Can the affective perception of fabrics be decoded from the human brain?

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DIGITAL SENSORIA AT UCL

MOTIVATION: Digital Sensoria is an EPSRC funded multicentre, multidisciplinary investigation which aims to provide designers, customers, corporations and communities with a ***new language*** that will enable them to communicate ***peoples' affective perceptions of textiles and fabrics*** through rich multi-modal digital interfaces.

RESEARCH QUESTION: Our focus at UCL is to investigate whether or not people's sensory perceptions of textile materials be captured from the human brain in conjunction with co-design self-report.

ABSTRACT OF RESEARCH: In an effort to derive a new perceptual language to describe different fabrics, this work is focussed to extract affective signatures of touch. A range of fabrics were used with a robotic skin stimulator for EEG recordings teamed in with behavioural self reporting. The somato-sensory areas exhibited sensorial touch with alpha-beta suppression. Alpha power asymmetry on the orbito-frontal areas was observed. Beta frequency was predominant on the frontal and parietal areas as an indication of pleasant versus unpleasant fabrics. These results are also aligned with the emotional occurrences stimulated through visual stimuli.

SKIN, TOUCH & EMOTION IN BRAIN

❖Touch is attributed to the skin which is the largest organ of the human body. The affective and sensorial responses from the skin are based on the receptors present in it.

Glabrous skin (palm of the hand)	Non-glabrous skin (forearm)
➤ Contains myelinated axons for rapid conduction ➤ Meissner's corpuscles and Pacinian corpuscles ➤ Merkel's disks and Ruffini endings	➤ Meissner units are replaced by hair follicles ➤ C-mechanoreceptive units on hairy skin (mostly found on non-glabrous skin) have closer relations to limbic functions than to motor and cognitive functions

❖Interpersonal touch is often regarded as the most invigorating interface of communication between humans. It has been used to detect 6 types of emotions such as: Anger, Fear, Disgust, Love, Gratitude, Sympathy

❖ Though different components of somatosensory cortex have been studied in tactile perception extensively, little is known about the neural basis of affective tactile perception with non-nociceptive stimulation. These emotional aspects of touch being of high saliency and high relevance for social interactions, emotional well-being.

❖Functional imaging of brain revealed the distinction between painful and pleasant touch. Rolls et. al., reported that the orbito-frontal area was activated by pleasant or painful stimuli while somato-sensory areas were relatively active in the case of neutral stimuli. The rostral part of the anterior cingulate cortex was activated by the pleasant stimulus and that a more posterior and dorsal part was activated by the painful stimulus.

❖Affective experiences of visual and auditory representations have been mainly described through hemispherical asymmetrical processing of emotions. Frontal lobes as well as parietal lobes have been researched for affective (emotional) experiences using electrophysiology [Bos et. al.,2006, Smith et. al., 1987]

❑Valence: positive, happy emotions correspond to a higher frontal alpha, and higher right parietal beta power, compared to negative emotion.

❑Arousal: Excited emotions corresponded to a higher beta power and coherence in the parietal lobe, plus lower alpha activity.

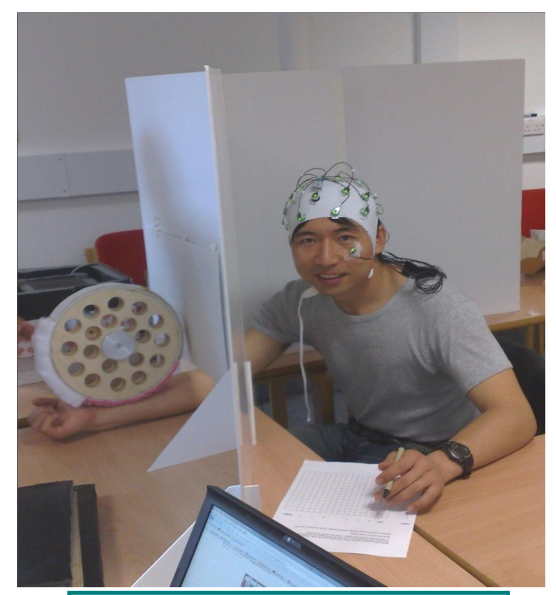
❑Dominance: strength of an emotion was expressed as an increase in the ratio of beta and alpha activity in the frontal lobe, plus an increase in beta activity at the parietal lobe.

