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Time-frequency analysis of cortical responses to gentle touch investigated with EEG

Degree Project in Medicine

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Abstract

The aim of this study was to investigate human brain activity following gentle touch. Two types of afferents register gentle touch on the hairy skin in humans: myelinated Aβ-, and the unmyelinated CT-afferents. Aβ have mostly qualities of discriminative processing of touch, whereas CT-afferents have been suggested to be important for pleasant touch. Since the cortical projections of the CT-afferents are not known, there is a reason to investigate them further, in order to gain more knowledge of pleasant touch, the brain mechanisms that are involved, and ultimately to understand the way this might affect behavior. With a difference in conduction velocity, there is a potential for seeing two waves of activity in the brain, with the first one being due to Aβ- and the second to CT-input. This was illustrated in an earlier EEG study. This late activity was however not detected in a following MEG study. Here, we wanted to further investigate this with EEG experiments using a 128-electrode cap, which provides a higher spatial resolution than the previous EEG study. We found a late event-related reduction of oscillations in the 15-30 Hz beta range (event-related desynchronization, ERD). This was not seen in previous studies, which might be explained by the higher spatial resolution of these recordings. Since this late activity both in time and localization might be explained by the late CT-input, this could be a reflection of the cortical processing of CT-afferents that has not been presented before. In order to conclude what brain area was responsible for this activity, source localization analysis should be performed.

Background

The human sensory system and its processing of non-painful stimuli has been rigorously studied. A great majority of this research has been in connection to Aβ-afferents, large diameter myelinated nerve fibers, conducting signals at velocities between 37-73 m/s (Kakuda, 1992). Able to distinguish the texture, shape, position and orientation of objects, Aβ-afferents are fundamental for the discriminative aspect of touch (Pruszynski JA and Johansson RS, 2014). There is however another type of nerve cell that is activated by non-painful stimuli, the less known C-tactile afferents (CT:s). CT:s were first found in humans in the infra- and supraorbital nerve with the microneurography technique, showing a low-threshold mechanical activation and conduction velocities typical for thin, unmyelinated afferents (0.6-1.4 m/s) (Nordin, 1990). This type of afferent has since been found on various areas of the body, such as thigh (Edin, 2001) and the dorsal hand (Löken et al., 2007). On the forearm skin, CT-afferent receptive fields can actually be detected as often as Aβ-afferent receptive fields (Vallbo et al., 1993) (Vallbo et al., 1999). No experiment has however detected CT:s in glabrous (non-hairy) skin, leading to the current opinion that there are no or very few CT-afferent receptors there.

Defining characteristics of CT-afferents include full activation at low force skin indentations (0.3-2.5 mN), with no difference in response between sharp and blunt objects and a fast fatigue in response to repeated stimuli. Stimuli moving slowly are particularly efficient at activating CT:s, while the response to high velocity stimuli is sparse. (Vallbo et al., 1999).

This last aspect has been important in discussing the function of CT-afferents. In an experiment combining microneurography and psychophysics, a CT-optimal interval of velocities between 1 and 10 cm/s was shown, with both slower and faster stimuli eliciting weaker responses. This in contrast to Aβ-afferents, that showed a linear increase in response to higher velocities. When the human subjects rated pleasantness of the different velocities, there was a significant correlation between this curve and that of CT-activation, meaning that the stimuli most efficient at activating CT:s were also the ones perceived as most pleasant. This has contributed to the idea that CT-afferents participate in the processing of pleasant touch, and that their function may be connected to social behavior (Löken et al., 2009). Further evidence to support this was found when studying patients with a specific genetic mutation, causing a lack of C-afferents and other thin fiber afferents. With sensory stimulation their rated pleasantness was lower than in healthy controls, and did not show the same velocity dependent pattern (Morrison et al., 2011a). These qualities have led to the conclusion that CT-afferents are not important for discriminative touch, but for another aspect of touch, affective touch. The type of stimulation that most effectively activates CT-afferents has been named gentle touch (McGlone et al., 2014).

