Title (& Running Head):

Putting pain out of mind with an 'out of body' illusion

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What does this study add?

Pain intensity in chronic pain patients was reduced by 37% by 'out of body' illusions. These data demonstrate the potential of such illusions for the management of chronic pain.

Abstract

Background

Chronic pain is a growing societal concern that warrants scientific investigation, especially given the ineffectiveness of many treatments. Given evidence that pain experience relies on multisensory integration there is interest in using body ownership illusions for reducing acute pain.

Aim

In the present study we investigate whether patients' experience of chronic pain could be reduced by full body illusions (FBIs) that cause participants to dissociate from their own body.

Methods

Participants with chronic pain **(including sciatica, osteoarthritis, fibromyalgia, muscular pain, IBS, and back pain)** viewed their own 'virtual' bodies via a video camera and head-mounted display for two minutes. In the 'back stroking FBI' their backs were stroked with a stick while they viewed synchronous or asynchronous stroking on the virtual body and in the 'front stroking FBI' they were stroked near their collarbone while viewing the stick approach their field of view in a synchronous or asynchronous fashion. Illusion strength and pain intensity were measured with self-report questionnaires.

Results

We found that full body illusions were experienced by patients with chronic pain and further, that pain intensity was reduced by an average of 37% after illusion (synchronous) conditions.

Conclusion

These findings add support to theories that high-level multisensory body representations can interact with homeostatic regulation and pain perception.

***Key words*:** Chronic pain; multisensory integration; body matrix; ownership illusion; pain intensity

Introduction

Chronic pain – pain that persists for three months or more (Boswell and Cole, 2005; Gureje et al., 1998) - is a complex, multi-perceptual experience (Merskey and Bogduk, 1994; Turk and Okifuji, 2002). Unlike nociceptive (acute) pain, which serves a protective function, chronic pain is considered a disease in itself (Niv and Devor, 2004), and there is growing evidence that it is caused by a central pathology (Wiech, 2000). Long-term pain can overwhelm wellbeing (Brennan et al., 2007; Latham and Davis, 1994; Von Korff et al., 1990), and is surprisingly common: a large scale survey (Breivik et al., 2006) found that 19% of adults reported chronic pain, 50% of whom received inadequate treatment (based on a patient satisfaction measure).

Efforts to improve treatment require an understanding of the pathophysiology of pain, an understanding which is becoming increasingly sophisticated (Pomper et al., 2013; Senkowski et al., 2014). Eisenberger (Eisenberger, 2012) conceptualised pain as composed of a sensory component, coding for stimulus location, quality and intensity, and an affective component, associated with the distressing experience of pain. There is mounting evidence that pain experience relies on multisensory integration: studies have shown that perceived pain intensity can be experimentally manipulated by multisensory signals, e.g., two recent studies (Longo et al., 2009; Wand et al., 2012) showed that body site-specific visual feedback of a painful area reduced pain. Given evidence (Haggard et al., 2013; Longo et al., 2012; Mancini et al., 2011; Moseley, 2008; Preston and Newport, 2011) that the multisensory experience of the bodily self and the conscious experience of pain are closely interlinked, we predicted that alterations in bodily self-consciousness induced by a full body illusion would modify the experience of chronic pain.

Alterations in bodily self-consciousness can arise from neurological causes, e.g. out of body experiences (OBEs) caused by abnormal activity in multisensory brain areas (Devinsky et al., 1989; Irwin, 1985). Experiences similar to OBEs can be induced in healthy participants using virtual reality setups to induce visuo-tactile conflicts (Ehrsson, 2007; Lenggenhager et al., 2007). These so-called ‘full body illusions’ (FBIs) induce a feeling of ownership for a virtual body and the feeling that one’s self is located outside of one’s own body. In the present study we tested whether, when ‘leaving one’s body behind’, one can also, to an extent, ‘leave one’s pain behind’, i.e., can the induction of the FBI reduce the intensity of chronic pain?

A recent study showed that phantom limb pain in two patients was reduced by a FBI in which patients viewed a mannequin’s body from a first person perspective (Schmalzl et al., 2011). Other studies investigated the experience of acute pain, however conflicting results have come from both rubber hand illusion (Hegedüs et al., 2014b; Martini et al., 2014a; Mohan et al., 2012a; Siedlecka et al., 2014b) and FBI studies (Hänsell et al., 2011b; Romano et al., 2014), some showing no effects of the illusions, and others showing reduced pain experience. In the present study, for the first time, the experience of chronic pain during ‘out of body’ illusions was tested to investigate the effect of multisensory illusions on a type of pain that has deeply embedded itself as part of a multisensory integrative process (Schmalzl et al., 2013; Wand et al., 2014). We hypothesised that ratings of chronic pain intensity would be lower during the FBI, when one’s self is experienced outside of one’s body. The present study tested two FBI setups to ascertain whether self-identifying with one’s seen virtual body (Lenggenhager et al., 2007) or feeling dissociated from the virtual body (Ehrsson, 2007) would produce greater analgesic effects.