METHODOLOGY

EXPERIMENTAL SETUP : A motor controlled fabric caressing device (FCD) was designed and developed to present the fabrics on the forearm of the participants. Strips of the four selected fabrics were mounted on this device and presented in a random order for 2 sec with a 2 sec rest periods in between fabrics. A brief 5 minute break was provided after 25 trials of each fabric and ~50 trials of each fabric was performed.

DATA RECORDING: A 32 channel EEG was acquired from 13 subjects (6 males, 7 females, 13 right handed) using a Brain products ActiCap using active electrodes. MR compatible EEG amplifier, BrainAmp, was used. VEOG was recorded for eye-blink detection. The FCD was interfaced into the trigger channel of the EEG using micro-switches for timing information. The fabrics were rated for level of pleasantness on a descending scale of 1-9 subjects before and after the EEG recording.

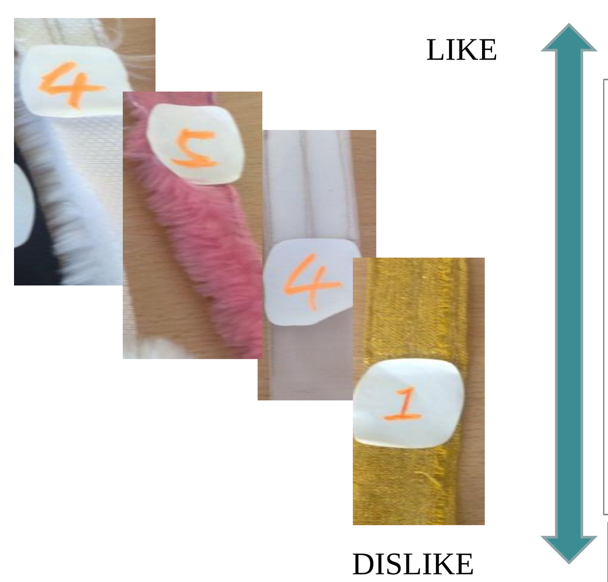
Fabric Caressing Device

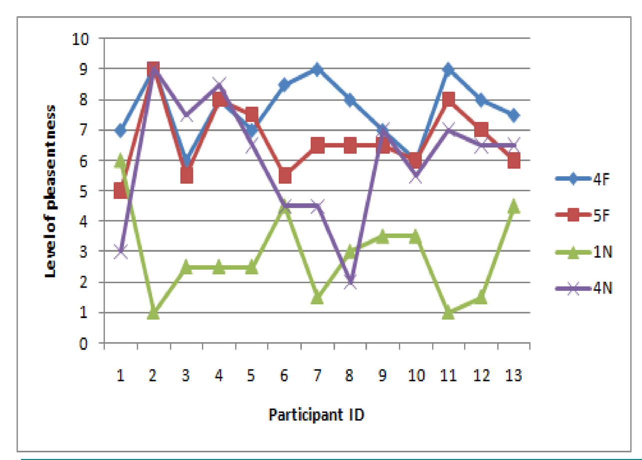


Experimental set up

Fabric selection was based on a behavioural study conducted by Suyi et. al., 2010

- Within subject consistency and between subject variability was observed.
- Two fabrics which were most liked, a central and a most disliked fabric were selected for the EEG study.





Self report ratings for the four selected fabrics for 13 EEG subjects.

