Title

An investigation of the effects of different pulse patterns of transcutaneous electrical nerve stimulation (TENS) on perceptual embodiment of a rubber hand in healthy human participants with intact limbs

Running Title

TENS pulse patterns and perceptual embodiment

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Authorship statement

All authors contributed to the conception, design, analysis and interpretation of data, drafting of the manuscript and final approval of version before submission. Dr M.R. Mulvey completed acquisition of data.

Conflicts of interest

All authors confirm no conflicts of interest

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Abstract

Objectives The aim of this study was to investigate the strength of perceptual embodiment achieved during a adapted version of the rubber hand illusion(RHI) in response to a series of modified TENS pulse patterns with dynamic temporal and spatial characteristics which are more akin to the mechanical brush stroke in the original RHI.

Materials and Method A repeated-measures counter balanced experimental study was conducted where each participant was exposed to four TENS interventions: Continuous pattern TENS; Burst pattern TENS (fixed frequency of 2 bursts per second of 100 pulses per second); Amplitude modulated pattern TENS (intensity increasing from zero to a pre-set level then back to zero again in a cyclical fashion); and Sham (no current) TENS. Participants rated the intensity of the RHI using a three item numerical rating scale (each item was ranked from 0-10). Friedman's analysis of ranks (one-factor repeated measure) were used to test the differences in perceptual embodiment between TENS interventions; alpha was set at $p \leq 0.05$.

Results There were statistically significant differences in the intensity of misattribution and perceptual embodiment between sham and active TENS interventions but no significant differences between the three active TENS interventions (amplitude-modulated TENS, burst TENS and continuous TENS). Amplitude-modulated and burst TENS produced significantly higher intensity scores for misattribution sensation and perceptual embodiment compared with sham (no current) TENS, whereas continuous TENS did not.

Discussion The findings provide tentative, but not definitive, evidence that TENS parameters with dynamic spatial and temporal characteristics may produce more intense misattribution sensations and intense perceptual embodiment than parameters with static characteristics (e.g. continuous pulse patterns).

INTRODUCTION

Perceptual embodiment of a prosthetic limb into the pre-existing body schema is a phenomenon whereby the prosthetic limb feels like it is part of the rest of the body [1]. Enhancing perceptual embodiment of a prosthetic limb aids its manual control [2-5] and can be facilitated by somatosensory feedback using simple inexpensive electro-tactile or vibro-tactile techniques [6-8]. In the laboratory setting, a simple visual-tactile illusion has been used to investigate perpetual embodiment of an artificial (rubber) hand. During this "rubber hand illusion", an individual observes a rubber hand being brushed (in view) whilst their real hand is also brushed synchronously but is out of view. Within a short space of time the individual starts to experience the brush sensation arising from the rubber hand which is perceived as their own hand (i.e. perceptually embodied), although it has been estimated that 25% of individuals may not respond [9-13]. Effects are measured using self-report of subjective perceptions including somatosensory experience, agency, proprioceptive drift, ownership and various physiological outcomes including temperature and electrodermal activity[13].

Previously, we hypothesised that perceptual embodiment of a rubber hand may be facilitated using transcutaneous electrical nerve stimulation (TENS), a technique that delivers pulsed electrical currents across the intact surface of the skin to stimulate the underlying nerves [14]. In experiments using a modified version of the rubber hand illusion we found that sensations generated during TENS could be made to feel as if they arose from a rubber hand in participants with intact limbs, producing a strong sense of perceptual embodiment and agency [15]. However, the intensity of perceptual embodiment achieved during TENS was weaker than that achieved by stroking the hand with a brush [16]. Priming the hand with brush strokes prior to TENS improved the intensity of perceptual embodiment during TENS [16]. We speculated that differences in the temporal and spatial characteristics of the dynamic brush strokes versus the static TENS pulses accounted for the differences in intensity of perceptual embodiment. We suggested that perceptual embodiment of a

prosthetic hand during TENS could be enhanced by delivering TENS using patterns of electrical pulses that are more akin to the temporal and spatial characteristics of brush strokes.