2. Methods

2.1. Participants

18 participants (six males and twelve females, mean age 44.61 ± SD 12.52) took part in this experiment; this approximates the sample size that has been used in previous FBI studies. All participants had been experiencing chronic pain symptoms for a minimum of 6 months, 8 patients for more than 5 years, and 10 for less than 5 years (mean =77.5 months, ± SD, 76.77). Participants' chronic pain conditions varied, for example, some participants felt localised pain with sciatica (hips and legs) or migraines, whilst other participants experienced pain all over the body in the case of those with fibromyalgia (a rheumatic condition characterised by muscular or musculoskeletal pain); see Table 1 for the full list. Participants were recruited from the university campus via poster advertisements and from the general public via announcements at pain support groups in the local area. Participants were excluded if they had any history of a neurological or psychiatric disorder. Experiments were conducted in accordance with the Declaration of Helsinki and ethical approval from the local university ethics board was obtained. All participants gave written informed consent after the experimental procedure had been described to them. They were told that the they would tested with a body illusion experiment and that they would be required to report their pain intensity at a number of intervals.

-Insert Table 1 around here -

2.2. Materials and Procedure

Two experimental setups were used, based on the first FBI studies published; we will here refer to them as the 'back stroking FBI' (Lenggenhager et al., 2007) and the 'front stroking FBI' (Ehrsson, 2007). The same equipment was used for both. Participants were seated for all conditions (because some participants had difficulties standing for long periods), and were able to view their own back via a head-mounted display (HMD; WRAP 1200 twin high-resolution 852 x 480 LCD displays, Vuzix, Oxford, UK) connected to a video camera (MV800 1/6" 800k pixel, Cannon, Surrey, UK) placed 1.5m behind them. Earphones played white noise for the duration of each stroking condition to mask sounds in the room, and a dark hood was placed over their heads and the HMD to occlude vision of the room. During the stroking periods participants were instructed not to move. A wooden stick (1m long) was used to gently stroke and tap participants' backs in the back stroking (BS) conditions. In both BS and front-stroking conditions the strokes and taps were delivered at a rate of approximately one per second. In the synchronous condition, participants were able to see their back and head and the wooden stick stroking their back in 'real time' via the HMD (see Figure 1a) but the experimenter was located out of view. In the asynchronous condition the back was stroked as before, but instead of viewing a live video feed, the participant viewed a previous recording of the back stroking, so that 'seen stroking' and 'felt stroking' did not match. Both conditions lasted for two minutes. After each condition participants completed the FBI questionnaire (as in [5]); see **Table 2**).

In the front stroking (FS) conditions the wooden end of a small paintbrush was used to tap and stroke their chests just above the collar bone, but the paintbrush was occluded from view by a white cotton sheet. A second wooden stick was moved back and forth near the bottom edge of the video camera lens, at the bottom of the participant's field of view. This setup gave the impression of seeing one's own back from behind while a stick seemed to approach and stroke the apparent location of the 'illusory chest' of their (unseen) 'virtual body' (see Figure 1b). In the synchronous FS condition the felt stroking on the chest and the seen stroking of the illusory chest were synchronous whereas in the asynchronous condition a previous recording of the stick moving near the camera lens was replayed via the video camera and the HMD. Both conditions lasted for two minutes. After each condition participants completed the FBI questionnaire (as in [14]); see **Table 2**).

The McGill Pain Questionnaire (MPQ; (Melzack, 2005)) was used to measure pain intensity. It is subdivided into sections related to sensory, affective-emotional, evaluative and temporal aspects of pain. Each subcategory contains relevant verbs and participants are instructed to rate their current pain on a scale of 0 to 5, 0 corresponding to no pain, and 5 to excruciating pain. The sum of each category is added together, and the total indicates an overall pain rating. The MPQ has been shown to be internally reliable and arguably assesses the physical and sensory component of pain better than any other pain measures (Hänsell et al., 2011b; Kilminster and Mould, 2002).

Procedure

Participants were presented with four conditions in randomised order: (1) front synchronous stroking, (2) front asynchronous stroking, (3) back synchronous stroking, and (4) back asynchronous stroking. Pain intensity was measured by administering the MPQ before and after each of the four conditions, and strength of illusion was measured by the FBI questionnaires after each of the four conditions, as mentioned above, using a within- subjects design.

