Touchy feely: the influence of affect on somatosensory potentials

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Introduction

Interpersonal touch affects attention, memory, emotion and decision making. Early research concentrated on the Midas Touch, the psychological effect describing that people are more likely to show conformity or generosity after being touched. Recent psychophysiological work investigated the mechanisms underpinning this effect, showing touch to enhance affective processing [1, 2]. Our previous study additionally pointed to an intriguing *inverse* effect. Perceiving a generous offer in an economic decision making game amplified late (> 200 ms) components evoked by subsequent vibrotactile stimuli (somatosensory potential, SEP). Another study showed that positive emotional stimuli can also attenuate SEPs, particularly at extremely early (ca. 50 ms) latencies [3]. Thus, not only does touch change emotion perception, but emotion changes touch perception as well.

We investigated SEPs as a function of emotion and touch. A sense of emotional significance was added by using a virtual environment involving social touch from a virtual agent (avatar). Rather than focusing only on emotional valence or a single tactile display, we presented five emotions and investigated four types of touch.

Methods

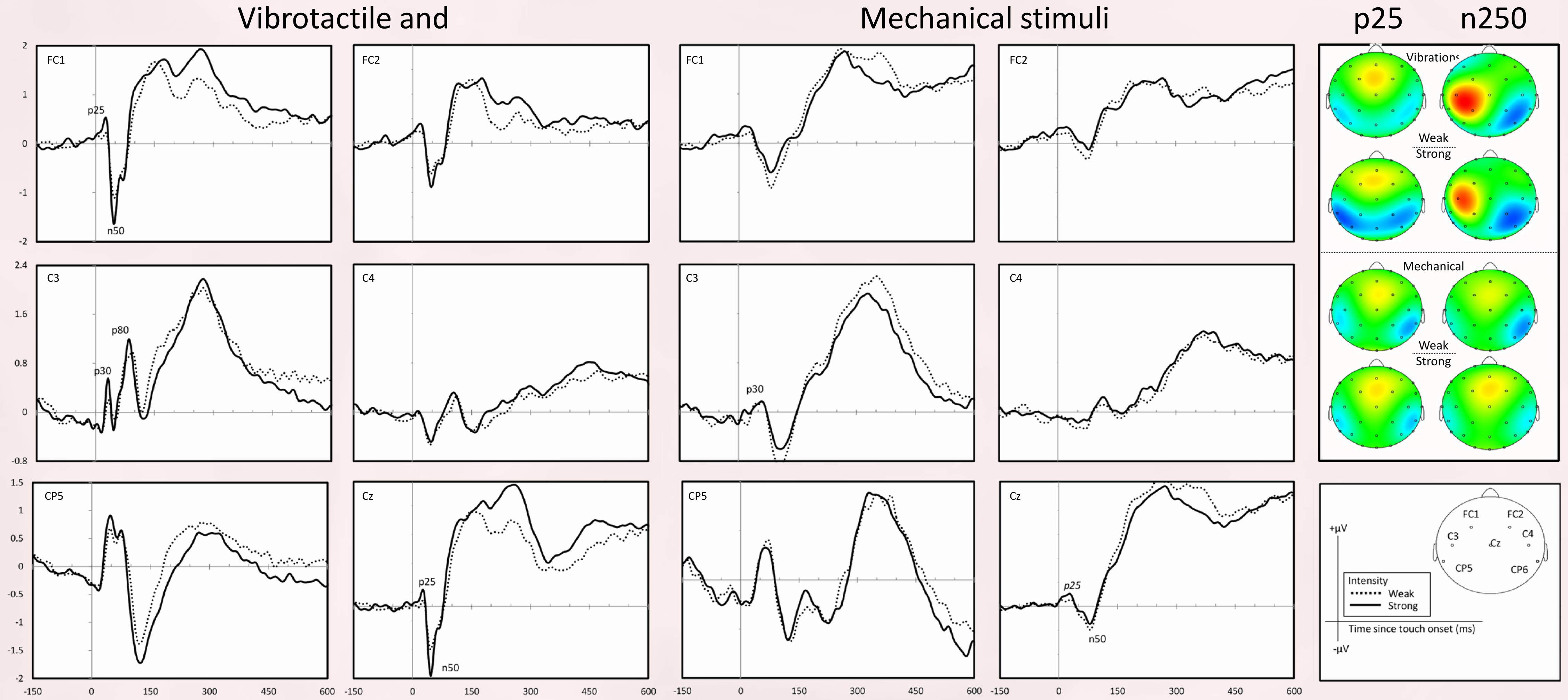
Forty participants took part in the study. A head mounted device (Oculus Rift DK2) was used to create an immersive environment: seated at a table with another person opposite. In reality, the subject was seated with their right hand on a glass table, above a hand tracking device (Leap Motion controller). This enabled a virtual, 3-D version of their hand: they could see "their hand" in virtual reality.