In our previous studies, TENS was administered using electrical characteristics consistent with conventional TENS: continuous pulse pattern, pulse frequency 120Hz, pulse duration 80μs. These electrical characteristics result in a 'monotonous' stimulus producing TENS sensations without intermittent 'silent' periods (i.e. static temporal characteristics) and that remain in same body part (i.e. static spatial characteristics). In contrast, sensations generated during brush strokes were punctuated with short 'silent' periods of no stroking (i.e. dynamic temporal characteristics) and were felt to move across the surface of the hand and fingers (i.e. dynamic spatial characteristics). We hypothesised that a modulated TENS pulse pattern that produced TENS sensations punctuated with silent periods of no TENS (i.e. dynamic temporal characteristics) that feel like they move across the surface of the hand (i.e. dynamic spatial characteristics) would result in more intense perceptual embodiment than conventional TENS using constant pulse patterns.

The effect of manipulating the electrical characteristics of TENS on TENS sensation is well documented, with pulse pattern and pulse frequency being critical variables [17-20]. It is possible to mimic the temporal characteristics of brush strokes using short bursts of high frequency currents punctuated with 'silent' periods of no TENS (i.e. burst pulse patterns) [21]. Amplitude modulated pulse patterns of TENS deliver currents that increase in amplitude to a pre-set maximum (of say 30mA) and then return to zero in a cyclic fashion. Amplitude modulated pulse patterns create TENS sensations that feel like they move across the surface of the skin in waves, mimicking to a certain extent the spatial and temporal characteristics of brush stroke.

The aim of this sham-controlled study was to investigate the strength of perceptual embodiment of a rubber hand in response to burst, amplitude-modulated and continuous TENS in able-bodied

participants. Sham (no current) TENS was included to control for the participant expectation and response bias.

METHODS

Design

The experimental design was a repeated-measures counter-balanced study where each participant was exposed to four TENS interventions and the intensity of the perceptual embodiment of a rubber hand measured. Experimental trials were conducted in a laboratory at the Centre for Pain Research, Leeds Beckett University and the Faculty of Health, Research Ethics Sub-Committee at Leeds Beckett University approved the study. All participants provided written consent and were aware that they could withdraw from the study at any time without giving a reason.

Recruitment and selection of participants

University staff and students were recruited through advertisements and given a study information pack and a verbal briefing. These materials explained that they would be required to attend our laboratory for a single visit lasting no more than 2 hours to take part in an experiment where they would be exposed to different types of TENS, including the possibility of inactive TENS. Inclusion criteria were; at least 18 years of age, no pre-existing medical conditions, and no previous use of TENS. Exclusion criteria were; contraindications to TENS including cardiac pacemakers, pregnancy, epilepsy and a fear of electrical stimulation, in line with current professional standards [22]. Twenty-four participants (7 male, 17 female; mean (SD) age 30 (9.5) years) met the eligibility criteria and completed the experiment.

Procedure

The principal investigator (MM) facilitated all experimental sessions with participants sitting at a table. Before the start of the experiment, optimal electrode locations to project TENS sensation into the fingers of the participant was determined. Field-testing in our laboratory suggested that amplitude-modulated TENS could be made to generate TENS sensations that were perceived to move distally from wrist to finger tips, in time with the rise in current amplitude. To achieve this one electrode was

positioned on the skin of the lateral aspect of the right forearm 1cm proximal to the wrist and the other electrode 2.5cm proximally to the first electrode. Thus, self-adhering electrodes (square 5x5cm, Palls Neurostimulation Electrodes, Physio Med UK) were applied at this position in the first instance. A standard TENS device (Pro-TENS device, Nidd Valley, UK) was used to administer TENS using the following electrical characteristics: pulse frequency = 100Hz; pulse duration = 80μs; asymmetric biphasic waveform; pulse pattern = dependent on intervention. Pulse pattern was set at continuous and participants were instructed to increase the intensity of TENS until a strong non-painful TENS sensation (electrical paraesthesiae) was felt beneath the electrodes or in the fingers of the hand. Small adjustments to the electrode placement were made to ensure that a strong non-painful TENS paraesthesiae was projected into the thumb and index finger of the participant's right hand.