When investigating the areas of the brain that are activated by CT-afferents, it must be considered that any stimulus that activates them, also activates Aβ-afferents. In order to circumvent this, experiments have been conducted on patients with a rare neurological disease, causing a total loss of Aβ-afferents. With thin and unmyelinated fiber afferents however remaining, the patients had a sense of pain and temperature, while they could not feel innocuous touch. But when being stimulated in a CT-optimal manner, they could feel a

faint, slightly pleasant, pressure. During this stimulation, fMRI detected activation neither in primary somatosensory cortex (S1) or secondary somatosensory cortex (S2), but in the insular cortex. That brain region was therefore suggested as a possible projection area in the brain for CT-afferents (Olausson et al., 2002; Olausson et al., 2008). Further evidence that CT:s project to insula was obtained when using fMRI and comparing CT-optimal stimulation velocity (3 cm/s) to 30 cm/s. The slower stimulation showed a significantly higher activation in insula (Morrison et al., 2011b). Part of the reason why insula is interesting in this context is that it receives input from other small diameter afferents (C and Aδ) and processes modalities such as pain, temperature and afference from inner organs (Craig, 2002). Insula has furthermore been discussed as responsible for self-awareness and subjective feelings (Craig, 2009).

However, the fact still remains that no one has stimulated CT-afferents without also stimulating Aβ-afferents in healthy individuals. With selective Aβ intraneural stimulation, fMRI has also detected substantial activity in the insular cortex (Sanchez Panchuelo et al., 2016). This complicates drawing any conclusions on which brain regions the CT:s actually are activating. There is nonetheless one aspect that can be considered in order to get closer to an answer. Since Aβ- and CT-afferents have a great difference in conduction velocity, input from them will likely reach the brain at different times, which could potentially give rise to brain activity in two waves.

When using fMRI, this concept can unfortunately not be applied. Although this technique has a very good spatial resolution, it has a temporal resolution of around 1 second, which is too long to detect the time difference of any activity resulting from Aβ- and CT-afferents,

respectively. With a time resolution of milliseconds, electroencephalography (EEG) and magnetoencephalography (MEG), are two techniques that would make it possible to detect this difference.

Accordingly, with EEG registration of CT-optimal stimulation, two waves of activity were detected. The first one was seen within the first second after stimulus onset, in concordance with the conduction velocity of Aβ. The second one started at 0.7 seconds. Given the distance from the stimulation point, this implicated an average conduction velocity of 1.2 m/s, matching with the velocity of CT-afferents. The localization of this later activity also supported previous proposals of CT:s projecting to insular and frontal cortices, but not to S1 and S2 (Ackerley et al., 2013). Further investigation of this has been done with MEG. The late wave assumed to be caused by CT-activation was in this case not seen. Using source localization analysis, there was however a sustained activity seen in insular and cingulate cortices, possibly caused by CT-input. The first onset of the activity in these areas was however seen in timing with Aβ-input. It was therefore concluded that the processing of gentle touch is likely an interplay between input from both types of afferents (Eriksson Hagberg et al., 2019). Even though these findings might be confusing, the difference between MEG and EEG is actually not very surprising due to their difference in spatial sensitivity (Ahlfors et al., 2010).

When analyzing EEG/MEG-data in response to sensory stimulation it must be considered that these signals are relatively weak, and can't be seen in a real-time recording. Therefore the stimulus is repeated many times, and the data is split into segments at the time of each

stimulus into something called epochs. The epochs are the basis on which further analysis is performed. One of the most common methods for this analysis is called evoked potentials, the method which was used for detecting the CT-related brain activity previously described. Evoked potentials are calculated by averaging the data over the epochs, leading to an enhancement of the activity that is time-locked to the stimuli. Potentials that are at random timing in relation to the stimuli, such as other brain activity and muscle activity, will on the other hand be diminished. This method has nonetheless its limitations, considering the possibility that some activation of the brain might not occur at the same phase each time the stimulus is processed, meaning that the potential elicited may have its positive peak at different times when the stimulus is repeated. That activity would then be averaged out when using evoked potentials. In this instance time-frequency (TFR) analysis could be useful. When performing TFR analysis, a mathematical method (such as the Fourier transform) is used to break down the EEG/MEG-signal into oscillatory components, giving a representation not only of when there is activity, but also of at what frequencies the nerve cells are signaling (Pfurtscheller and Lopes Da Silva, 1999). The oscillatory measures are in the unit of power, which equals μV/Hz (Pfurtscheller and Aranibar, 1977).

Oscillatory changes in brain activity can either be event-related synchronization (ERS) or event-related desynchronization (ERD), meaning that more nerve cells either are synchronized in a specific firing frequency or cease to be synchronized. ERS in the alpha frequency (8-15 Hz) is believed to represent a deactivated cortical area, whereas an ERD in alpha occurs when an area is activated (Neuper and Pfurtscheller, 2001). Tactile stimuli elicits alpha ERD in contralateral somatosensory cortex. In the beta frequency (15-30 Hz) an initial

ERD with a late ERS is seen. The early ERD is similarly believed to reflect activation of somatosensory cortical areas. This later ERS phenomenon is called the beta rebound, it starts after the end of a stimulus, and its functional significance is not known (Cheyne et al., 2003).

