SAHLGRENSKA ACADEMY

Source analysis of cortical responses to gentle touch investigated with EEG

Degree Project in Medicine

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Abstract

Light touch to the hairy skin is encoded by two systems of sensory afferents; myelinated Aβ and unmyelinated C-tactile (CT). While there is a scientific consensus on the nature of the Aβ afferents, the function of the CT afferents remains somewhat more elusive. Previous studies have attributed their function as related to the processing of pleasant, gentle touch, and have found that areas such as the insula and parts of the medial frontal cortex are likely involved in the processing of this information. With the high temporal resolution of the EEG, it should in theory be possible to differentiate between the activation of the CT-system and the Aβ-system due to the difference in their conduction velocity.

The study was conducted with 14 test subjects. A 128-electrode cap was used for evaluating the brain's response to gentle touch delivered by a custom-made robotic device on the forearm. MRI scans were done to calculate the patterns of cortical sources for the recorded EEG responses. Data was processed and analysed using MNE-Python. To analyse our data statistically, we used a cluster-based permutation test with threshold-free cluster enhancement (TFCE). This modern method was not used previously to analyse EEG or MEG data.

Early brain responses (from 20 ms, Aβ-driven) showed numerous electrodes with statistically significant activity, and source analysis showed activation around the arm area of the contralateral primary sensory cortex (S1). Mid-late activity (1.6 s) showed a negativity in central electrodes consistent among all participants. Source analysis at 1.6 s showed activation bilaterally in the frontal midline, likely the posterior and anterior MCC. This late activation of the MCC is consistent with previous studies using MEG and MRI.

We conclude that 128-channel EEG combined with TFCE statistics can be used to study the brain's late responses to gentle touch.

Introduction/background

The sense of touch is undoubtedly essential for the human race as a whole. It is vital for social interaction as well as interaction with our surroundings and helps us determine the nature of objects we are touching. It is also the first of the human senses to develop in the womb as early as 6 weeks after gestation, and even after birth remains important for helping the new-born discover the world due to their poor eyesight, as well as promoting normal development. (*Affective Touch and the Neurophysiology of CT Afferents*, 2016; McGlone, Wessberg, & Olausson, 2014).

The afference from the human skin is mediated by several different kinds of nerve fibres. The largest and most fast conducting are the myelinated Aβ afferents, mediating discriminative touch from low-threshold mechanoreceptors (LTMs), followed by the Aδ afferents, mediating information such as pain and temperature from nociceptors and cool receptors, respectively. Since the Aδ afferents are not involved in the somatosensory system they will not be further discussed in this paper. The last group, the C fibres, are thinner than the A fibres and thus more slow conducting, and lack myelin. These slow conducting fibres carry information from nociceptors, itch-, and temperature receptors in addition to LTMs. The type of C fibres involved in tactile sensation are called C-tactile (CT) afferents, and have been described as having a role in mediating touch that is perceived as pleasant (Löken, Wessberg, Morrison, McGlone, & Olausson, 2009). While C-fibres in general have long been recognised in humans and associated with senses such as pain and temperature it was long thought that the CT afferents, while having been proven to exist in animals almost a century ago (Zotterman, 1939), did not in exist in humans. It was theorised that they had disappeared with evolution, partly based on the fact that they seemed more numerous in cats than in primates (Kumazawa & Perl, 1977). More than 50 years after the initial discovery, they were discovered in the human face by researchers in Uppsala (Nordin, 1990). However, even then it was thought that

the distribution was not general and that this was merely an evolutionary remnant. A general distribution of these fibres was finally discovered in humans by A. Vallbo, Olausson, Wessberg, and Norrsell (1993) using microneurography. The fibres were then further studied and characterised during the 90's using similar techniques (A. B. Vallbo, Olausson, & Wessberg, 1999). Using brushstrokes was early the stimulation method of choice due to it causing an optimal firing frequency in the CT afferents (A. B. Vallbo et al., 1999), leading to the hypothesis that they are involved in transmitting innocuous touch.

Further progress was made with the help of a patient lacking large-diameter myelinated sensory fibres in the forearm; the patient could detect tactile stimuli directed at activating C fibres, but could not do so in the palm suggesting that the CT afferents exist only in hairy skin. This has been proven repeatedly in studies (A. Vallbo et al., 1993; A. B. Vallbo et al., 1999; Wessberg, Olausson, Fernström, & Vallbo, 2003). It was also observed that the stimuli led to activation in the insular cortex but not the primary somatosensory cortex (which is the projection site of the Aβ fibres, indicating that the CT afferents could be part of another type of system). (H. Olausson et al., 2002).

The connection to pleasantness was made in 2009 (Löken et al., 2009). It was noted that optimal CT firing frequency coincided with the highest pleasantness ratings in hairy skin, and that the pleasantness ratings dropped significantly when instead performing the same test on the glabrous skin of the palm. (Löken, Evert, & Wessberg, 2011)

Studies have also been performed on members of a group of patients in northern Sweden with a hereditary mutation affecting sensory nerve fibre density, reducing the amount of C fibres more than the amount of A fibres. It was found that the reduction in C fibre density affected the patients' pleasantness ratings compared to the healthy control group. When viewing a video of gentle skin stroking they also perceived the stroking as less pleasant than did the control group (Morrison et al., 2011).

The connection between pleasant touch and the insula has also been shown in studies on patients with insular lesions, showing that these patients indeed had a reduced perception of pleasantness bilaterally (Kirsch et al., 2020). Apart from the insular cortex, other areas that have been suggested to be involved are the medial prefrontal cortex and the posterior superior temporal sulcus, as well as different parts of the cingulate cortex (Eriksson Hagberg et al., 2019; Gordon et al., 2013; McGlone et al., 2014).

Considering the above-mentioned characteristics of the CT afferents, it has been suggested that the CT fibres have a role in the sensation of pleasant touch and are tuned to the characteristics of affiliative body-to-body contact. They seem to have a function separate from the Aβ afferents, suggesting that two different systems for touch processing exist; one for discriminative touch, and one for the emotional aspects of touch. (Morrison et al., 2011; H. W. Olausson et al., 2008)

Light touch on the skin of a healthy individual will activate both the CT and Aβ afferent systems, making it difficult to differentiate the effects of the two different tracts. Furthermore, it is likely that the sensation of pleasant touch relies on the integration of the two kinds of afferent activity, even though it is unknown exactly how and where in the brain this happens. Since the signals in CT afferents travel much slower to the brain (about 1 m/s) compared to Aβ (around 40-80 m/s), brain activity resulting from activation of the two systems should in principle be possible to resolve using the high temporal resolution of EEG or magnetoencephalography (MEG). This is, however, not possible when using fMRI due to its lack of temporal resolution.

A previous study using EEG exclusively (Ackerley, Eriksson, & Wessberg, 2013) showed a late wave (with its peak at 2+ seconds after the stimuli) with positive potentials around the frontal midline, but this could not be further localised due to the spatial limitations of the 64-channel EEG recording used in that study. A later MEG study with the purpose of analysing

this late wave (Eriksson Hagberg et al., 2019) did, however, not find this pattern, the authors speculating that this was possibly due to the different spatial sensitivities of EEG and MEG. Instead, sustained activation in the midline frontal cortex in addition to activation in the insula and postcentral gyrus was found.

This study attempts to recreate the late wave seen in previous studies with high-density 128-channel EEG, as well as further localising its cortical sources. Further, due to developments in the methods for statistical analysis of EEG data, a more advanced statistical method will be used compared to the previous study (Ackerley et al., 2013).

Aim

To use high-density (128-channel) EEG to characterise the cortical sources of the late response to light touch on hairy skin.

Material and methods

Study population

The study population consisted of 14 healthy individuals between 20 and 39 years of age, recruited from the University of Gothenburg (8 female). All participants gave informed consent, and the study was approved by the ethics board at the University of Gothenburg. The study was done in accordance with the Declaration of Helsinki, meaning that participants were free to stop their participation in the study at any time without having to state the reason. Participants not working as researchers at the Department of Physiology were compensated for their time.