- ***Insert Figure 1 around here*** –

Data Analysis

To assess illusion strength we first compared the mean value of the ratings for the illusion questions 1-3 with the mean values of the questions that served as controls (4-7 for the back illusion and 4-10 for the front illusion) using a two-tailed, three-way repeated measures analysis of variance (ANOVA) with factors *Synchrony* (synchronous, asynchronous), *Illusion Type* (front, back) and *Question Item* (illusion, control), following methods used in previous related studies (Palluel et al., 2012; Slater et al., 2008). To follow up on the ANOVA we carried out planned comparisons using paired t-tests. Based on previous research (Aspell et al., 2009; Botvinick and Cohen, 1998; Lenggenhager et al., 2007) we predicted higher ratings for the illusion items in the synchronous conditions than in the asynchronous conditions but no difference for the control items. We did not expect ratings to significantly differ between the two illusion types as ratings were of similar magnitude in previous studies (Ehrsson, 2007; Lenggenhager et al., 2007). We used the Bonferroni method to adjust the significance level for multiple comparisons ($p = .0125$).

To assess the whether ratings of pain (the total pain rating index – PRI - assessed by the MPQ) changed after the four illusion conditions we computed the difference in pain change before and after the four conditions. In order to standardise the pain scores between participants (since there were large differences in ratings between some participants), the percentage difference between the pain scores measured before and after each condition was calculated. The 'post-illusion' pain rating was subtracted from the 'before-illusion' rating and the difference was then divided by the 'post-illusion' pain rating value and then multiplied by 100 to get a pain change percentage value. The pain change percentage values were entered into a two-way repeated measures ANOVA with factors *Synchrony* (synchronous, asynchronous) and *Illusion Type* (front, back).

Finally, in order to examine whether the strength of illusion experienced predicted the degree of pain change Pearson's r correlation coefficients were computed between the mean ratings for the illusion questions for the four conditions: BS synchronous, BS asynchronous, FS synchronous and FS asynchronous, and the respective percentage change in pain ratings after these conditions. We used the Bonferroni method to adjust the significance level for multiple comparisons (p= .0125).

3. Results

3.1 Full body illusions – Questionnaire Ratings

The mean scores for the illusion and control questions for the two illusions are shown in figure 2 and the ratings for individual questionnaire items are shown in **Table 2**. The ANOVA showed significant main effects of *Synchrony* (F(1,17) = 21.84, p<.0001) and *Question Item* (F(1,17) = 39.17, p<.0001) and a non-significant effect of *Illusion Type* (F(1,17) = 4.372, p=.052). All interactions were significant: *Synchrony x Illusion Type* (F(1,17) = 8.69, p<.01); *Synchrony x Question Item* (F(1,17) = 46.42, p<.0001); *Illusion Type x Question Item* (F(1,17) = 8.58, p<.01); *Synchrony x Question Item x Illusion Type* (F(1,17) = 21.18, p<.0001). Using planned comparisons, we showed that, for the illusion question items, for the front-stroking illusion, the illusion strength was significantly greater (p<.01, one-tailed) in the synchronous condition (M= 5.43, SE= .33) than in the asynchronous condition (M= 4.59, SE= .35). Illusion strength was also significantly greater (p<.0001, one-tailed) in the synchronous condition (M= 5.48, SE= .22) than in the asynchronous condition (M= 2.78, SE= .34) for the back-stroking illusion. For the control question items no significant differences between synchronous and asynchronous conditions were found, neither for the front nor the back-stroking illusion (all *p*s>.0125, one-tailed).

- ***Insert Figure 2 around here*** –

-Insert Table 2 around here-

3.2 Changes in pain experience

The mean percentage pain change after synchronous and asynchronous stroking for the BS and FS FBIs are shown in figure **3** and data for individual participants are plotted in Figure **4**. The ANOVA showed a significant main effect of *Synchrony* (F(1,17)=6.12, p=.024), with synchronous stoking (M=37.01, SE=7.15) having a greater effect on pain reduction than asynchronous stroking (M=14.59, SE=8.07). The ANOVA also showed a non-significant effect of *Illusion Type* (F(1,17) = .832, p=.375), and there was no significant interaction between factors (F(1,17) = .32, p=.579). One-sample t-tests were conducted to compare the percentage change in pain intensity in the different conditions to no-change (i.e. to zero). These revealed significant differences for synchronous front (p=0.043), asynchronous front (p=0.030) and synchronous back (p=0.034) conditions, but not for the asynchronous back condition (p=0.117).

- ***Insert Figure 3 around here*** –

- ***Insert Figure 4 around here*** –

3.3 Relations between the measures

Pearson's *r* correlation coefficients were computed between the mean ratings for the illusion questions for the four conditions: BS synchronous, BS asynchronous, FS synchronous and FS asynchronous, and the respective percentage change in pain ratings after these conditions. Only one (positive) correlation was found to be significant – that between the strength of the illusion in the BS synchronous condition and the percentage pain change after this condition (*r*=.583; p=.006). All other correlations were non-significant: BS asynchronous condition (*r*=.074; p=.385); FS synchronous (*r*=.36; p=.07) and FS asynchronous (*r*=-.14; p=.29).