When presenting the late wave evoked potential caused by gentle touch, Ackerley et al., 2013 also found an oscillatory modulation in form of a theta frequency (6 Hz) ERS, with similar timing and location. It was therefore suggested to represent CT-input. When using MEG, this late oscillatory change was however not found (Eriksson Hagberg et al., Manuscript a), which may again be explained by difference in spatial sensitivity of the two methods (Ahlfors et al., 2010).

This thesis is part of a project that is a continuation of the research of Ackerley et al., 2013 and Eriksson Hagberg et al., 2019. The same type of CT-optimal stimulation will be used on healthy volunteers. The additions include the use of a 128-electrode EEG cap, which will allow for a higher spatial resolution than the 64 electrodes used in previous EEG research, and source localization analysis, which was not used in the EEG study. Since the findings of the two studies were not entirely in accordance with each other, there is a need for verifying and further investigating them. This in order to gain a fuller understanding of where, when and in what way the brain responds to gentle touch. Especially interesting will any late wave activity be, since this could indicate activation by CT-afferents. The focus of this thesis will be the oscillatory changes that are elicited.

When performing statistics on EEG- and MEG-data, one is faced with the problem of multiple comparisons. Since the recordings consist of several electrodes measured in frequency over time, the possible comparisons will be thousands. This means that Bonferroni-corrected t-tests will lead to no activation coming out as significant when dividing the p-value threshold by the number of possible comparisons. The solution to this is to use so-called nonparametric permutation tests with cluster analysis. Clusters consist of activation that is adjacent in both space and time. Permutation testing means taking data that are from two different conditions and creating a null distribution by assuming that there is no difference between the two conditions. This implies randomly assigning data with one of the conditions and then calculating a test statistic for the difference of the mean. This procedure is repeated up to thousands of times, and the results provide the permutation distribution with which the activation clusters are compared and deemed significant at $p<0.05$ (Maris and Oostenveld, 2007). Taking this one step further, there is another method called Threshold-Free Cluster Enhancement (TFCE), which doesn't use an arbitrary threshold at which clusters are defined. Instead it uses permutation testing to estimate whether each individual data point is significant, making it a more precise method. The downside of this is the very long computation time. Therefore it is common to analyze the data in one specific frequency band, with a lower time resolution and in shorter time segments when using TFCE (Smith and Nichols, 2009).

Aim

The aim of this project is to investigate the oscillatory changes elicited by gentle touch, using a 128-electrode EEG cap and a soft brush stimulus. This in order to gain a fuller understanding of the human processing of stimuli that are non-painful and perceived as pleasant.

Methods

14 healthy human volunteers were recruited, aged 20-39, 8 females. Exclusion criteria were any neurological or neuropsychiatric diagnosis and any current psychoactive medical treatment. Metallic implants not suited for an MRI scan also excluded participation. The subjects signed a form of informed consent before the experiments and received compensation of 200 SEK/hour. This project received ethical approval from the local ethics committee in Gothenburg and was done in accordance with the Declaration of Helsinki. In order to maintain voluntary participation and prevent a position of dependency of the volunteers, no current student under the institution of physiology was recruited. Furthermore, the volunteers could terminate the experiment at any time without stating a reason.

No power analysis was made when choosing the number of subjects. This is typically not done in observational neuroscience, since the activation can be seen on an individual level. The many repetitions of stimuli makes this possible. A group of subjects is nonetheless normally chosen in order to get more robust results.

EEG data were acquired from each subject using a 128-electrode cap with a Biosemi ActiveTwo amplifier and acquisition system (Biosemi, Inc., Amsterdam, The Netherlands). Sampling rate was set to 512 Hz. Using a PATRIOT motion tracker (Polhemus, Colchester, Vermont, USA) a 3D image of electrode positions, head shape and three anatomical landmarks (2 preauricular and 1 nasion) was registered. Thereafter the subjects were seated in an adjustable chair, enabling a comfortable and fixed position for the left arm. The arm was further fixed with a vacuum pillow. A screen was put up blocking the subject's view of their arm.