All subjects were asked about metal implants before entering the project, as well as informed about the dangers of bringing metal into an MRI machine. They were also informed of the procedure that would be taken if any abnormalities were found on the MRI scan.

The experiment

All experiments were conducted at the EEG lab at the Department of Physiology, University of Gothenburg. The MRI scans were done at Queen Silvia Hospital for Children and Youth (DSBUS) in Gothenburg.

Each participant was fitted with a 128 electrode EEG-cap manufactured by BioSemi (Amsterdam, Netherlands). Correct placement of the cap was ensured using a regular measuring tape. Each electrode position as well as the participants head shape and anatomical landmarks were then digitalised using a Polhemus PATRIOT (Polhemus, Colchester, Vermont, USA) motion tracker. Anatomical landmarks were used to simplify fitting the digitalised points to the head shape provided by the MRI pictures. The system compensated for inevitable head movements using a second motion detector fastened on the forehead of the participant.

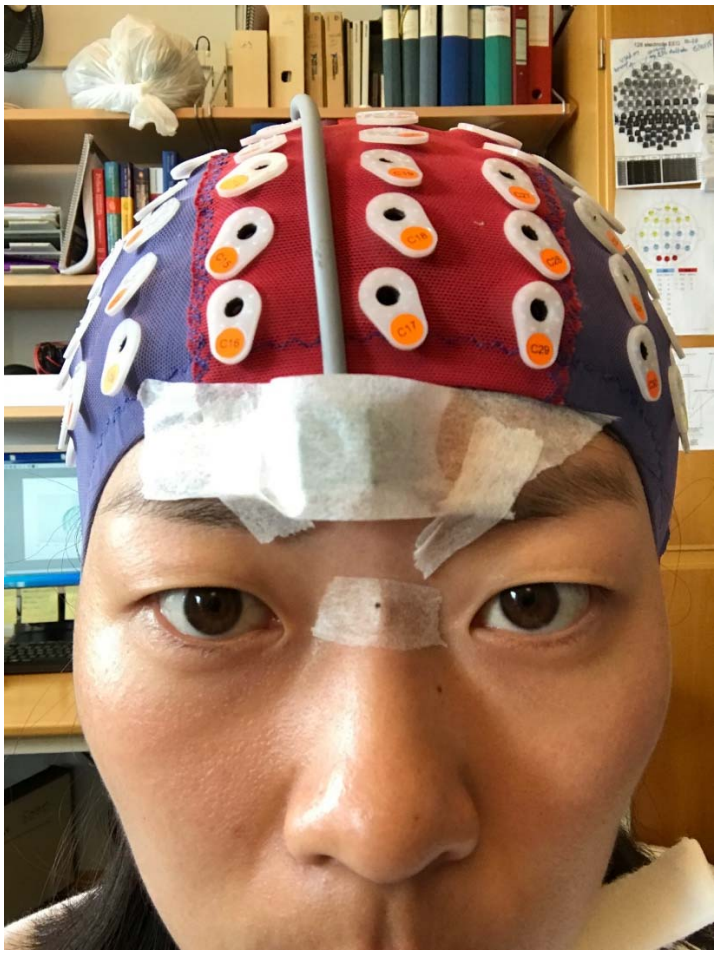

Figure 1. A participant with an electrode cap during the registration of electrode positions, using the Polhemus system. The motion detector on the participants forehead was removed after the registration was complete. The nasion point, used as an anatomical landmark, is marked with a dot.

Following the digitalisation electrode gel was applied to improve connectivity and the electrodes fitted into the cap. The participant was then seated comfortably in a dentist chair with their left arm fixated in a vacuum pillow.

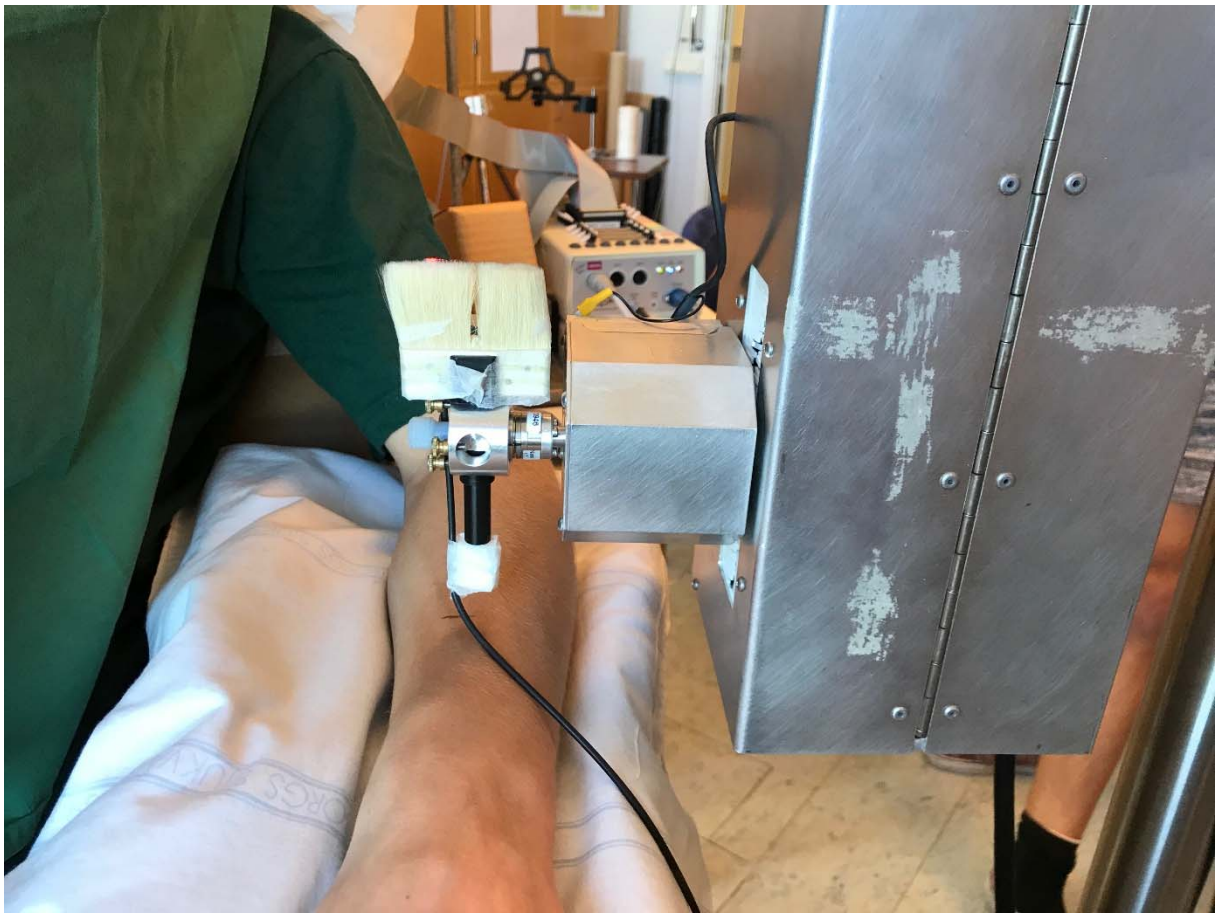

Figure 2. A participant's left arm fixated on the vacuum pillow. The RTS brush is seen in standby mode with the brush pointing up. The optical sensor is barely visible at the top.

The experiment was made using a custom made robotic RTS (rotary tactile stimulator; Dancer Design, UK) device driven by LabVIEW (National Instruments, TX) software with the capacity to provide highly replicable brush strokes on the dorsal side of the participants left lower arm in a proximal-distal direction. The brush used was made of soft goat-hair, 5 cm wide. The brush stroke velocity was set to 3 cm/s and the force was calibrated to 0.4 N, since this force and velocity (Löken et al., 2009) has been shown to optimally activate the CT afferents.

To prevent visual triggers, the participants' view of their left arm was obscured using a curtain. Earphones with white noise were used to block sounds made by the moving RTS.