Discussion

In the present study we found, as predicted, that ratings of pain by patients with chronic pain is reduced after induction of full body illusions (FBIs). We show that FBIs can be elicited in patients with chronic pain as effectively as with healthy participants, with patients showing higher ratings for illusion questionnaire items than for control items and higher ratings for illusion items in synchronous than in asynchronous conditions. Patients experienced a maximal average pain reduction of 37% in the synchronous (illusion) conditions. The two types of illusions did not show an overall difference in the degree of pain reduction induced, however the degree of pain change only correlated with illusion strength in the synchronous BS condition.

Our findings of pain reduction following a body illusion are compatible with previous findings that the related rubber hand illusion (RHI) has physiological effects - i.e., it leads to a reduction in the temperature of the stroked hand (Moseley et al., 2008) and also an increased reactivity to intradermal histamine (Barnsley et al., 2011) – likely arising from top-down alterations to homeostatic regulation. Consequent predictions that the RHI would also reduce pain experience have been borne out in some studies (Hegedüs et al., 2014a; Martini et al., 2014b; Siedlecka et al., 2014a), but not others (Mohan et al., 2012b). These contradictory results may be due in part to the sizeable methodological differences between studies and also the varied effects of acute pain application on the RHI: the RHI can be induced with painful tactile stimulation (Capelari et al., 2009), but there is also evidence that the illusion is weaker during pain stimulation (Valenzuela-Moguillansky et al., 2011). There are also discrepancies between the two FBI studies which applied acutely painful stimuli (Hänsell et al., 2011a; Romano et al., 2014). Hansel and colleagues (Hänsell et al., 2011a) measured pressure pain thresholds to the finger during the back stroking FBI while stroking was viewed either on a mannequin or a non-body like object. Although they found an increased pain threshold during the mannequin conditions compared to the object conditions, they found no effect of synchrony, thus it could be argued that the pain modulation was not illusion-specific. A more recent paper, (Romano et al., 2014) reported a reduced skin conductance response to painful stimuli during the BS FBI, but experienced pain intensity was unaffected.

Taken together, body ownership illusion studies involving acute pain stimulation in healthy participants offer mixed conclusions, in contrast to the clear effect of FBIs on chronic pain reduction in the current study, but there are reasons to expect that ownership illusions would be more effective for the experience of chronic pain than acute pain. A number of authors have argued that chronic pain is the result of sensorimotor incongruencies (Harris, 1999) and distorted body representations (Bultitude and Rafal, 2010), thus such centrally mediated pain is likely to be more amenable to multisensory illusions – induced via multisensory incongruency - than is acute pain. Indeed, there is evidence that visual feedback can effectively reduce chronic pain: e.g., mirror therapy can be effective for phantom limb pain (Chan et al., 2007), and a multisensory illusion of distorted fingers reduced the pain of osteoarthritis (Preston and Newport, 2011). To our knowledge, the only previous study to explicitly test effects of an ownership illusion on the experience of chronic pain is a recent RHI study (Reinersmann et al., 2013) involving patients with complex regional pain syndrome (CRPS). The illusion was successfully induced in the patients, but no changes in pain intensity were observed. Why should full body illusions be effective in reducing chronic pain when a body-part illusion is not? Full body illusions arguably induce more extensive and holistic changes in self-representation than does the RHI (Blanke, 2012; Blanke and Metzinger, 2009), and are induced via the generation of multisensory spatial conflicts of greater magnitude. Given these considerations, we can expect that FBIs would be more effective than the RHI in reducing chronic pain, but additional studies of the RHI in patients with different types of chronic pain (not only CRPS) will be needed to confirm this.

There are number of possible explanations for the pain reduction observed in the present study, however we note that at present, these are still somewhat speculative. The simplest explanation might be that of a visual analgesic effect caused by viewing the body, as first reported by Longo and colleagues (Longo et al., 2009). Indeed, this is likely to be part of the cause, given that some degree of pain reduction was found in all conditions, regardless of synchrony, and a previous study employing the same back-stroking FBI (Hänsell et al., 2011a) found a non-synchrony specific effect of viewing a mannequin on pain thresholds in healthy participants. Merely seeing the body cannot be the only cause of the pain reduction, however, given that we found a significant synchrony effect, with greater pain reduction after the synchronous conditions, and also a moderate, positive correlation between the magnitude of pain change and illusion strength in the synchronous back-stroking condition.