Once optimal electrode placement had been determined, the TENS device was switched off, disconnected, and set aside until the appropriate time point in the experiment. TENS electrodes were left in situ. Participants were told that during the experiment they would be asked to increase the amplitude of TENS until they felt a strong non-painful electrical paraesthesia in their thumb and index finger or when the amplitude dial on the TENS device read "six" (i.e. sham (no current) TENS), whichever came first. It was explained to participants that they may not be able to feel TENS sensations before reaching dial number six in some interventions and not to be unduly concerned about this. In addition, it was explained that the intensity of TENS may fluctuate and that they should set the highest intensity of TENS to produce the strong non-painful sensation at the peak of the fluctuation. This pre-experimental procedure took no more than 10 minutes.

At this point the experiment began and time taken as zero. There were five measurement cycles: baseline (pre-TENS) followed by four TENS interventions (Figure 1). There was a 10 minute rest (washout period) between each measurement cycle. The four TENS interventions were:

- Continuous pattern TENS

- Burst pattern TENS (fixed frequency of 2 bursts per second of 100 pulses per second)

- Amplitude-modulated pattern TENS (intensity increasing from zero to a pre-set level then back to zero again in a cyclical fashion)

- Sham (no current) TENS

Each participant was exposed to each TENS intervention once. The order of four TENS interventions was counter balanced across participants using a Latin Square design with participants.

[Insert Figure 1 here]

During each measurement cycle, participants were asked to place their right hand inside a canvas box and a rubber hand was placed parallel to the canvas box (Figure 2). A towel was placed over their shoulder to cover the wrist of the rubber hand and obscure the participant's right upper arm. Participants positioned themselves so that the rubber hand was visually congruent to the perceived position of their right hand in the box. No TENS electrodes were applied to the rubber hand. Participants were asked to try to keep movement of their right hand and arm to a minimum whilst it was placed in the canvas box.

[Insert Figure 2 here]

Each measurement cycle lasted two minutes, during which participants rated the intensity of various aspects of the subjective experience of perceptual embodiment. During the pre-TENS measurement cycle, participants observed the rubber hand for two minutes. During each of the four TENS intervention measurement cycles participants were asked to: *".... turn on the TENS device in front of you and increase the intensity until you can feel a strong but comfortable tingling sensation in your thumb and index finger or the intensity dial reads six, whichever comes first. Please do not discuss sensations experienced during TENS with the investigator, unless you wish to stop the experiment."* Once participants confirmed that they had followed the instructions, they were asked to observe the

rubber hand for two minutes, after which they were asked to rate the intensity of the illusion. Each measurement was followed by a ten-minute rest period (washout) where participants removed their right arm from the canvas box.

Blinding participants to the sensation of TENS was impossible because each pulse pattern produced a different sensation, although attempts were made to reduce expectation bias. The electrical characteristics of four TENS devices were pre-set before the start of the experiment by a technician who was not part of the investigating team and this was concealed from the participant and the principal investigator. Each device was marked A, B, C, or D and lights on the TENS device covered so that there was no indication of the pattern of stimulation, although the power on light remained visible to give the impression that the TENS device was delivering current. The names of pulse patterns were concealed from participants and participants were discouraged from revealing sensations experienced during TENS to the investigator. Participants were informed in pre-experimental information that some commercially available TENS devices do not produce sensations and that they may receive a no current TENS intervention. Blinding was removed after all data had been analysed.

Outcome measures

Participants rated the intensity of perceptual embodiment of the rubber hand at end of each measurement cycle using the three item embodiment scale adapted from Mussap and Salton [23] which asks:

- How strongly do you feel that the rubber hand is your hand?
- How strongly do you feel that the rubber hand is in some way part of, or connected to, your body?
- How strongly do you feel that if you moved your right hand, the rubber hand would move?

Each item was scored on an 11 point numerical rating scale (NRS) anchored 0 = 'not at all strong' and 10 = 'strongest sensation imaginable'. The embodiment scale score was calculated as the mean of the three items, and was used as the primary outcome measure of response.

In addition to the embodiment scale, participants were also asked to report the degree to which they experienced TENS sensation arising from the rubber hand. This was captured by asking the question "How strongly can you feel the tingling from the TENS device coming from the rubber hand?" which was rated on an 11 point NRS anchored 0 = 'not at all strong' and 10 = 'strongest sensation imaginable'. During the rubber hand illusion, misattributing a tactile sensation to the rubber hand is a separate feeling to that of ownership of the rubber hand [23]; however, tactile misattribution can only occur once the prostheses has been successfully assimilated into one's own internal body schema [24].