The brush was equipped with an optical sensor (V. Jousmäki, Aalto University, Helsinki, Finland), giving a trigger at the start of each brush stroke that was recorded by the EEG recording system. The interval between the strokes varied slightly due to waiting times being randomised, with a median waiting time of 14 seconds. The mean duration of the stroke as measured by the optical device was 2.3 seconds, meaning that the length of the stroke was approximately 6.9 cm. This was confirmed by calculating the time between the onset and offset of the optical trigger in MATLAB.

Each participant received a total of 200 brush strokes divided into 10 blocks with 20 strokes each. To ensure participant attentivity as well as preventing drowsiness, so called odd-balls were also used, adding two additional brush strokes at random points during each block with a different velocity (6 cm/s) that the participant was asked to verbally identify. These were later removed from the analysis. The participant was carefully instructed to remain as still as possible during the sessions, as well as to avoid blinking or swallowing while the brush was moving and directly afterwards.

A form was filled out by the attending assistant researchers during the experiment, noting any irregularities or disturbances (sudden sounds, sneezing etc) as well as the participants proficiency at detecting the odd-balls.

The EEG data was collected using a BioSemi ActiveTwo system. Two EEG caps in different sizes were used depending on the subjects' head circumference: both with 128 electrodes and otherwise identical. The signals were collected with a sampling rate of 512 Hz using BioSemi ActiView.

MRI scans of the head and brain were T1-weighted, using a sequence optimised for differentiating between the relevant anatomical structures (brain cortex, meninges, skull) with 1 mm^3 spatial resolution.

Data processing

Data processing and analysis was started in MATLAB (Mathworks Inc., Natick, MA, USA) using the Fieldtrip (Oostenveld, Fries, Maris, & Schoffelen, 2011) software toolbox and finished in MNE-Python. MNE-python is an open-source Python software specifically made for analysing human neurophysiological data developed at the Martinos Center for Biomedical Imaging, Charlestown, MA, USA.

The data for each participant was inspected individually. Filters were applied with a highpass cut-off frequency at 0.1 and a lowpass cut-off frequency at 48.0. The raw EEG data was plotted and electrodes with large artifacts, indicating inadequate contact with the skin, were excluded from further analysis through interpolation. In different subjects, 0-2 electrodes were removed, the median being 0. The data was then re-referenced to an average reference. A FastICA algorithm using the Independent component analysis (ICA) technique was used to plot artifact components for manual removal. Studies have shown that this method is capable of isolating most common artifacts encountered in EEG and MEG data such as eye movements and blinking, as well as myographic disturbances (Hyvärinen & Oja, 2000). The data was divided into epochs around the optical trigger point, starting at 2 seconds before the trigger and ending at 5 seconds after the trigger. Epochs with signals surpassing a peak-to-peak amplitude of more than 100 μV were rejected since this would indicate the presence of an artifact that was not removed by the ICA procedure, for example random electrical interference. Epochs were also manually inspected and removed if they contained major disturbances.

Data analysis

Event-related potentials (ERPs) were calculated for all subjects by averaging all EEG epochs. A grand average ERP was calculated by averaging the ERPs from all 14 subjects.

The digitalised head shape and electrode positions made with the Polhemus motion tracker was co-registered with the MRI, fitting the head shape to the anatomical landmark fiducials automatically using only small manual adjustments for proper positioning. No scaling was done.

Brain segmentation was done using FreeSurfer (PySurfer), a software suite developed at the Martinos Center specifically for processing and analysing human brain MRI images.

A surface-based source space was set up based on the MRI pictures with a total of 10248 grid points distributed over the cortical surface of each hemisphere. (A finer grid with more points would not have added any additional information since it is not possible to achieve higher spatial resolution than is permitted by the 128 EEG electrodes on the scalp.)

Boundary-element model (BEM) contours were added to the different surfaces of the model based on the conductivity values of the compartments, outlining the outer skin, outer skull, inner skull, and brain surfaces. During this process a topology check was made, ensuring that each surface was inside each other as expected (no brain outside the skull or similar), that there was no intersection between the surfaces and that each surface was complete.

Based on the source space and the BEM a forward solution was calculated. A forward solution is a way of calculating the expected patterns of EEG activity resulting from the neural sources on the cortical surface.

Source localisation was done first using Minimum Norm Estimation (MNE), and was then normalised using the dSPM (dynamical Statistical Parametric Mapping) method; this is a way of compensating for the depth-bias of the minimum norm estimation (Hauk, Wakeman, & Henson, 2011). dSPM was done with a loose parameter of 0.8, meaning that the orientation of calculated cortical sources was free with respect to the local cortical surface. A depth-weighting coefficient of 0.8, which is the standard value in MNE.

Source analysis was first done on each subject individually, and the resulting source maps were then transformed to a common anatomical space, the standard brain provided by FreeSurfer. This was done using a "morphing" algorithm implemented in MNE. The "morphed" source maps were then averaged for a common dSPM map of average source activity at the group level.

Statistical analysis

Statistical analysis was done using Threshold-Free Cluster Enhancement (TFCE), a kind of modified variant of cluster statistics.

The goal being a statistical comparison between the base line and the time-space after t=0 s, other options for statistical analysis prove less convenient. For example, a t-test quickly gets inadequate considering the need to correct for multiple comparisons (many points in time, many sources), while also considering that the data is correlated (that is, adjacent points in time/space are not independent of each other). Cluster statistics, on the other hand, are based on searching for clusters of adjacent points (in space or time) that portray strong activity (Maris & Oostenveld, 2007). In TFCE, no threshold is defined, meaning that the definition of what actually is "strong" is tested. The algorithm creates 1000 random permutations of data where baseline and data randomly trade places and looks for clusters. This way, a distribution is created that shows how rare "strong" clusters are in the data when assessing random noise. This is then compared to the real data (where all the baseline- and test data is in the "right" place) to see which clusters are actually statistically unusual ($p<0.05$) in the randomised distribution that the algorithm calculated. Studies (Smith & Nichols, 2009) show that this method adequately corrects for multiple comparisons, meaning that every point of data displaying significance with $p<0.05$ is correct. Without TFCE, conclusions can only be drawn about clusters and not isolated points of data. The analysis in the present study takes about

four hours to run correctly on a high-performance computer due to the amount of calculations required.

Results

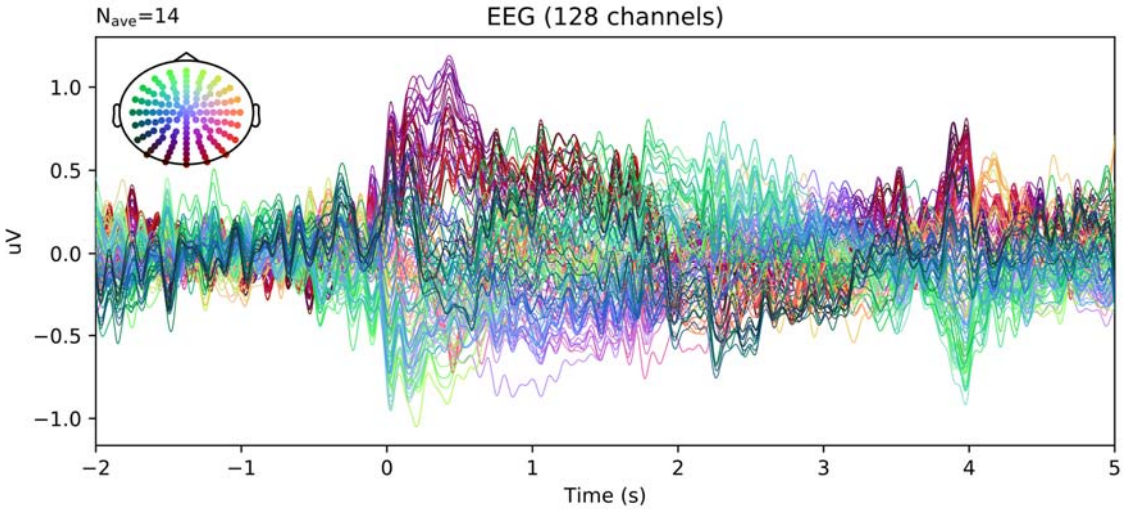

Figure 3. Grand Average showing the Event-Related Potentials (ERP) for all 128 EEG channels, from all participants. The channels are colour-coded by location, see inset.