The degree of pain change was the same for both illusion types – front and back stroking – thus the key feature(s) of the FBI driving the pain reduction must be something common to both illusions that varies with synchrony. In the BS FBI, participants typically experience a stronger self-identification with the seen virtual body, as well as a stronger drift in self-location and referral of touch towards the virtual body in the synchronous condition (Aspell et al., 2009; Lenggenhager et al., 2007). In contrast, in the FS FBI, the synchronous condition induces self-location and referral of touch to the location of the unseen 'illusory body' (at the location of the camera lens) and the experience that the seen virtual body in front is 'someone else' (Ehrsson, 2007). Despite the differences, they have this in common: both illusions induce a degree of disembodiment, i.e., a decrease in the sense that one's self is located in one's own body, thus they are both often referred to as 'out of body' illusions. Furthermore, although the feeling of disownership for one's real body is not usually explicitly measured in the FBI or RHI, it has been argued that the RHI is driven primarily by a sensation of disownership of the stroked hand (Longo et al., 2008) and that this disownership leads to the reductions in body temperature in the RHI (Moseley et al., 2008) and in the FBI (Salomon et al., 2013). Temperature changes do not occur until after around 5 minutes in the RHI (Moseley et al., 2008), even though subjective effects of the illusion are typically apparent from 11 secs (Ehrsson et al., 2004), and in the FBI, temperature differences between the conditions were not observed until after 24 secs of stroking (Salomon et al., 2013).

Could decreases in the feeling of embodiment and ownership for one's own body in the FBI cause the reduction in pain? This would be compatible with reports of decreased pain intensity during neurological OBEs in which a very strong sense of disembodiment is experienced (Bünning and Blanke, 2005; Irwin, 1985). Further research will be needed to understand the mechanism by which the FBIs reduce pain but it may relate to the recent theory of a cortical body matrix (Moseley et al., 2012): a network of brain areas that integrates multisensory signals from and about the body and functions to uphold the homeostatic and psychological integrity of the body. This model is supported not only by findings – including those of the present study - that body illusions cause physiological changes, but also evidence the reverse can occur: the strength of the RHI can be increased by artificially cooling the hand (Kammers et al., 2011). This field of research is still in early stages but a hint as to what may constitute the neural basis of these physiological alterations comes from the finding that temporarily disrupting activity in the posterior parietal cortex (PPC) - an important multisensory area modulated by the FBI (Blanke et al., 2015) - can reduce hand temperature (Gallace et al., 2014). Connections between the PPC and autonomic brain regions such as the insula may mediate the physiological changes induced by these illusions (Calzolari et al., 2015), including the FBI.

In conclusion, the present findings add to a growing body of evidence that physiological changes can be induced by alterations in bodily self-consciousness via ownership illusions such as the FBI, and add support to the theory that high-level multisensory body representations influence homeostatic regulation and pain perception. In addition to their theoretical importance, these findings also have implications for chronic pain symptom management. The reduction in pain experience that the FBIs induced in the present study was significant: the maximal level of pain reduction (in the synchronous conditions) was 37%, which arguably constitutes a clinically useful analgesic effect (Kovacs et al., 2008). The potential usefulness of FBIs for aiding the management of chronic pain conditions will depend, in part, on how long lasting and generalizable these effects are, therefore further research on this topic is clearly warranted.

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Author Contributions

J.P. and J.A. designed the study; J.P. collected the data; J.P. and J.A. analysed the data; J.A. and J.P. wrote the manuscript.

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Figure & Table Legends

Figure 1 – Experiment setup for (A) Back stroking FBI (B) Front stroking FBI. Circle insets show what participant sees via the HMD.

Figure 2 - Mean scores of ratings for illusion and control question items for FS and BS synchronous and asynchronous conditions. Error bars show standard error of the mean.

Figure 3 - Mean percentage pain change for each illusion condition. Error bars show standard error of the mean.

Figure 4 - Percentage pain change for each illusion condition for individual participants (numbered 1-18 on x-axis).

Table 1 – Description of chronic pain conditions of participants

Table 2 - Questionnaire items with mean ratings (mean) and standard deviations (SD) for Back Stroking FBI (top) and Front-stroking FBI (bottom).

Table 1

Chronic Pain condition	*Area affected*
Spinal cord injury	Lower Back and legs
Shoulder condition	Shoulder & upper back
Herniated spinal disk	Lower back and right leg
Spine and hip nerve damage	Lower back and hips
Post-surgical complications	Right upper body
Sciatica	Both hips, legs and feet
IBS, Endometriosis, Muscle issues in neck	Lower left abdominal, neck and shoulders
Fibromyalgia	All over
Migraines	Head
Osteoarthritis	Hips, knees, right hand
Muscular dystrophy	All over
Sciatica	Lower back pain, right leg
Fibromyalgia & Diabetic neuropathy	All over
Osteoarthritis, slipped disks, ulcerative colitis	All over
Osteoarthritis	Knees, hips & both hands
Stomach, neck and back muscle problems	Upper body
Back condition	Upper body
Misaligned pelvis	Hip, knee, back

Table 2

Back Stroking FBI

Questionnaire Items	Mean	SD
Q7. It appeared visually as if the virtual body was drifting (backwards) towards my real body	2.11	1.49
Q6. It seemed as if the touch I was feeling came from somewhere between my own body and the virtual body	2.67	1.81
Q5. It seemed as if I might have more than one body	2.67	2.06
Q4. It felt as if my (real) body was drifting towards the front (towards the virtual body).	2.61	1.91
Q3. I felt as if the virtual body was my body	4.83	2.12
Q2. It seemed as though the touch I felt was caused by the stick touching virtual body.	5.5	1.76
Q1. It seemed as if I were feeling the touch of the stick in the location where I saw the virtual body touched	6.11	1.37