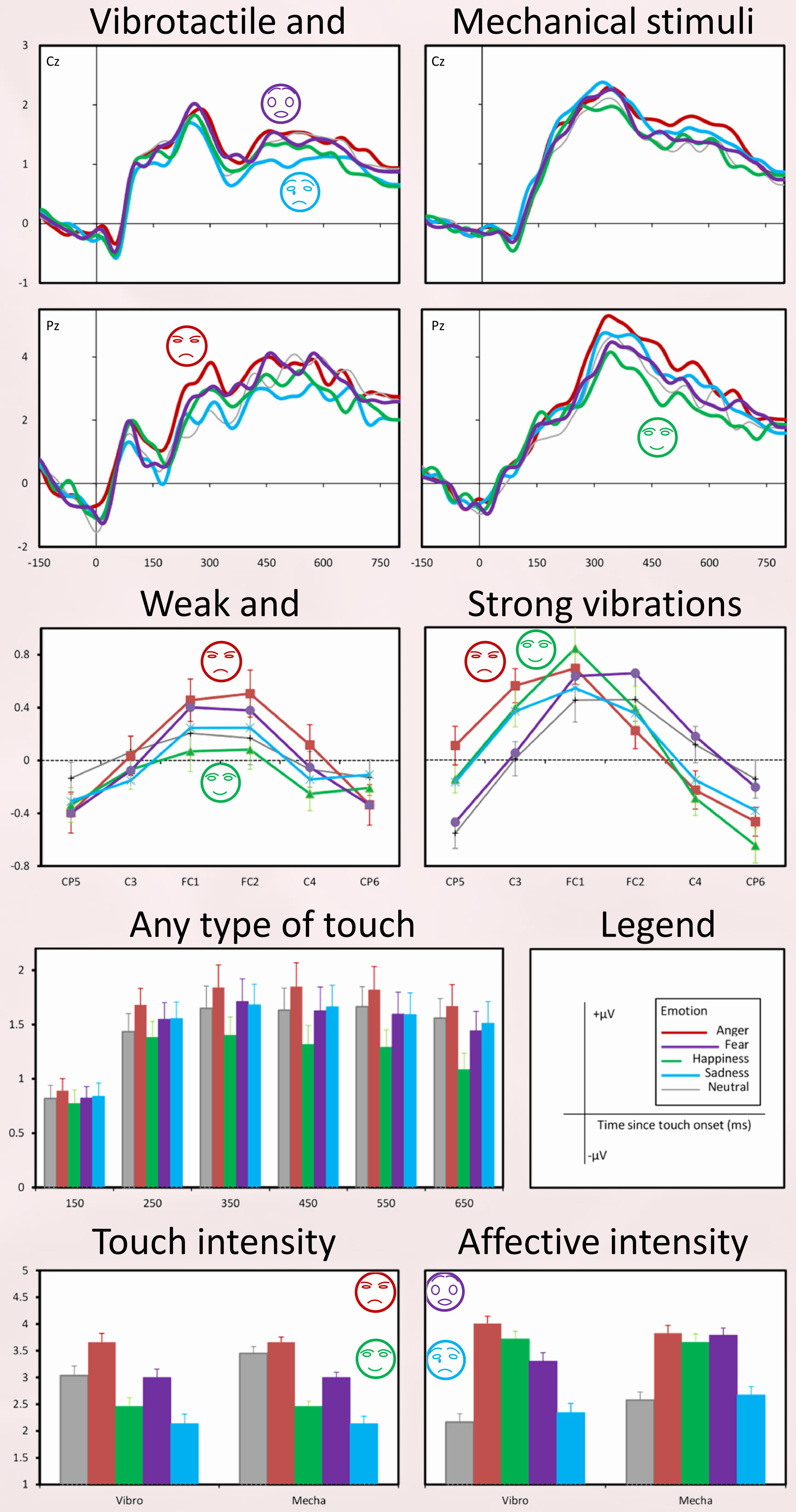
Procedure. As shown above, a cue was presented to start a trial. The avatar (with a neutral expression) was shown as soon as the subject moved their virtual hand on top of the cue. The emotional expression animation commenced upon touching the blue crosshair. Following an interval of 2.0±0.6 s, the avatar's reached out towards the visual cue – with the participant's virtual hand resting on top. The 0.5 s of tactile stimulation was presented at this point of contact (at 1.0 s). After 1.0 s, either the next trial started or questionnaires were displayed. These concerned the touch, the avatar (both Likert scales), or the recognition of emotions (five alternative forced choice), randomized between blocks.