DATA ANALYSIS

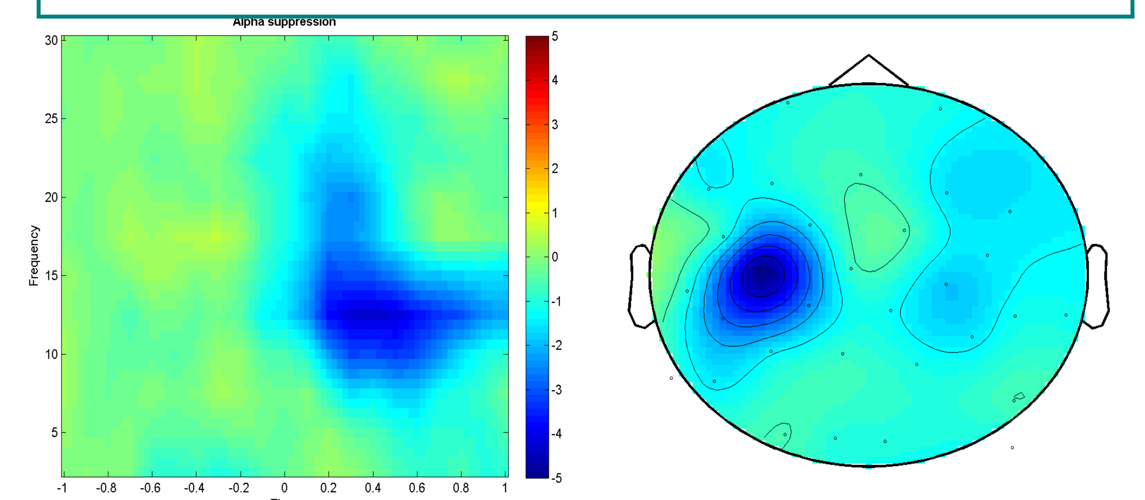
DATA CLEANSING: A Principal Component Analysis (PCA) based variance maximisation methods was used for eye-blink and artifact rejection. Artifact removal was done by first applying a PCA that was used to identify (principal) components that correspond to eye-movement related activity as well as motor related artefacts. Such components were subtracted from the data, along with removal of individual noisy trials and channels. This procedure was applied to the entire dataset before splitting the trials into conditions.

TIME-FREQUENCY ANALYSIS: MATLAB based open source toolbox Fieldtrip was used to compute subject-wise Time-frequency representation (TFRs) of power to investigate the event related potentials with 1s post and pre stimulus time. Hanning window with a window length of 0.4s was used for frequency analysis till 30Hz with a resolution of 2.5Hz. Trials were sorted into conditions and a grand average of TFRs was calculated across all 13 subjects.