Front Stroking FBI

Questionnaire items	Mean	SD
Q10. The visual image of me started to change appearance so that I became (partly) transparent.	2.05	1.43
Q9. I could no longer feel my body, it was almost as if it had disappeared	2.61	1.75
Q8.I did not feel the touch on my body but at some distance in front of me	2.56	1.76
Q7. I felt as if my head and body were at different locations, almost as if I had been 'decapitated'	2.5	1.89
Q6. I experienced a movement-sensation that I was floating from my real body to the location of the camera	2.72	1.96
Q5. I experienced that my (felt) body was located at two locations at the same time	3.67	2.3
Q4. I felt that I had two bodies.	3.44	2.09
Q3. I experienced that the hand I was seeing approaching the camera was directly touching my chest (with the rod)	6.28	1.23
Q2. I felt as if my head and my eyes were located in the same place as the camera, and my body just below the camera	4.78	2.1
Q1. I experienced that I was located at some distance behind the visual image of myself, almost as if I was looking at someone else.	5.22	2.13

Fig 1.

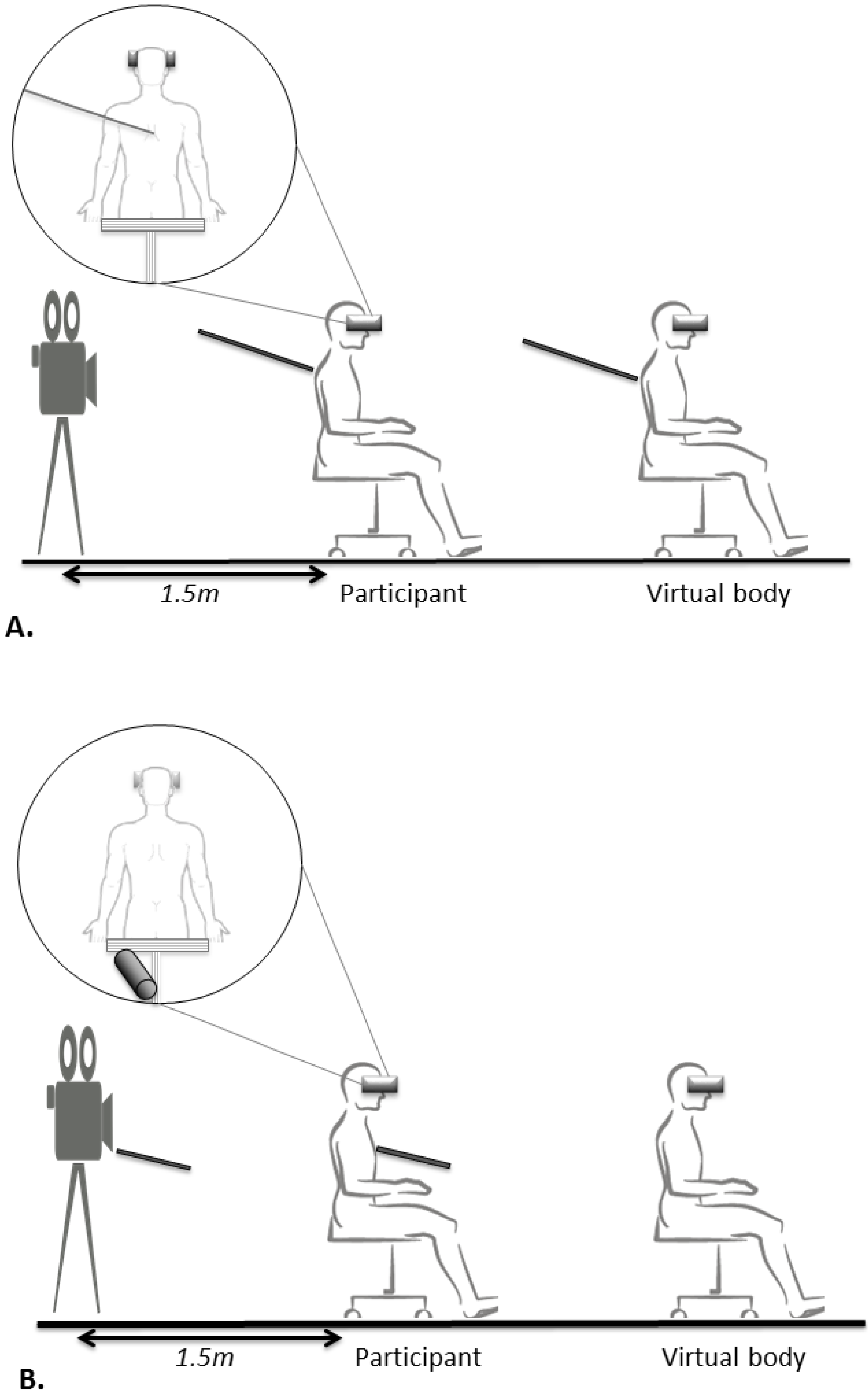

1.5m
Participant
Virtual body
A.
1.5m
Participant
Virtual body
B.