Data analysis

The analysis protocol was designed to compare the effect of TENS pulse patterns on re (i) the intensity of perceptual embodiment, and (ii) the intensity to which participants misattributed TENS sensation to the rubber hand. A sample size of 22 was estimated using data obtained from our previous study [16] and based on a repeated measures design with a comparison of multiple within-subject means over time [25]. This would provide 95% confidence intervals of ± 5% for detecting a 1-unit difference on the perceptual embodiment scale assuming 90% precision estimate. To ensure equal distribution across the counterbalanced design, 24 participants were recruited and enrolled in the study.

The embodiment scale demonstrated adequate reliable internal consistency, as determined by the Cronbach's alpha which ranged from 0.90 – 0.99 for each of the five measurement cycles. Thus, the mean of the three items was calculated per participant to give a perceptual embodiment scale score. A participant was considered to have experienced the illusion if a scale score of ≥1 was obtained for each condition. It was intended that if data were normally distributed, a one way repeated measures

analysis of variance (ANOVA), with post-test comparisons using t-tests, would be conducted. If data were non-normally distributed, a one way Friedman's ANOVA with Wilcoxon Signed Rank post-test comparisons would be conducted. Bonferroni corrections for multiple tests were applied resulting in alpha level adjusted to 0.005 for the embodiment scale score data and to 0.008 for the TENS misattribution item.

RESULTS

The data were not normally distributed and square root and logarithm transformations did not render a normal distribution of the data. Therefore non-parametric Friedman's ANOVA, with Wilcoxon Signed Rank post-test comparisons were performed to compare the intensity of perceptual embodiment and the intensity of TENS misattribution.

Embodiment scale score

There was a statistically significant difference in the intensity of perceptual embodiment across the five experimental cycles (χ2=72.9, p<0.0001, Table 1). Post-test comparisons revealed that embodiment scores were higher than pre-TENS condition for amplitude modulated TENS (z=3.2, p<0.005) and continuous TENS (z=3.1, p<0.005) (Table 2). Embodiment scores were higher than sham TENS for amplitude modulated TENS (=3.8, p<0.005), burst TENS (z=3.4, p<0.005) and continuous TENS (z=3.3, p<0.005, Table 2). There were no statistically significant differences in embodiment scores between the three active TENS interventions (amplitude modulated TENS, burst TENS and continuous TENS); however there was a non-significant trend towards higher embodiment scores during amplitude modulated TENS (Table 1).

[Insert Table 1 and Table 2 here]

TENS sensation misattributed to the rubber hand

There were statistically significant differences in the intensity of TENS sensation misattributed to the rubber hand across the five experimental cycles (χ2=65.5, p<0.0001, Table 1). Post-test comparisons revealed that there were higher intensities of TENS misattribution during amplitude modulated TENS (z=3.3, p<0.008) and burst TENS (z=-2.7, p<0.008) when compared with sham TENS (Table 2). There were no significant differences in the intensity of TENS misattribution between continuous TENS and sham TENS, or between any of the three active TENS interventions (amplitude modulated TENS, burst

TENS and continuous TENS) at the adjusted α level (Table 2). Interestingly, 5 of 24 participants anecdotally reported experiencing a 'mild' TENS paraesthesia arising from the rubber hand during sham (no current) TENS.

DISCUSSION

The finding that active TENS enhances perceptual embodiment a rubber hand and that TENS sensation can be misattributed to a rubber hand are consistent with our previous findings [15, 16]. The magnitude of perceptual embodiment and TENS sensation misattribution achieved during the continuous TENS intervention were similar to that seen in these previous studies [15, 16].

In the present study, the failure to detect statistically significant differences between the three active TENS interventions suggests that the electrical pulse pattern of TENS does not influence the intensity of TENS misattribution sensation or perceptual embodiment. Nonetheless, amplitude-modulated and burst TENS produced significantly higher intensity scores for misattribution sensation and perceptual embodiment as compared with sham (no current) TENS. This finding provides tentative, but not definitive, evidence that TENS parameters with dynamic spatial and temporal characteristics are more likely to produce more intense misattribution sensations and intense perceptual embodiment than parameters with static characteristics (e.g. continuous pulse patterns).