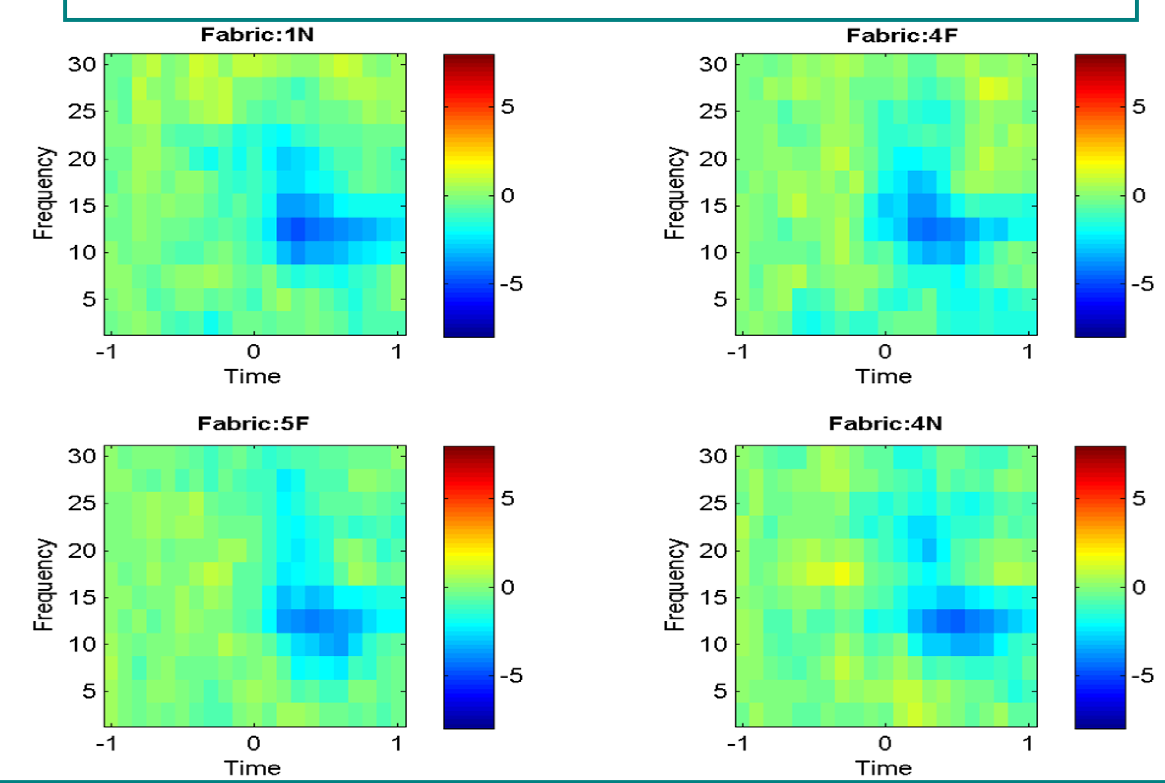
RESULTS

TFR- grand average of all subjects clearly exhibited a clear alpha-beta power suppression over the somatosensory area just after stimulation at t=0. Since all but two of the subjects were right handed this effect was pronounced on the C3 electrode.

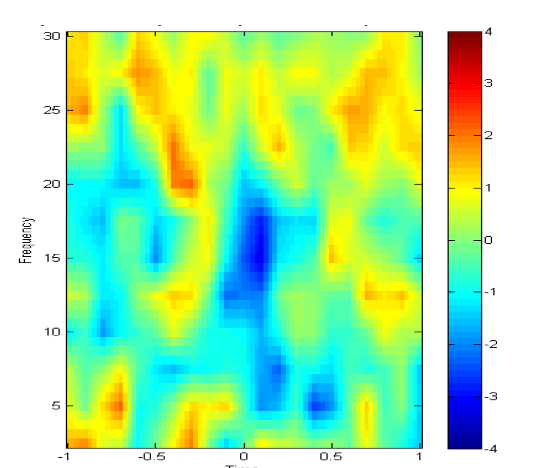
ALPHA BETA SUPPRESSION ON THE SOMTATOSENSORY AREA



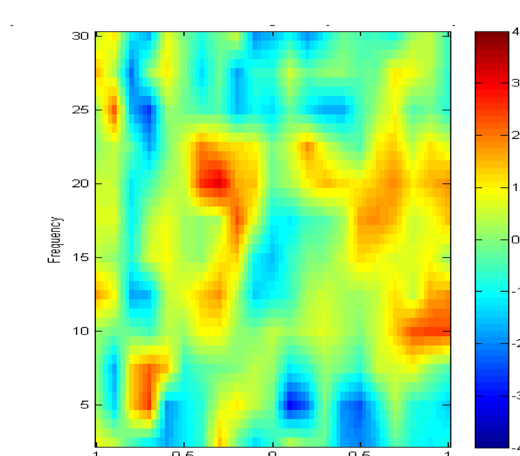
ALPHA BETA SUPPRESSION FOR THE FOUR SELECTED FABRICS



Interestingly this effect was highest for most disliked/ unpleasant fabric (1N) as per ratings.