The experiments were performed with a custom-built rotor tactile stimulator (RTS) (Dancer Design, St. Helens, UK) stroking a goat hair painter's brush over a marked point on the middle of the dorsal left forearm. The stimulator was controlled in a program written in LabView (National Instruments, Austin, TX, USA). A fiber optic sensor attached to the brush provided trigger signals, marking the timing of contact between the brush and the skin. The subjects were given air tube earphones playing white noise to minimize auditory input from the RTS.

The stimulation was done in 10 blocks with 20 strokes at the speed of 3 cm/s and force of 0.4 N. For each block, 2 additional strokes with a speed of 6cm/s were added. The participants were asked to give a verbal response for these so-called odd-ball stimuli, serving the purpose of maintaining focus on the sensation of the brush moving across the skin. The EEG recorded during the odd-balls was later removed before analyzing. In order to avoid the factor of expectancy, stimulation was done at random time intervals.

Once obtained, the EEG data was analyzed in the program MNE Python. The functions and scripts used for the analysis were written by members of the research group. 128 channels of EEG data (one for each electrode) and 200 event triggers from the optical sensor were uploaded. A bandpass filter consisting of a lowpass at 48 Hz and a highpass at 0.1 Hz was applied to the data, diminishing signal oscillations outside of this interval. The data was visually inspected to manually remove noisy EEG electrodes, with average from adjacent electrodes replacing the removed data. Thereafter, a method called independent component analysis (ICA) was used. This results in a description of the data, consisting of a number of components that represent different recurring patterns. The main purpose of this is to remove EMG artifacts caused by blinking and eye movements, which can be done manually by identifying these two components based on their visual characteristics. After being done with this preprocessing, the data was segmented into epochs based on the trigger events. This means cutting up the data in time segments, in this case 2 seconds before and 5 seconds after each trigger event. Removal of noisy epochs was done by an automatic rejection of those where any individual electrode reached 100 μV, which was deemed to be caused by artifacts such as external electrical noise.

The epochs were the basis on which time-frequency (TFR) analysis was made. The interval of frequencies to be analyzed was set from 1 to 50 Hz. The two conditions compared in this case were activation and baseline before the onset of stimulation. Baseline was set at -2 to -0.2 seconds in relation stimulus onset and activation was everything after 0 s. The ERS/ERD response was calculated as the proportion of change in power over time for all frequencies, in

relation to the power present in the baseline (ERS = increase in power; ERD = decrease). The scale to visualize ERD/ERS was set at -0.2 to 0.2 in the proportion of change, i.e. 0.2 = 20% increase compared to baseline. After calculating the TFR on each subject a grand average was calculated, in order to visualize activity that was shared by all the subjects.

In order to evaluate the statistically significance of the oscillatory modulations, nonparametric cluster-based permutation tests were performed on the TFR images. The data during activation, consisting of change from baseline, was randomly assigned positive or negative values creating randomized clusters. The data points of the clusters were summated to create cluster values. After repeating this 1000 times, the cluster values provided the permutation distribution. The clusters of the original data were then compared to this distribution to test their significance.

The final step of analysis was threshold-free cluster enhancement (TFCE). The analyses were performed on different time segments on two fixed frequency bands, alpha (8-15 Hz) and beta (15-30 Hz), showing at what times there was significant ERD/ERS within these intervals.