The importance of vision in driving the experience of body ownership is well documented [1, 26-29]. Previously we reported that just viewing a rubber hand placed congruently to an individual's real hand (without any mechanical stimulation of either the real or rubber hands) was sufficient to induce a mild sense of prosthesis embodiment; although significantly stronger embodiment scores were achieved when synchronous visual and tactile stimuli were simultaneously integrated [16]. In the present study, participants experienced TENS misattribution sensation and perceptual embodiment in the absence of congruent visual stimuli on the rubber hand; scores for these measures were lower than when participants observe congruent visual-tactile stimuli [15, 16]. This suggests that multi-sensory integration of congruent visual and tactile somatosensory stimuli produces the strongest priming effect for perceptual embodiment [11, 15, 16, 24, 29-31]. In future studies we aim to add a congruent

visual component related to TENS sensation on the rubber hand to determine whether this would increase the intensity of perceptual embodiment and misattribution sensation.

In 2009 we proposed that TENS may be used as a novel tool to aid perceptual embodiment of a prostheses into the body schema of individuals with limb amputations via a neurocognitive model of embodiment [14]. We hypothesised that TENS could facilitate perceptual embodiment by referring a somatosensation to a visually congruent corporeal object, in this case misattribution of TENS sensation into a rubber hand, which then gives rise to the subjective experience of body ownership (perceptual embodiment). The lack of visual stimuli congruent with the sensation of TENS may be a limitation in the use of TENS for this purpose. In clinical practice, it may be necessary to cultivate the initial sense of perceptual embodiment in the first instance to facilitate multi-sensory integration of congruent visual and somatosensory stimuli. This could be achieved by careful positioning of TENS electrodes so that TENS sensation projects into the amputee's prosthesis [32] and administering TENS using electrical characteristics that produce a spatiotemporally dynamic sensation (e.g. amplitude modulated pattern). The practitioner could stroke the rubber hand with a hand held electrical device to provide the amputee with a visual stimulus that looks like it was delivering TENS at the same location and in time with TENS sensation. The ability of the practitioner to match TENS sensation experienced by the amputee with the stroking action may prove challenging so it may be necessary for the amputee to perform the stroking action themselves.

In the present study, the finding that five participants receiving sham (no current) TENS reported misattributing TENS sensations to the rubber hand requires explanation. Four of these five participants received an active TENS condition prior to the sham TENS condition and were therefore aware that TENS may generate sensations. This may have led to intentional reporting of sensations that were not being experienced (i.e. expectation bias). Participant blinding is inherently problematic in studies on TENS because participants experience a somatosensation during active TENS but not

during sham (no current) TENS. It is also plausible that some of our participants experienced a phantom sensation during sham TENS, perhaps from a carryover and/or learning effect. Lewis and colleagues [29] recently reported inducing phantom-like sensations in non-amputees using a modified version of the rubber hand illusion. Furthermore, Armel and Ramachandran [30] reported that participants who had perceptually embodied a rubber hand experienced odd sensations including tingling, numbness, pain and kinaesthetic sensations. As yet, unpublished data from our laboratory found that approximately 50% of participants reported phantom sensations, mostly 'tingling' at the site of the stimulus, when a perceptually embodied rubber hand was threatened with a needle stick injury. Armel and Ramachandran [30] suggested that such sensations arise when the brain integrates contradictory sensory information.

The failure to detect a statistical difference between the three active TENS interventions may be a lack of statistical power. The sample size calculation for this study was based on the difference between a TENS and a no TENS condition from our previous work [16] because there was no published data on the difference in perceptual embodiment of a prosthesis between two active TENS interventions to inform the calculation. Furthermore, it is arguable that the counter-balanced design did not adequately control for an order effect. Counter-balanced designs are commonly employed in studies that use the rubber hand illusion but are vulnerable, to some extent, to the effects of order [9, 24, 33-36]. The counter-balance design controls in part for bias associated with the order of the measurement cycles but nevertheless an associated standardised counter balanced order effect remains present [37]. Our inclusion of a suitable washout period between measurement cycles should have reduced the likelihood of carry-over effects from one condition to the next providing confidence in our findings.

