them (pleasant–unpleasant, *F*(2,91) = 0.831, *p* = .439; empathic – unempathic, *F*(2,91) = 0.372 *p* = .691; dominant – submissive: *F*(2,91) = 2.903, *p* = .060). Finally, the two groups receiving different eye gaze treatment did not differ in their views of how eye gaze affects pain perception (*F*(1,62) = 0.007, *p* = .934). Of all these participants, 32.8 % thought that receiving direct eye gaze would lower pain perception, 21.9 % thought that direct eye would amplify pain perception, and 45.3 % thought that eye gaze would not have any effect on pain perception.

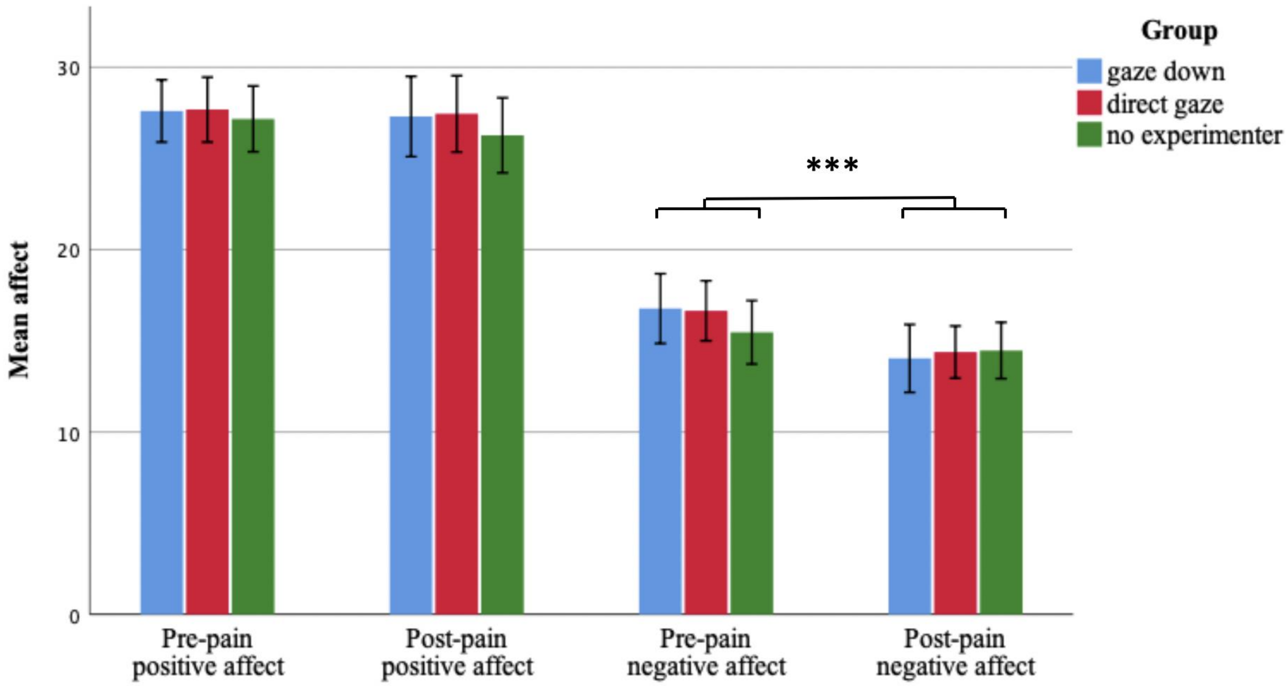


Figure 2. Mean values of positive and negative affect before and after pain induction for different experimental groups. *** < p = 0.001. Error bars represent standard deviations.

Table 3. Means, standard deviations and test values for different scales of self-awareness (SSAS and bodily self-awareness).

	Gaze down		Direct gaze		No experimenter			
	M	*SD*	*M*	*SD*	*M*	*SD*	F	*p*
Surroundings	9.73	4.18	8.59	3.88	8.60	3.92	0.834	.438
Public awareness	6.50	3.15	7.65	4.08	5.83	3.30	2.139	.124
Private awareness	9.70	2.88	11.03	3.55	10.43	3.48	1.274	.285
Body-awareness	9.73	3.50	9.50	3.99	9.50	3.94	0.038	.963
Mean	35.67	1.71	9.75	1.67	34.37	11.03	0.453	.637

4 Discussion

4.1 The effect of another individual's eye gaze direction and presence on pain intensity

The aim of this experimental study was to examine what kind of an effect does a perception of another person's watching eyes have on the experience of pain intensity. We also investigated the overall effect of another individual's presence on pain perception. In this study, 98 participants were randomly assigned into three experimental groups. The participants experienced mild to moderate pressure pain in their finger induced by a flat-tipped stylus. During the pain induction, the first group received direct eye gaze and the second group received averted eye gaze. The third group experienced the pain induction alone. All the participants were asked to report the amount of sensory pain they experienced with the help of a numeral pain rating scale. In addition, positive and negative affects before and after pain induction and participants' self-awareness after the pain induction were measured by questionnaires.