Fig. 2

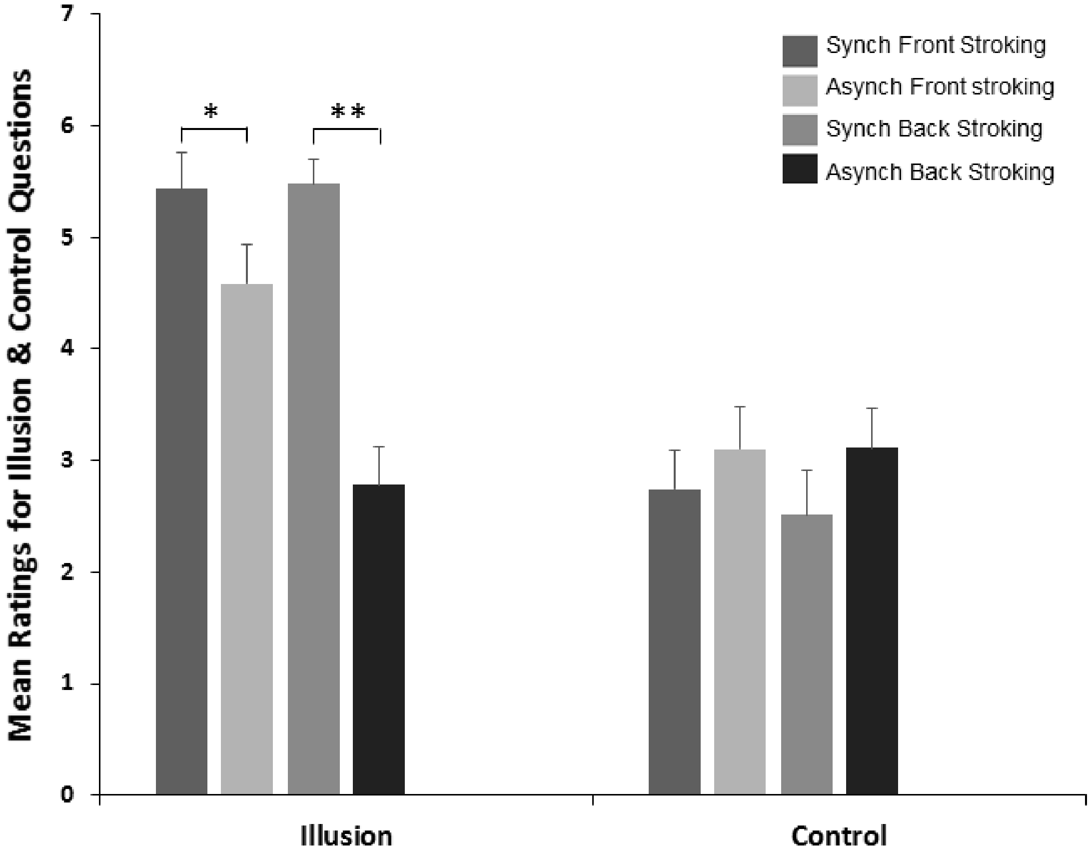

Mean Ratings for Illusion & Control Questions
7
6
5
4
3
2
1
0
*
**
Synch Front Stroking
Asynch Front stroking
Synch Back Stroking
Asynch Back Stroking
Illusion
Control