The study design did not include a control condition where perceptual embodiment and misattribution would not be expected to occur using an incongruent stroking pattern achieved by asynchronous

stroking of the rubber and real hand. In addition, there was no question to control for the possibility that judgements were based on the pleasantness and/or novelty of the TENS pattern biasing higher scores of perceptual embodiment. Thus, follow-up studies should include physiological correlates of perceptual embodiment such as local skin cooling [38, 39], proprioceptive drift [24], galvanic skin response [40, 41], local histamine reactivity [42] and neural activity in the brain [43].

The present study has suggested that TENS had the potential to aid prosthesis embodiment regardless of the stimulation parameters, indicating an inherent flexibility for treatment profiles. The study also demonstrates the potential of using the rubber hand illusion in pre-clinical studies to inform the design of possible "future prosthetic devices" [44, 45]. It is now necessary to develop this knowledge within a clinical context to identify the optimal stimulation parameters of TENS as well as developing a protocol to identify the optimal electrode placement sites so that TENS may be administered effectively to treat both phantom limb pain and stump pain, and to aid prosthesis embodiment. Furthermore, there is emerging evidence that tactile sensation can be conveyed to a rubber hand to enhance feelings of embodiment and ownership by simple but precisely targeted stimulation of stump nerves [46] [47]. There is now a rationale to investigate the effects of TENS on prosthesis embodiment within an amputee based study.

Conclusion

This study provides tentative evidence that dynamic spatial and temporal electrical characteristics of TENS (e.g. amplitude-modulated and burst) may produce stronger misattribution sensations and perceptual embodiment of a rubber hand. The study provides further evidence that may be useful to aid perceptual embodiment of prostheses into the body schema of individuals with amputations and should catalyse investigations to determine clinical utility.

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Table 1.

Summary of scale scores for each of the five measurement cycles. Data are presented as median (IQR)

Variable	Pre_TENS	Sham TENS	Con TENS	Burst TENS	Amp TENS	Friedman value	P value **
		Experimental condition					
Embodiment Score	1.7 (0.8-4.7)	1.7 (0.7-3.2)	3.0 (1.7-7.8)	3.3 1.7-6.3)	5.2 (0.7-8.5)	72.9	<0.0001
TENS miss-attribution score*		2 (1.0-3.5)	2.5 (1.0-9.0)	4.0 (1.5-7.0)	5.5 (1.5-8.5)	65.5	<0.0001

* TENS missattribution score recorded for the four TENS interventions only

** p values derived from Friedmans ANOVA .

Con TENS = continuous TENS; Amp TENS = Amplitude-modulated TENS

Table 2.

Summary of post-hoc analyses to determine the difference in embodiment scores between the five

measurement cycles.

Post-hoc comparison	Z value	P value
Embodiment scale scores		
Pre TENS *vs* Sham TENS	-1.4	0.15
Pre TENS *vs* Amp TENS	3.2	0.0012*
Pre TENS *vs* Burst TENS	1.9	0.063
Pre TENS *vs* Con TENS	3.1	0.0023*
Sham TENS *vs* Amp TENS	3.8	0.0001*
Sham TENS *vs* Burst TENS	3.4	0.0008*
Sham TENS *vs* Con TENS	3.3	0.001*
Amp TENS *vs* Burst TENS	-2.5	0.01
Amp TENS *vs* Con TENS	-1.4	0.14
Burst TENS *vs* Con TENS	1.5	0.13
TENS misattribution scores		
Sham TENS *vs* Amp TENS	3.3	0.0009**
Sham TENS *vs* Burst TENS	2.7	0.0072**
Sham TENS *vs* Con TENS	2.3	0.02

Amp TENS *vs* Burst TENS	-1.2	0.216
Amp TENS *vs* Con TENS	-1.4	0.152
Burst TENS *vs* Con TENS	0.82	0.41

* significant at adjusted α-level of 0.005

** significant at adjusted α-level of 0.008

Con TENS = continuous TENS; Amp TENS = Amplitude-modulated TENS

Notes:

1. Significantly higher embodiment score during Amplitude-modulated TENS (Amp-mod) and Continuous TENS compared to Pre-TENS.