The results of the present study showed no significant differences in subjective pain intensity between participants perceiving direct eye gaze and averted eye gaze. Neither was the previously demonstrated lowering effect of another person's presence on pain perception replicated (Brown, et al., 2003; Edwards, et al., 2017; Gallant & Hadjistavropoulos, 2017; Seidman, et al., 1957). Likewise, no significant differences in attentive or emotional states were detected between the experimental groups.

The results suggest that the perception of watching eyes is simply not a strong enough signal to have an effect on perception of pain. Pain is one of the most fundamental bodily experiences that demands our immediate act of reaction in order to survive. It is possible, that in order to have an effect on pain perception, eye gaze should convey a clear social message of danger or safety along with other manifestations of social messages. For example, another person's presence, support or touch along with eye contact could therefore communicate empathy and possible help. Our study explored only one social situation and context, where the spectator was a stranger and the direct eye gaze was somewhat meaningless. Because of this, it would be intriguing to find out if there would be a different kind of an effect if the spectator had, for example, a specific social relationship to the target person (close one / enemy) or expressed a distinct expression (comfort / anger), in which cases the direct eye gaze would convey more clearly a message of safety or harm in the social encounter.

As previously mentioned the perception of direct eye gaze has been shown to attract a perceiver's attention and elicit positively valenced affective reactions (Conty et al., 2016; Hietanen, 2018). In this study we expected these factors to lower perception of pain intensity, since attentional distraction and positive affect have been shown to have a lowering effect on pain experience (Eccleston & Crombez, 1999; Rhudy, 2001; Villemure & Bushnell, 2002). On the other hand, it was also possible that the pain perception could be heightened, because previous literature has demonstrated that direct eye gaze evokes self-referential processing (Baltazar et al., 2014; Hietanen & Hietanen, 2017) and attention directed towards a painful stimulus heightens pain experience (Crombez et al., 2005). Since direct eye gaze evokes several different psychological processes that can have opposite effects on pain perception, one simple explanation for our result can be that ultimately these competing mechanisms break even, in which case the overall sum effect of direct eye gaze on subjective pain intensity would be zero.

Interestingly, this study did not find a significant lowering effect of another person's presence on pain intensity. As previously presented, numerous studies have shown, that people who experience pain alone report higher pain ratings to those who have another person present in the situation (Brown et al., 2003; Edwards et al., 2017; Kleck et al., 1976; Seidman et al., 1957). How come then our research failed to replicate this phenomenon? A recently published article offers an explanation for our result. In their meta-analysis Che and colleagues (2018) demonstrate that the mere presence of others does not have enough supportive power to lower a person's conscious pain perception. To have a lowering impact on pain perception, the other person needs to give a clear expression of support by e.g. hand-holding or verbal communication. In their article, the previously positive results indicating another person's presence to have a lowering effect on pain perception are explained by to have an evolutionary mechanism: when hurt, one does not want to show weakness and in that way she/he rates subconsciously the pain experience to be lower than it really is. However, in their meta-analysis the presence of a close one showed to have a strengthening effect on other objective outcome measures of pain like painful facial expressions and physiological arousal. This is explained by the other side of the coin; when in pain, some of our autonomic responses are enhanced for the purpose of receiving hoped social responses like comfort from our loved ones, but the actual pain perception is not relieved. This research thus gives evidence, that the mere presence of a stranger does not have enough supportive power to ease pain.

Another possible explanation for us not finding presence of another person alleviating pain ratings could be that we failed to create the feeling of aloneness in the research. In the situation, the researcher told to the participants that she would come and finish the pain induction shortly after the demanded time, so the participants knew that the researcher would be somewhere close by and within hearing range. In the "no experimenter" -group 4 participants (13 %) had evaluated that they did not feel being alone in the situation. Also after the experiment, several participants also told to the experimenter that they knew they were alone in the space, but at the same time, knew that the researcher was behind the partition screen and thus did not fully feel alone. In addition, the research was conducted in a university-lobby and even though the participants wore isolating earphones, the nature of the space possibly failed to create an overall sense of loneliness to begin with.