Design. Two types of touch, two intensities of touch, and five emotional expressions (happiness, fear, sadness, anger and a neutral control condition) were randomized within five blocks of 100 trials each, lasting approximately 100 minutes in total.

EEG recording and pre-processing. Correction for ocular and head-mounted display induced artefacts was performed using ICA on filtered data [4]. Components were visually inspected based on topography, event related activity, spectral power, and EOG activity [5]. ICA weights, excepting previous, artefact-designated components were applied to unfiltered data and back-projected to scalp level. A further ca. 10% of trials were removed as part of a threshold based artefact detection procedure. Early peaks were defined as significant deviations between stimulus and baseline (P25), or between intensity conditions (N50). P25 latency was in vibrations the most positive peak in Cz or FC1 between 23–29 ms (T=27±3) and N50 the most negative between 37 and 75 ms (T=51±9). All data are with reference to the common average.

Results





Tactile processing

Very early somatosensory evoked potentials (SEPs) can be detected with a possible sub-cortical source localisation (P25). A related, subsequent (N50) potential shows a scalp topography consistent with a source dipole in the contralateral somatosensory (BA1-3) or motor (BA4) cortex. Later activity is more consistent with other modalities EPs, with a possibly relevance-related P2/P3.

Early (<100 ms) effects

Peak amplitudes of P25, P30 and N50 were analysed separately for vibrotactile and mechanical stimuli. These showed:

- An effect of **stimulus intensity on P25** for both mechanical, p = .04, and vibrotactile, p = .01, stimuli, and for vibrotactile stimuli, also on N50, p =.002.
- An **interaction between electrode site, stimulus intensity and emotion**, as portrayed under "Weak and strong vibrations", p = .02, for both N50 and P25, only for vibrotactile stimuli.