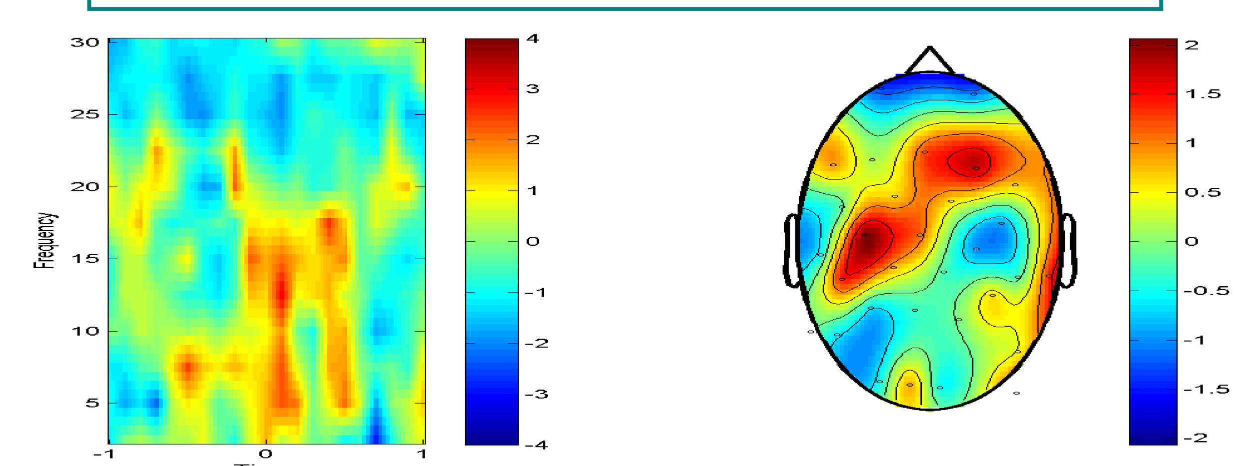
Differences in pleasant (4F), unpleasant (1N) fabrics (Raw power)



Stimulus induced changes for differences in pleasant (4F) and unpleasant (1N) fabrics

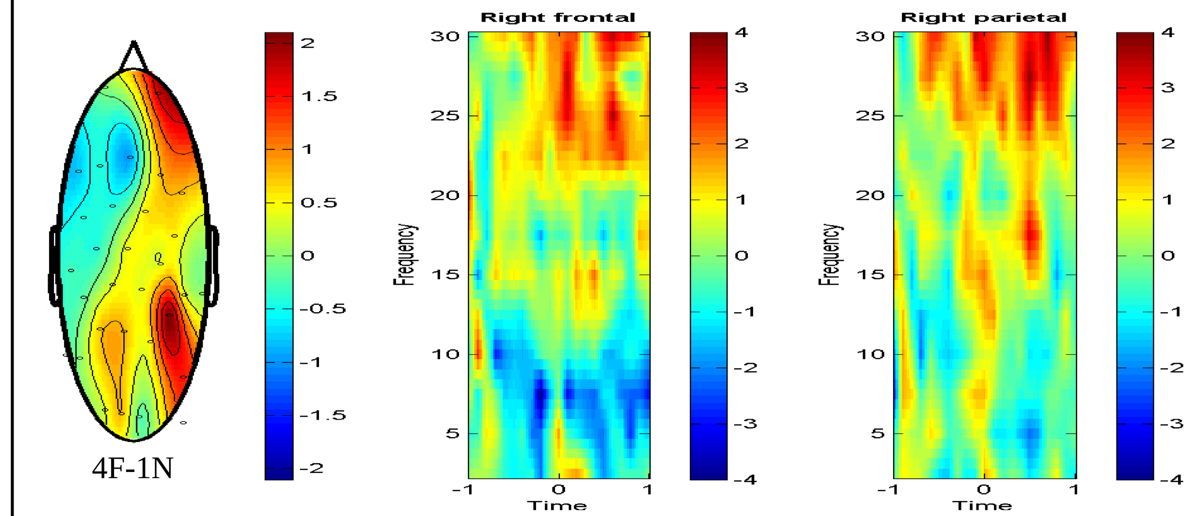
In the case of somatosensory cortex, there is a change depicting the difference in fabrics on stimulus induced brain activity (left fig) at onset of the caressing motion but this was absent during the sustained phase while no clear pattern on raw power (right figure) was observed.