Interestingly, even though we did not find any differences in affective state between the experimental groups, negative affects across all the participant groups decreased significantly between the two timepoints (i.e. before and after pain induction). Since pain has been shown to elicit usually aversive and unpleasant responses (Cervero, 2012, p. 89), it is intriguing that our study showed the opposite effect. A reasonable explanation for our result is that the participants were anxious for the upcoming pain and were therefore relieved after pain induction. This result however raises further questions concerning our research. Previous literature has shown that expectations towards upcoming pain can affect pain experience by either heightening or lowering perceived pain intensity (Wiech et al., 2008). Anticipation, possible nervous thoughts before pain and possible relief during pain induction might then have had unexpected effect on our results, since this study did not control expectations towards upcoming pain. In experimental pain research, a practice block is often used to set the appropriate magnitude of pain stimulus for every participant (for examples, see Kenntner-Mabiala et al., 2007; Master et al., 2009). This procedure of "baseline nociceptive stimulation block" also simultaneously enables the participant to psychologically adapt to the upcoming pain stimulus. As we did not control these anticipatory psychological factors by using a practice block, the baseline emotional state of our participants might have been more negative than what it is normally, and it could have had an effect on our study's reliability.

4.2 Limitations

A notable challenge of his study lies in the pain induction used. Since we chose to use the fixed weight for every participant, the variance of pain ratings was considerably large. We aimed to produce moderate pain experience, but because of participants' varying sensibility to pain, we needed to determine weight suitable for every participant. As a result, the mean values of pain ratings were lower than expected and some participants did not even report perceiving pain at all. Furthermore, centering the stylus exactly to the center of the finger was challenging for the participants, which might have resulted in varying experiences of pressure. Also the circumference and the amount of fat in one's finger could have had an effect on the sensitivity towards the stimulus, which we did not control in any way. Because the participation was voluntary and included experience of pain, many approached women did not want to participate in this study at all. Because of this, our sample was probably quite homogeneous, since many pain-sensitive or nervous women refused the invitation to take part in the study.

This study was conducted as a between-subject design. Although, no significant differences in pain values between the experimental groups were found, the visual examination of pain ratings showed that the mean pain ratings of the group receiving downward eye gaze were regularly lower compared to the other groups (see Figure 1). With within-subject design the sensitivity of the study would have been stronger. Thus, it would be interesting to find out if this trend would be significant if the study was conducted in within-subject design.

In addition, the measurement of self-awareness and affective state might have had some methodical and time-related problems. This study did not find previously demonstrated effects of direct eye gaze on affective state or self-directed attentive processes (Baltazar et al., 2014; Chen et al., 2017; Conty et al., 2016; Hazem et al., 2017; Hietanen, 2018; Hietanen & Hietanen, 2017; Reddy, 2003). Because the experience of affective state was measured before and after the actual pain induction, and the self-centered attention was measured after the pain induction, the real sense of these processes when in pain was possibly not truly grasped. A slight change in subjective psychological state during the pain experience possibly does not last to another later timepoint. Because of this it would have been more reliable to measure emotions and self-awareness during the pain induction. Since this study was executed outside of laboratory, we wanted to keep the pain measurement as short and simple as possible. This is why we chose to measure other psychological states in a different timepoint and possibly missed the searched phenomenon. Due to this, the measurement of these psychological states during pain induction would be advisable to consider in future research.

4.3 Conclusion and future research

This study did not find evidence of perception of another person's eye gaze or presence having an effect on the experience of pain intensity. It therefore seems that the perception of another person's direct eye gaze does not have enough of social power affecting pain perception compared to other previously described social stimuli. Also the impact of another person's presence on pain perception is still not completely understood.

In the future, a more controlled laboratory setting and the utilization of more accurate measurement methods are recommended. For example, individualization of the pain stimulus, use of within-subject experimental design, and measurement of possible cognitive-emotional processes simultaneously with the pain induction would be advisable to take into consideration.

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6 Appendix

Appendix 1. Sample size, mean age, mean score and standard deviation of the pain scores in different groups

		Gaze down		Direct gaze		No experimenter	
		n = 30		n = 34		n = 30	
Mean age ± SD		23.80 ± 3.69		25.44 ± 5.78		25.73 ± 5.97	
		M	*SD*	*M*	*SD*	*M*	SD
1	1	81.87	42.67	88.47	40.31	90.00	32.87
	2	95.53	43.27	103.91	37.35	102.00	33.62
	3	107.93	41.13	116.32	34.17	115.57	31.28
	4	114.00	40.18	124.15	33.28	122.77	30.04
	5	120.87	39.50	130.91	31.97	130.40	26.11
	mean	104.04	40.11	112.75	33.22	112.15	28.93
2	1	78.80	42.24	91.26	31.62	89.00	33.05
	2	93.10	39.15	109.21	32.61	103.40	32.98
	3	108.50	34.08	122.53	24.52	116.37	31.83
	4	120.57	32.75	127.76	22.22	127.03	32.10
	5	128.00	31.93	132.74	20.99	134.50	32.99
	mean	105.79	34.09	116.70	24.68	114.06	30.86
	Grand mean	104.92	35.49	114.73	25.78	113.10	28.66