Late (>100 ms) effects

Average amplitudes for centro-parietal electrodes were averaged in six bins and analysed. This showed:

- A **main effect of emotion** (anger>neutral>happiness), p = .0002.
- An **interaction effect between emotion and time**: anger affects subsequent processing of touch after ca. 200 ms, further affective variegation occurs later, p = .0002. The interaction effect was stronger in some electrodes than others, p = .03.
- Very strong effects of physical parameters of touch **but no interactions between these and emotion.**

Cross-modal experience

The subjective experience of the touch and the avatar were analysed for possible cross-modal effects. These showed:

- **Mechanical touch was** felt as slightly **more intense** than vibrotactile touch, p = .02.
- **Touch experience depended on the preceding emotion**, p < .001. Touch intensity was rated more intense after perceiving anger, less after sadness.
- The rating of the **avatar's affective intensity** depended on both the **type of touch**, p =.04, **the emotion**, p < .001, **and the interaction** between these, p = .02.

Discussion

How we feel changes what we feel in two stages:

- An **early stage** with amplified early SEPs (p25, n50), due to intensity becoming more pronounced after *anger* and *happiness*. We interpret this stage as reflecting top-down emotion modulation related to the approach motivation [6]. Touch is perhaps more socially consequential after angry and happy expressions (as opposed to after e.g. fearful expressions). To deal with these socially valuable or threatening stimuli, cortico-subcortical connectivity is enhanced.

- A **late stage** shows amplified SEPs after anger, similar to findings by [3]. However, we notice two major differences with the early stage. One, the effects on late potentials do not interact with any physical aspect of the touch (and are similar for weak, strong, vibrotactile and mechanical stimuli). This suggests the differences emerge after a tactile stimulus has been interpreted as *a touch = any touch*, reflecting a more *bottom-up* process. Two, both happiness and anger affect amplitude, but now in opposite direction. Accordingly, we interpret this stage as reflecting generic tactile processing being modified by emotional valence: more with negative, neutral in between, and less with positive emotions.

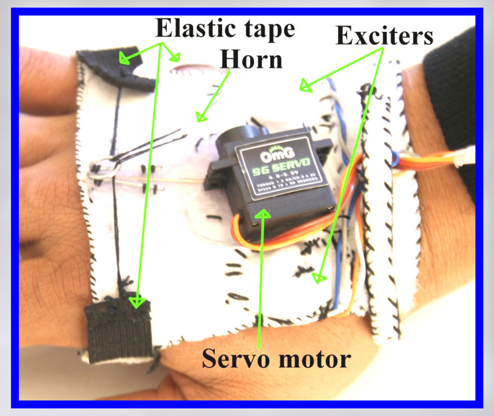
Materials

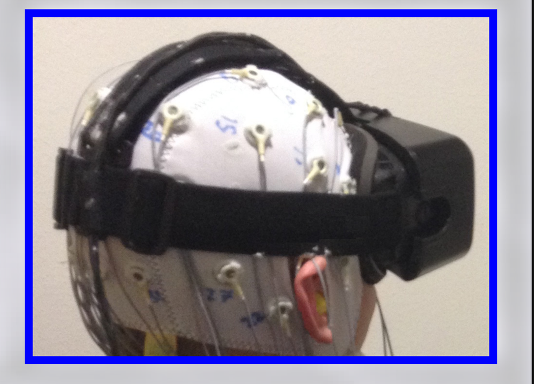
- **Vibrations**: generated using "Exciter" actuators placed above the metacarpal bones of the little finger and thumb. The amplitude, shape (square) and duration (1s) were constant, but varied in frequency: 35 (weak) and 100 (strong intensity) Hz.

- **Mechanic:** generated using a motor pulling fabric across the palm. Stimulus intensity varied with degree of rotation: ca 120° (weak) and 180° (strong intensity).

- **Expressions:** created using Faceshift software (uses the Kinect to measure facial features in 3-D). A pre-study, from a pool of ca. 90 timed recordings of a professional actress showed highest recognition scores for the five emotions (each three distinct animations) used in the present study (now: 86% correct recognition).

- **A head-mounted display** (HMD) was used to present a virtual, immersive environment. It is likely that the proximity between HMD and electrodes can cause interference. A pre-study using a standard oddball task [5] showed that given appropriate care, ICA can correct for HMD-induced artifacts.





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