Event-related Potentials

Figure 3 shows the grand average of the event-related potentials (ERP) based on data from all participants. T=0 s is the point where the optical trigger on the brush indicated contact with the skin.

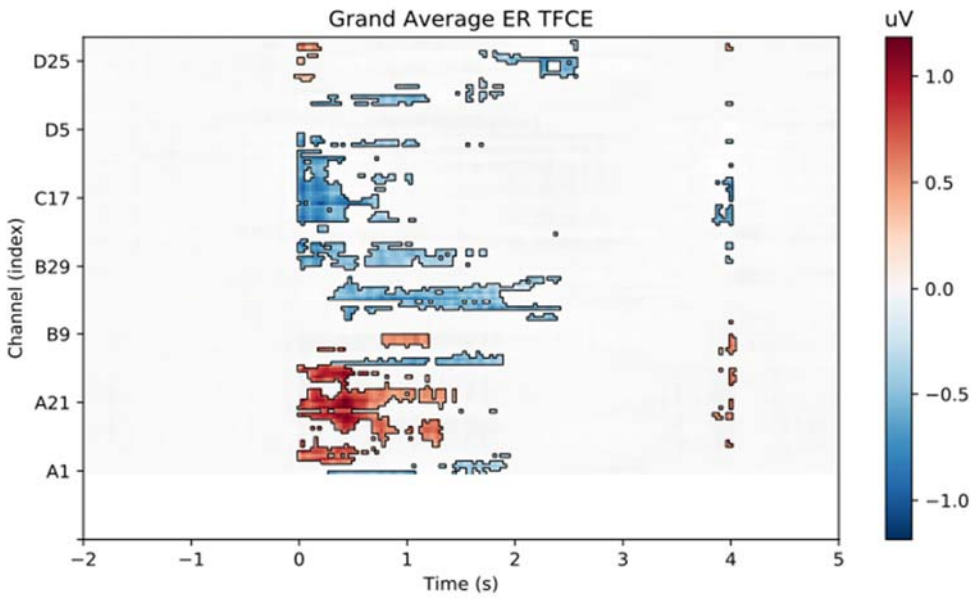

Figure 4. TFCE cluster statistical analysis of the grand average ERP done on all electrodes for all participants. Statistically significant ($p<0.05$) event-related potentials (ERP) are highlighted by red (positive potential) or blue (negative potential).

The TFCE cluster statistical analysis done on all electrodes for all participants showed statistically significant activity; see Fig. 4. Each point in the chart is individually corrected for multiple comparisons and showed significance at $p<0.05$. Note that electrodes that are adjacent numerically are not necessarily adjacent on the electrode cap, see Figure S1 (Appendix) for a diagram of the electrode positions. No statistically significant activity was seen in the baseline (before t=0 s). The cluster of significance seen at 4 seconds is likely an artifact caused by the electronics in the experimental setup, likely the RTS, since this point lies long after the brush has lost contact with the skin at 2.6 s.

Early activity

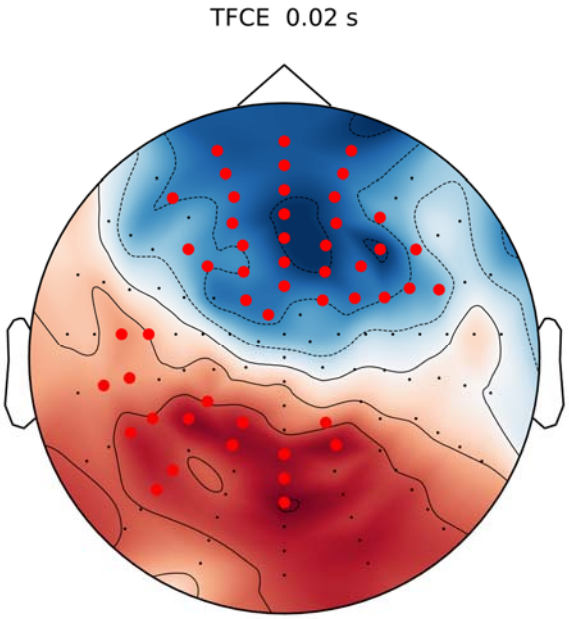

Figure 5. Topographic plot of the potential field of the scalp at 0.02 seconds (20 ms). Scale as in Fig. 4, with positive potential indicated by red and negative by blue. Electrodes showing statistically significant ERP at 0.02 seconds (20 ms) is marked with a red dot.

The first main peak in the deflections in the grand average ERP occurred at 20 ms. Fig. 5 shows a topographic plot of the potential field on the scalp at 20 ms. A wide range of electrodes showed statistically significant activity at this time, with negative potential over the midline frontal cortex, and positive potential over the midline parietal cortex. This first peak was followed by another peak at 150 ms, and then a succession of several ERPs. These early peaks followed roughly the same pattern as in Fig. 5, but with slightly broader distribution on the scalp. This can be seen from the colour-coded electrodes in the grand average in Fig. 3, and the plot of statistically significant electrodes in Fig. 4.

Mid-late activity

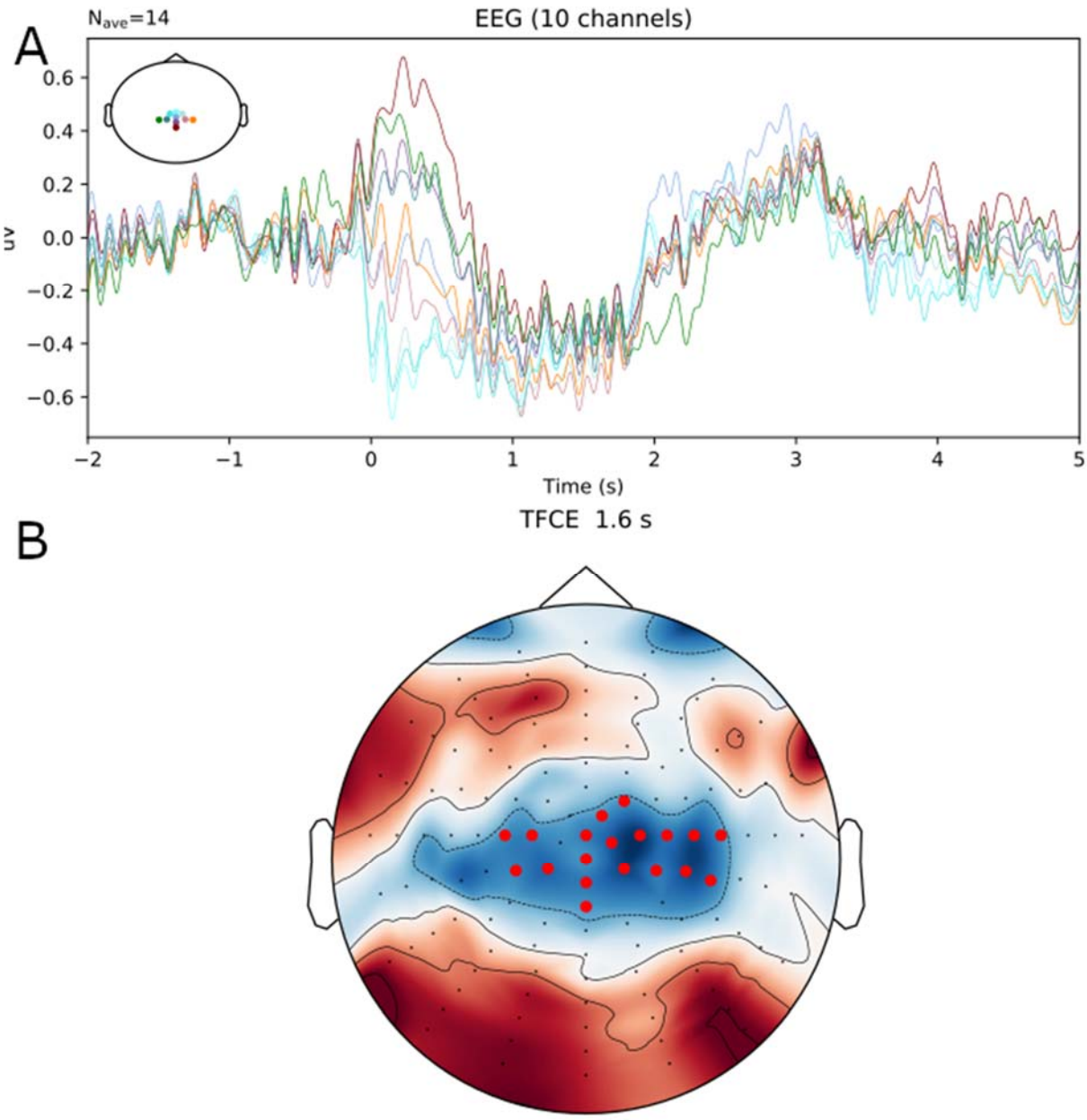

Figure 6. A. Grand average of 10 electrodes over the posterior central midline. B. Topographic plot of the potential field at 1.6 s. Electrodes showing statistically significant ERP in the TFCE analysis (p<0.05) are indicated with a red dot.