2. No significant differences between Pre-TENS and Sham TENS, or Pre-TENS and Burst TENS

3. Significantly higher embodiment scores during Amplitude-modulated, Burst TENS, Continuous TENS compared to Sham-TENS.
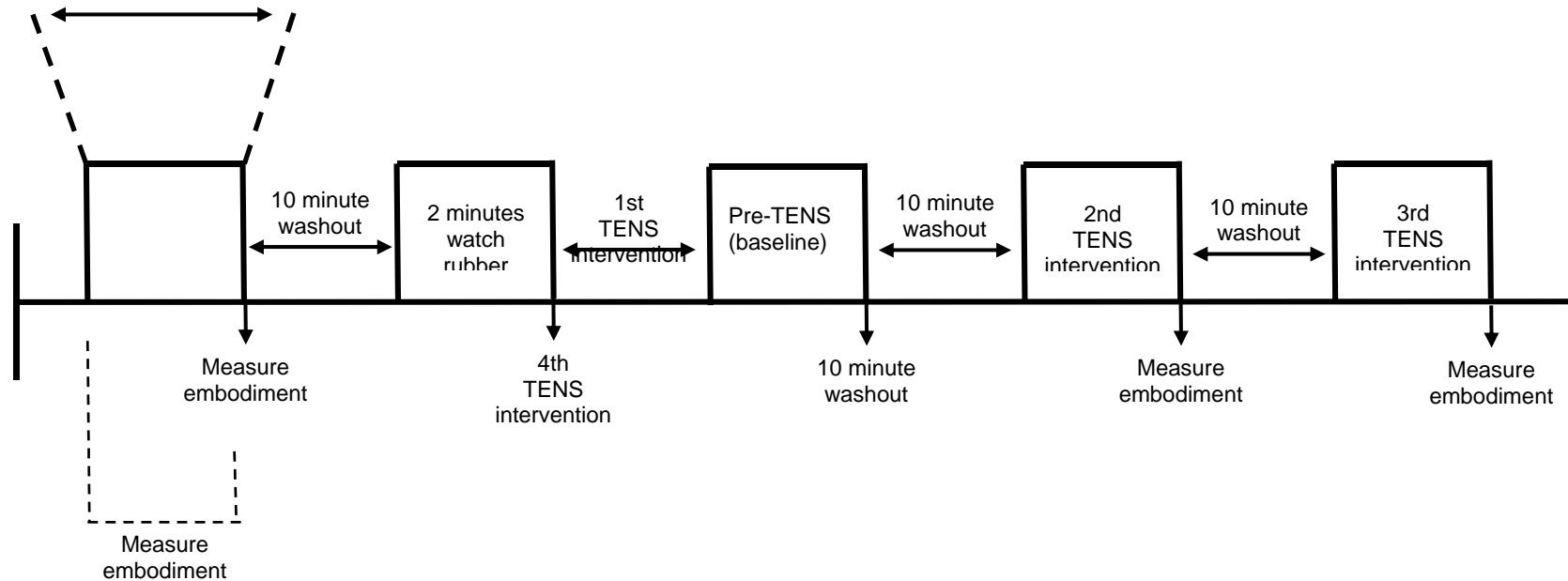
Figure 1

Figure 2 Experimental procedure
Each participant was the first measurement cycle was a "pre-TENS" measurement cycle. The order of four TENS intervention measurement cycles was counter balanced across participants using a Latin Square design. Each participant was exposed to each TENS intervention once as follows: A,B,C,D for participants 1, 5, 9, 13, 17, 21; B,C,D,A for participants 2, 6, 10, 14, 18, 22; C,D,A,B for participants 3, 7, 11, 15, 19, 23; and D,A,B,C for participants 4, 8, 12, 16, 20, 24. A = Amplitude modulated pattern TENS; B = Sham (no current) TENS; C = Burst pattern TENS and D = Continuous pattern TENS.

Figure 2

Figure 2.

Experimental set-up. The same experimental set up was used to take ratings of the intensity of various aspects of perceptual embodiment at baseline (pre-TENS) and for the four TENS interventions. The white towel was use to obscure the participant's view of their right hand (which was placed in the blue canvas box).