Fig. 3

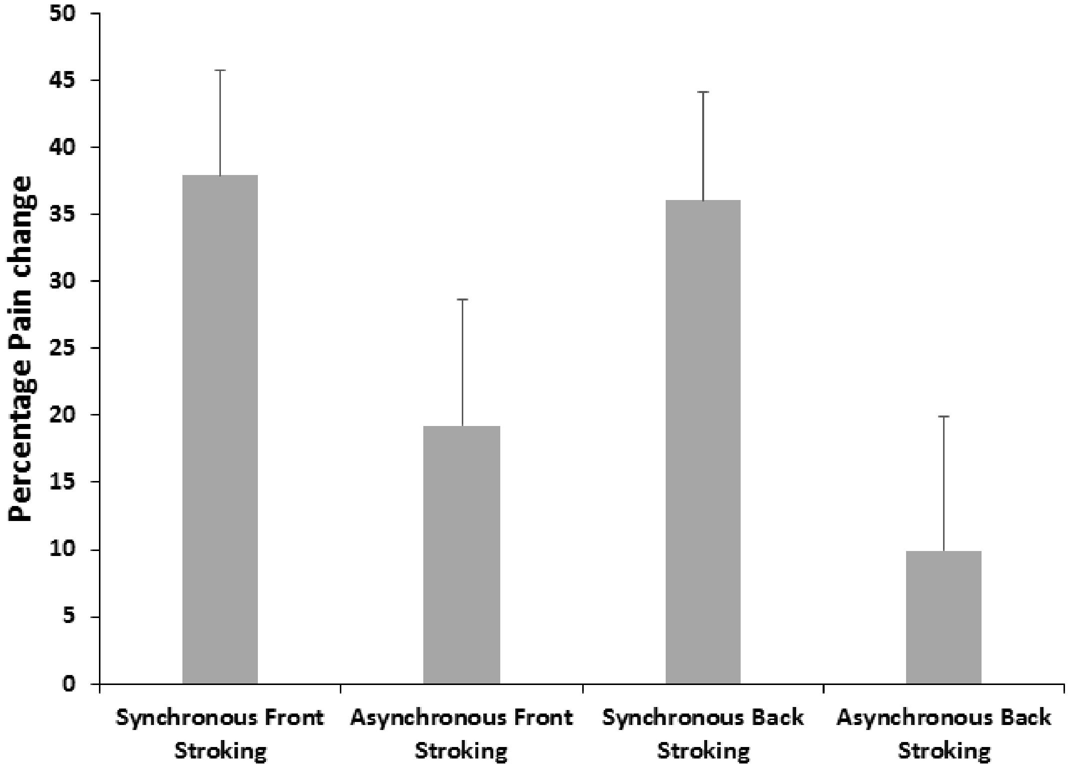
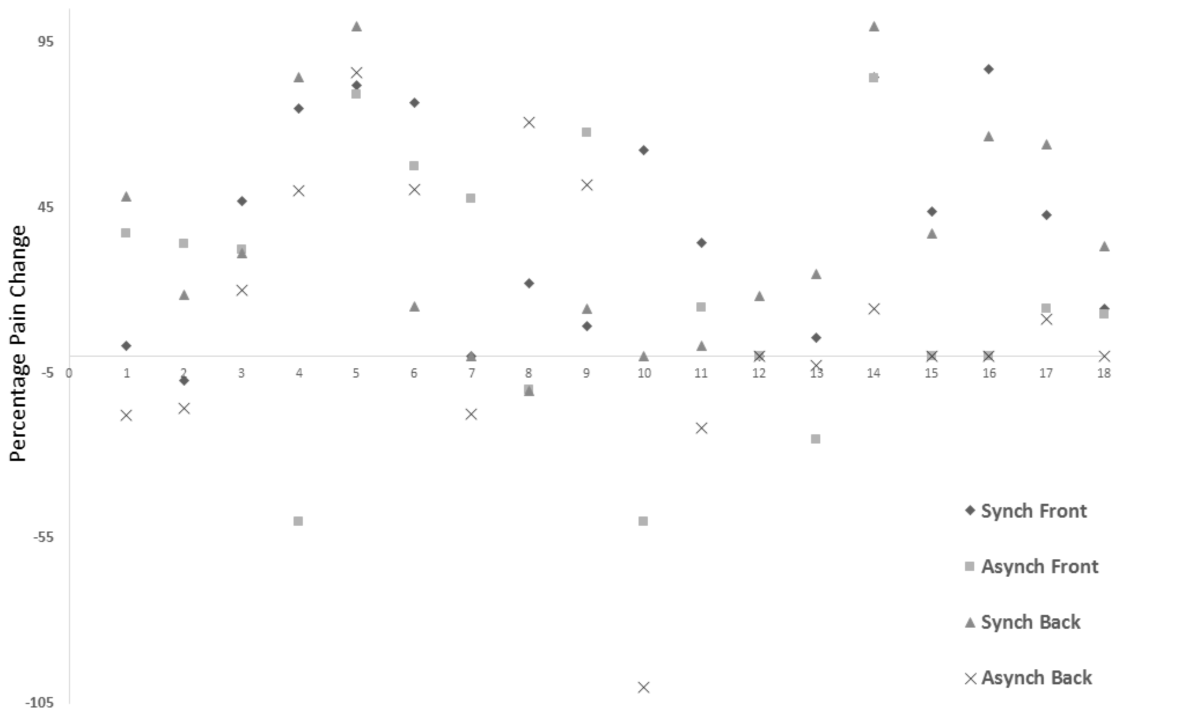

Percentage Pain change
50
45
40
35
30
25
20
15
10
5
0
Synchronous Front Stroking
Asynchronous Front Stroking
Synchronous Back Stroking
Asynchronous Back Stroking

Fig. 4


95
45
-5
-55
-105
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
Percentage Pain Change
Synch Front
Asynch Front
Synch Back
Asynch Back