In Fig. 3, and more clearly in Fig. 4, it can be seen that another pattern starts emerging after around 0.8 s. This pattern is seen in the grand average for a subset of 10 electrodes over the central midline in Fig. 6A. There was negativity in central electrodes, with a non-distinct onset and lasting until around 2 s. This mid-late negative wave was consistent among all participants and thus statistically significant (Fig. 6B).

Late activity

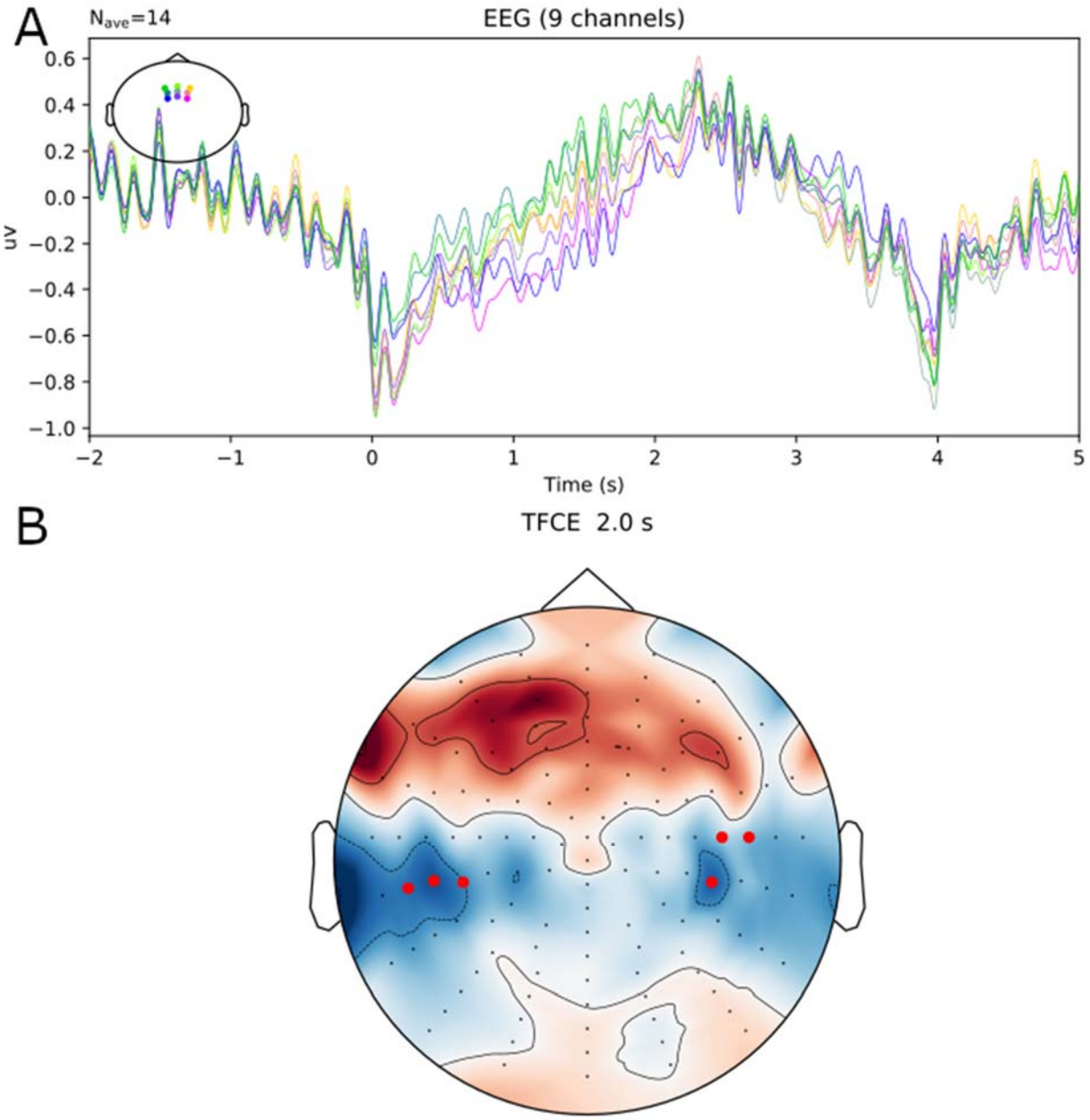

Figure 7. A. Grand average of a subset 9 midline frontal electrodes. B. Topographic plot of the scalp potential at 2.0 s. Electrodes showing statistically significant ERP have been indicated with a red dot.

As can be seen in figure 7A, the midline frontal electrodes showed the same late positive wave that was observed in a previous study (Ackerley et al., 2013). However, as shown on the topographic scalp plot in Fig. 7B (and in the plot for all electrodes in Fig. 4), the activity that gave rise to the late positive wave is in fact not statistically significant on a group level using

the TFCE statistical method. Individual plots of the midline frontal electrodes of all participants can be seen in figure S3 in the Appendix.

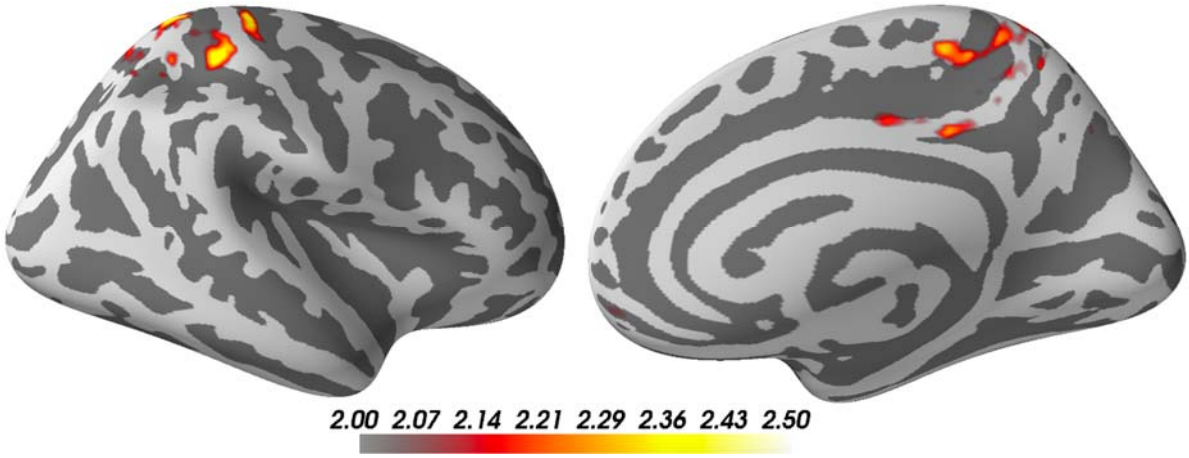

Figure 8. Source localisations done with dSPM. The images show the average of all subjects, projected on the Freesurfer common cortical surface. The cortical surface has been "inflated", where dark gray areas show the sulci and the light gray show the gyri. dSPM activations have been thresholded at 90% of peak activity. The gradation scale shows the dSPM score. Source image at 20 ms after stimulus onset. Contralateral hemisphere, lateral and medial view.