HEMISPHERICAL ALPHA POWER ASYMMETRY



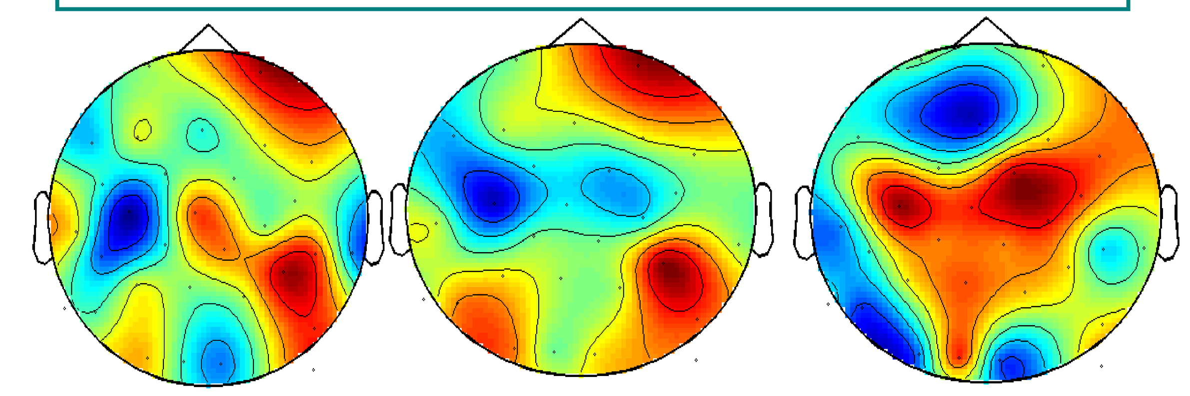
Subtraction of pleasant and unpleasant fabric shows alpha power is higher after stimulation contralaterally and lower ipsilaterally. These results are consistent with neurophysiological changes for emotional pictures, where alpha power asymmetry is observed [Wheeler et. al., 1993, Allen, J., 2004].

FRONTAL AND PAREITAL BETA ACTIVITY



Beta activity has been reported to be associated with emotional tasks, specifically a differential hemispherical beta activation is observed. Right beta power has been associated with positive emotions and the ratio of alpha and beta power on the frontal lobes has been used to be a measure of positive emotional experiences [Bos et. al.,2006, Smith et. al., 1987, Min et. al., 2005].

FRONTAL AND PAREITAL BETA ACTIVITY FOR DIFFERENCES BETWEEN LIKEABLE AND UNLIKEBALE FABRICS



The topographic plot reflects the differences between the most liked fabric 4F and the most disliked 1N. It is interesting that this trend in beta activity remains unchanged between second best liked fabric 5F and 1N as well as third best liked 4N and 1N. But then this beta effect disintegrates when differences between likable fabrics 4F and 4N is computed.

CONCLUSIONS & FUTURE SCOPE

Affective touch is one of the less researched areas in neuroscience. One of the reasons is the challenges to dissociate the touch initiated complex interactions as well as simultaneous associated affective processes. The difficulty is to separate the purely physical aspects of the different fabrics and their movement over the skin (their impact on somatosensory system) from their impact on affective sensation. The results show that the main difference of fabrics (most pleasant versus unpleasant) are not only in primary somatosensory cortex but in more frontal and also parietal areas - which is unlikely explained by such pure physical aspects. Further investigations by using the subject specific subjective ratings and the within-individual variation in subject's responses to different fabrics will be conducted to confirm this relative independence of physical and subjective aspects. Machine learning algorithms will be utilised to extract features of electrophysiological brain activity to automatically detect the emotional sensation related to touch.

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