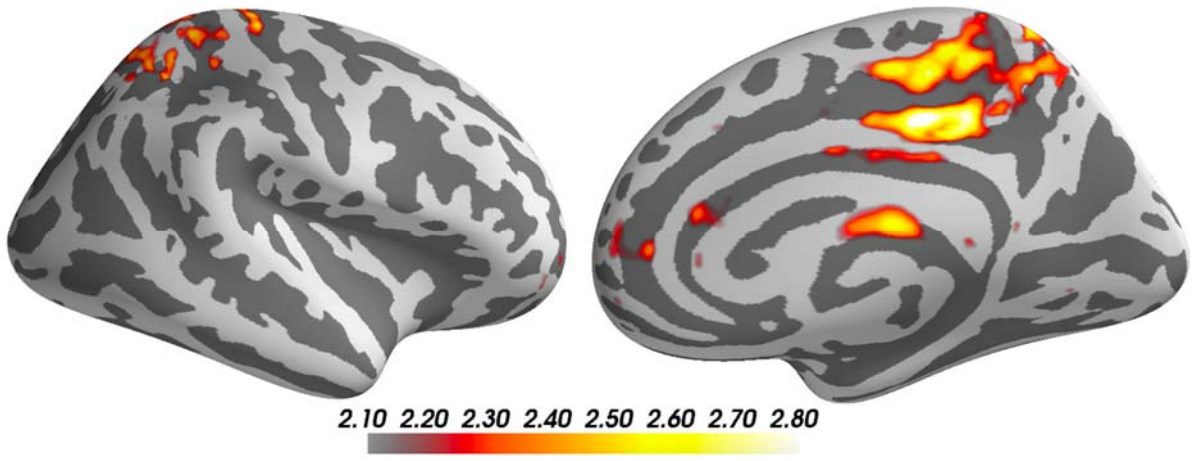

Figure 9. Source image at 150 ms, as in Fig. 8.

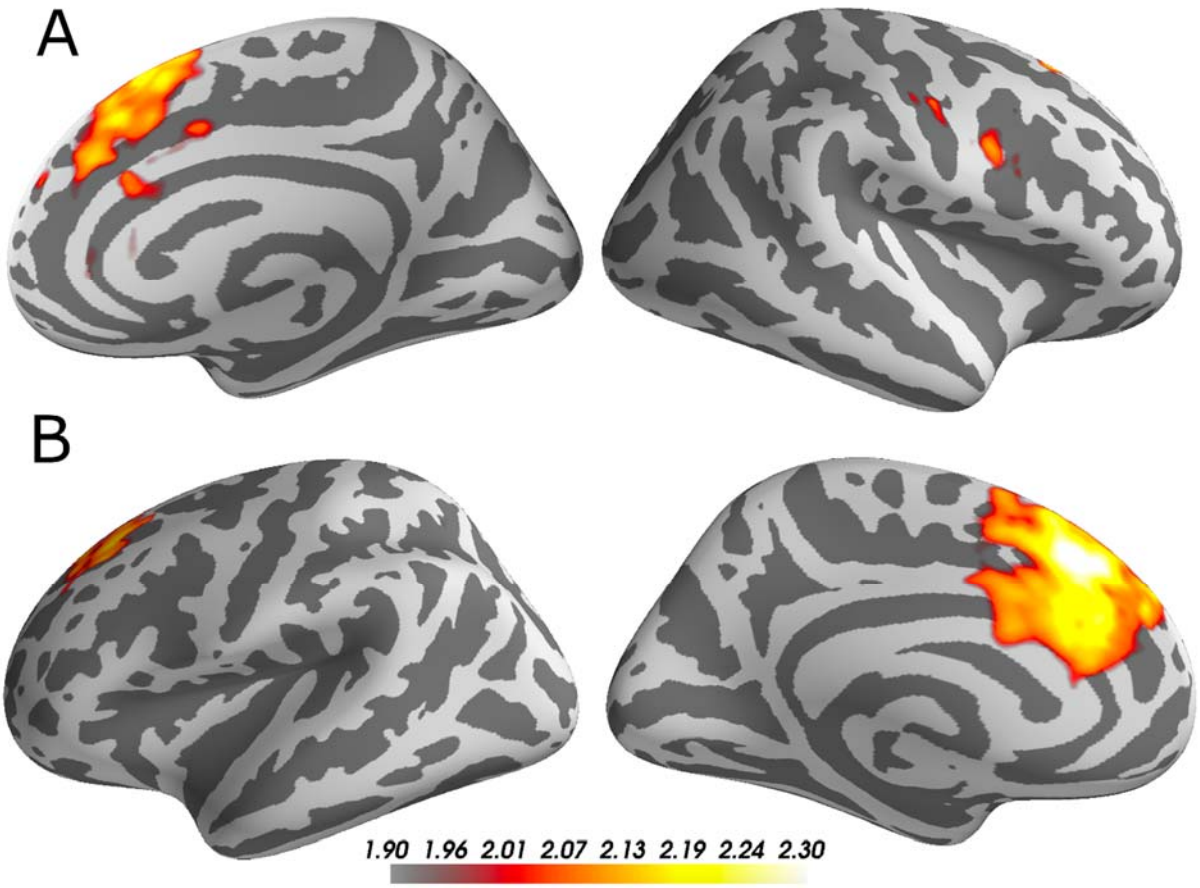

Figure 10. Source images at 1600 ms, contralateral hemisphere in A, and ipsilateral in B.

Source Analysis

Fig. 8, 9 and 10 shows the dSPM source analysis for all subjects. Fig. 8 shows activity at 20 ms. The activity is centred on the primary sensory cortex (S1) in the contralateral postcentral gyrus, with peaks near the forearm area in the central sulcus (Brodmann area 3b) and the postcentral sulcus (Brodmann area 2). There is also some activity in the midline near the fronto-parietal junction, and posterior parietal cortex. Fig. 9 shows the activity at 150 ms, where the activity in the midline has become more widespread, involving the frontal midline (SMA) and potentially the dorsal cingulate cortex. There were no activations in the ipsilateral hemisphere at 20 or 150 ms.

Fig. 10 A shows the contralateral hemisphere and B the ipsilateral at 1600 ms, near the peak of the late central negative wave described above (Fig. 6). The activity is centred bilaterally in the frontal midline, in the medial prefrontal cortex and mid-cingulate gyrus (MCC).

Discussion

In this study, we investigated the cortical responses to gentle touch by combining high-density 128-channel EEG data with MRI images. Our results indicate a widespread amount of statistically significant activity following the stimuli, starting early immediately after onset of the stimulus.

Cluster-based statistics are often used in neuroimaging studies due to their higher sensitivity compared to voxel-based statistics. The TFCE method can be seen as an integration of two methods: cluster-based statistics, and a random permutation test. The TFCE in particular requires no set threshold, meaning the clusters have not been defined beforehand. The main advantage is that the method offers a solution for controlling for multiple comparisons(Mensen & Khatami, 2013). Each point of data is tested independently for significance rather than pre-defined clusters, meaning the "clusters" created can be as small as one point of data or larger. Other methods, such as t-tests, assume that each test is done independently of the others. This makes it less than ideal for neuroimaging studies since one electrode out of 128 cannot possibly be statistically significant alone; electrical activity in the brain works on too large a scale.

The early wave of widespread activity was seen in the grand average of the ERP. This activity is presumably driven purely by myelinated fibres (Aβ) based on the fact that the impulse in the much slower conducting unmyelinated CT-afferents (1 m/s compared to 40-80 m/s) would not be influencing the cortical response this early. Looking at the source localisation, similar early activity in the central sulcus has been seen in previous studies (Eriksson Hagberg et al.,

2019; Wegner, Forss, & Salenius, 2000), but in comparison our results show a lack of activity in the insular and cingulate regions at this point in time. This is likely due to the inferior spatial sensitivity of the EEG compared to both the MEG and the fMRI (Mulert, 2013; Singh, 2014).

The mid-late, negative wave

Seen over the MCC (Midcingulate cortex) and the medial dorsal frontal lobe, this wave is late enough that the CT afferents could be involved. It is of course impossible in this situation to say for sure which type of nerve fiber gives rise to this pattern, but it does correlate well with activity in the same area seen in previous studies (Eriksson Hagberg et al., 2019; Rolls et al., 2003). The functional significance of this activity is not known, but this area is known to be involved in a large number of sensory and emotional brain functions, including pain, itch, emotional reward, and emotional and body awareness (discussed in Eriksson Hagberg et al. (2019), Rolls et al. (2003) and Misra and Coombes (2014)). This correlates well with the theory that the CT afferents are involved in emotional aspects of touch (McGlone et al., 2014; Morrison et al., 2011; H. Olausson et al., 2002).

The late, positive wave

As previously stated, the positive wave seen at around 2 s in midline frontal electrodes was not statistically significant when the inter-individual variations were taken into account, which was not the done in previous studies (Ackerley et al., 2013; von Mohr et al., 2018). It could be argued that there is some significant activity happening in the brain also at this late point in time since some electrodes are marked as significant, but the activity over the frontal midline cannot be considered significant based on this analysis.

Looking at the individual data, it can be observed that some individuals did indeed have a prominent late positive wave. The reason for this variation between individuals can be

theorised at length; it could be because of some parameter that we do not take into account in how the participants' brains react to the brushstroke, for example the level of the participants' attention, if they are focusing specifically on the sensation caused by the brush stroking the arm, or how engaged they are in the trial. It is also possible that this late wave is something that can be seen in just a subset of the population of all healthy persons, similar to the well-known inter-individual variation on alpha waves over the occipital cortex when the eyes are closed. Further studies on larger populations would be required to determine how common this activity is and possible causes for the inter-individual difference.

Conclusion

This EEG study demonstrates that the late activity that has been thought to be consistent with gentle touch stimulation is more variable than previously thought. Our findings do indicate a consistent mid-late negative wave that was most prominent over central midline electrodes, where source analysis showed activity in the bilateral frontal midline. This result is consistent with previous results from a study using MEG. However, the previously described late positive wave previously seen in EEG was not proven to be statistically significant on a group level in the present study.

Populärvetenskaplig sammanfattning

Var i hjärnan hanteras impulser från behaglig beröring?

Känseln är ett av våra viktigaste sinnen och utgör en stor del av hur vi upplever omvärlden. Den hjälper oss till exempel att identifiera föremål, varna oss för faror och är också en viktig del av vårt sociala samliv. Avsikten med detta projekt var att analysera ursprunget till de mönster i hjärnan som ses vid behaglig beröring av huden. Vi vet sedan tidigare att det i princip finns två typer av nervfibrer som leder information om beröring från huden till hjärnan, och lite förenklat kan de delas upp i snabba och långsamma fibrer. Studier har visat att dessa ger upphov till lite olika mönster i hjärnan; de snabba fibrerna leder till den del av hjärnan som huvudsakligen är känt för att hantera känsel medan de långsamma leder till områden som bland annat avgör hur vi upplever beröringen. Eftersom vi känner till de olika fibrernas egenskaper och hur fort de kan fortleda impulser, kan vi i princip skilja på deras aktivitet i hjärnan genom att se när aktiviteten börjar. Till detta används en metod som kallas EEG, som mäter hjärnans elektriska aktivitet. Den behagliga beröringen har getts med hjälp av en specialbyggd robot försedd med en mjuk borste.

Det vi letat efter är mönster i hjärnans aktivering som upprepar sig om och om igen. Inom vetenskapen kallas detta statistisk signifikans – lite förenklat att det inte är sannolikt att mönstret du ser beror på slumpen. Vi fick resultat som man kunde förvänta sig, det vill säga tidig aktivitet i de områden av hjärnan som hanterar ”vanlig” beröring från de snabba fibrerna och senare aktivitet i områden som kopplats till de långsammare fibrerna, där aktiviteten kan kopplas till emotionella aspekter av beröring.

Nästa steg skulle kunna vara att upprepa försöket med fler försökspersoner eftersom vi sett skillnader mellan individer. Att ha en bra förståelse för hur denna typ av beröring normalt sett

analyseras i hjärnan kan ge en insikt i vad det är som inte fungerar när beröringen upplevs annorlunda eller obehaglig. Detta ses till exempel hos personer med autism.

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Supplementary appendix

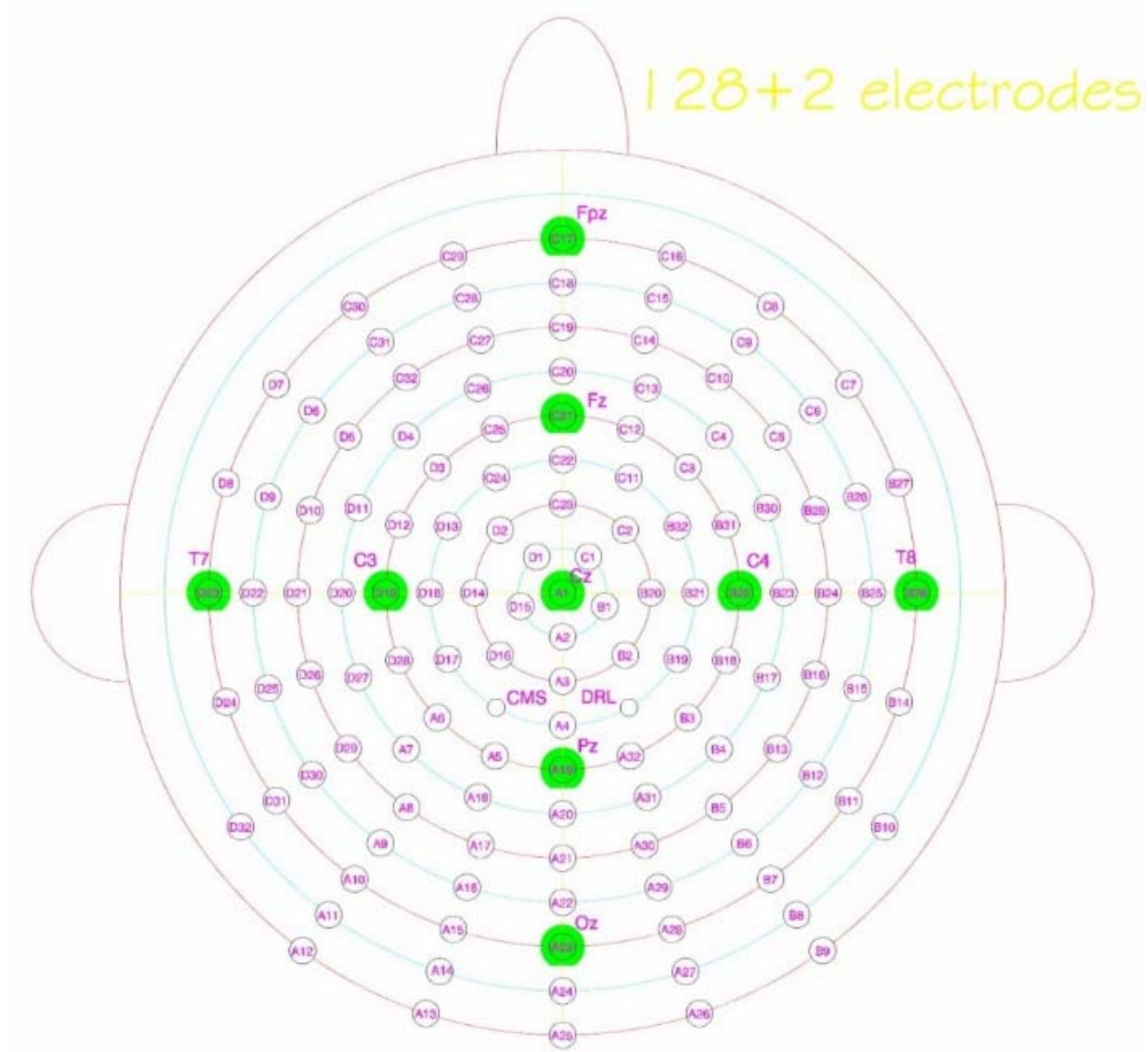

Figure S1. Chart of all the 128 electrode positions in the BioSemi cap.

https://www.biosemi.com/headcap.htm

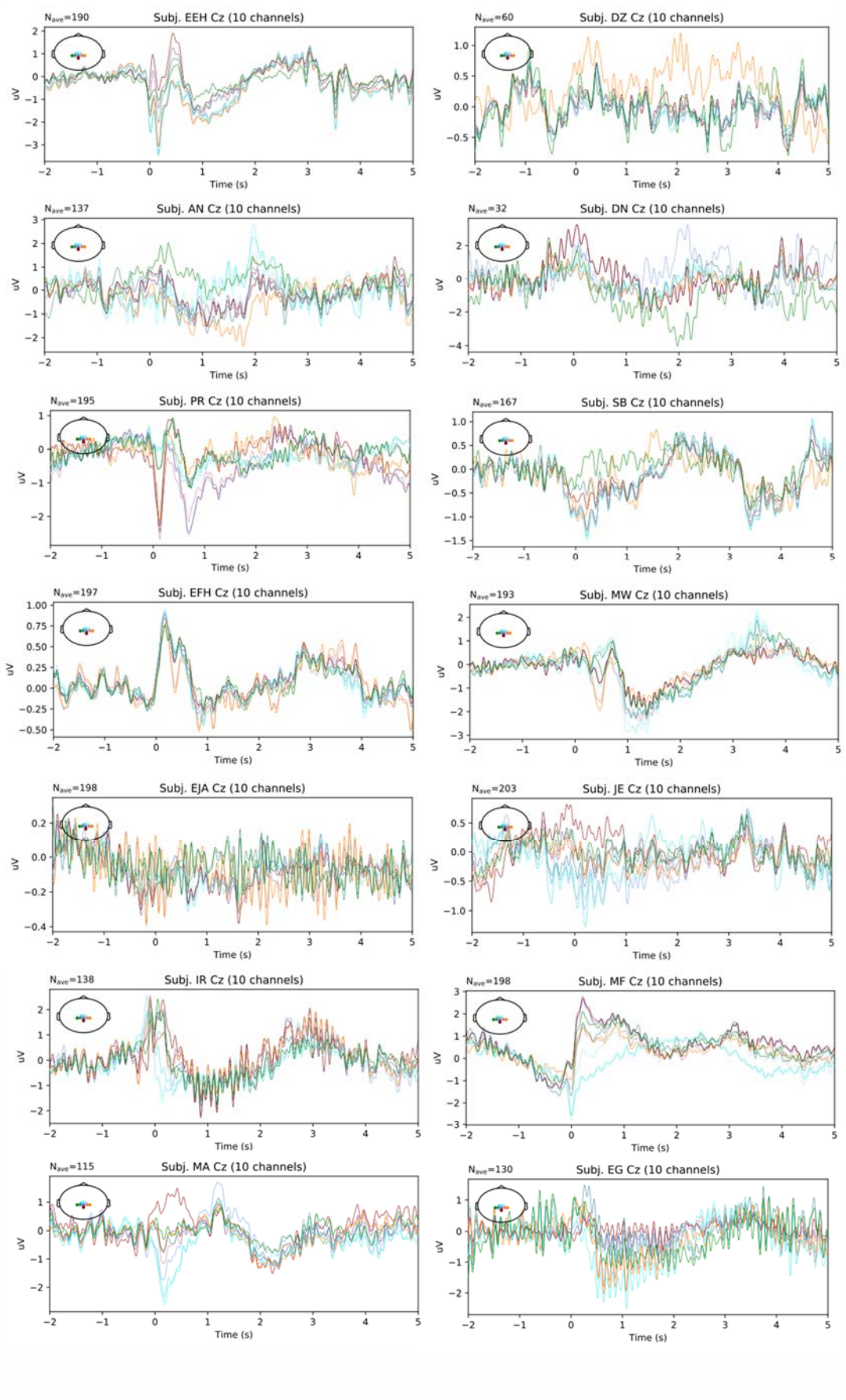

Figure S2. Event-related potentials in 10 posterior midline electrodes in the 14 individual subjects. Compare to the grand average for all subjects in Fig. 6A.

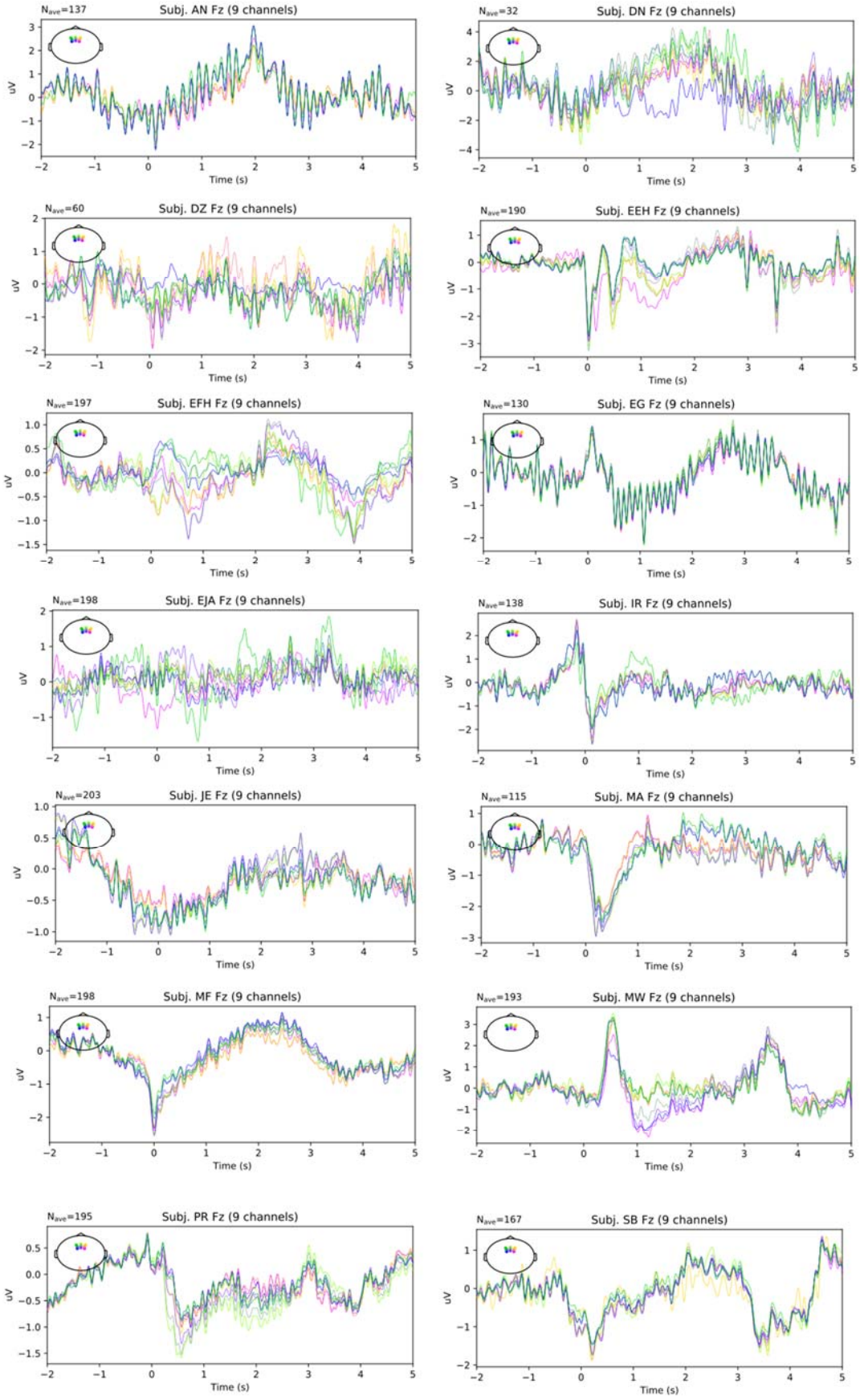

Figure S3. Event-related potentials in 9 central electrodes in the 14 individual subjects. Compare to the grand average for all subjects in Fig. 7A.

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