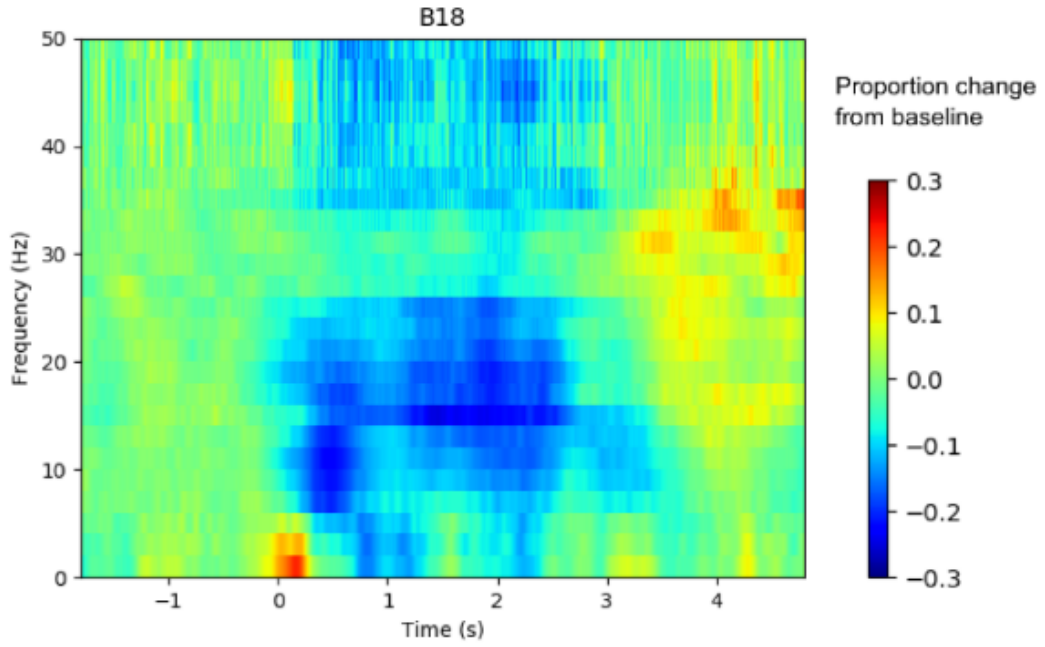
Results

Time-frequency analysis

The time-frequency plots showed four different prominent time-frequency response (TFR) patterns, both of which could be seen at either the group level average, or when analyzing individual subjects. Three of these TFR patterns had their maximum in the area around the contralateral sensorimotor cortex (right hemisphere). This can be illustrated by showing the

electrode B18 from the group average (Fig. 1A), which is located in this area. First, in the alpha frequency band (8-15 Hz) there was an ERD starting around 0 and finishing at 3.5 seconds. In contrast, two of the subjects showed an alpha ERS at this localisation and time. Second, in the beta frequency band (15-30 Hz) there was an ERD lasting from 0 to 2.7 seconds, this was also seen in 11 individual subjects. Third, the beta ERD was succeeded by a beta ERS starting at 3.3 and lasting beyond the time window of 4.8 seconds, this was seen in 9 subjects. Around this time there was also a strong beta ERS in frontal and occipital brain regions in several subjects. The fourth pattern that could be seen was an alpha ERS located at the parietal midline and the ipsilateral S1 and lasting from 0 to 1 second. This is illustrated with electrode D19 from the group average, which is situated near left hemisphere S1 (Fig. 1B).

A



B

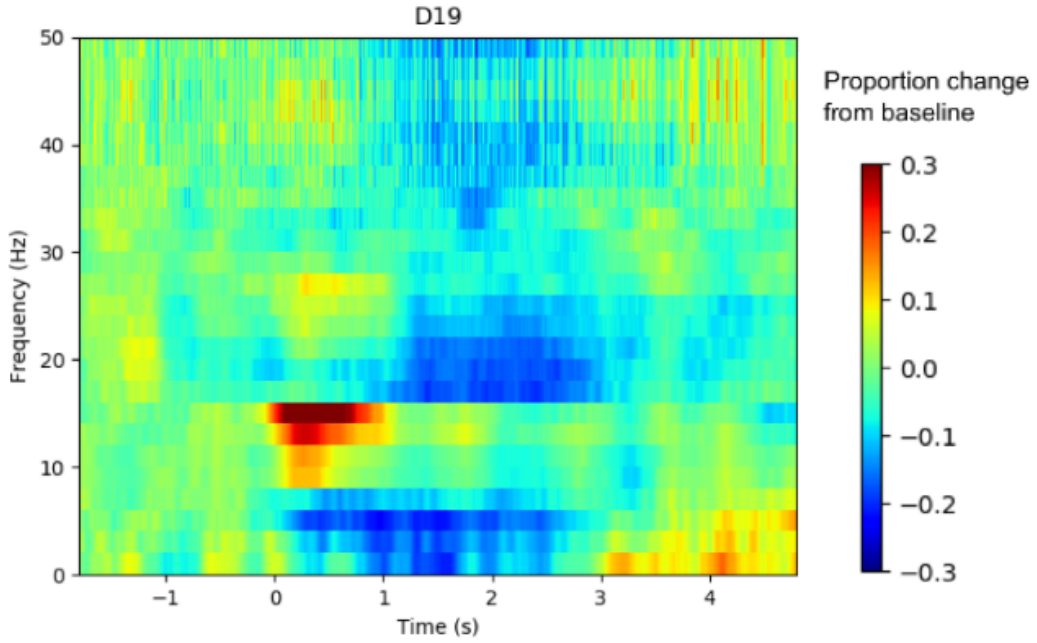


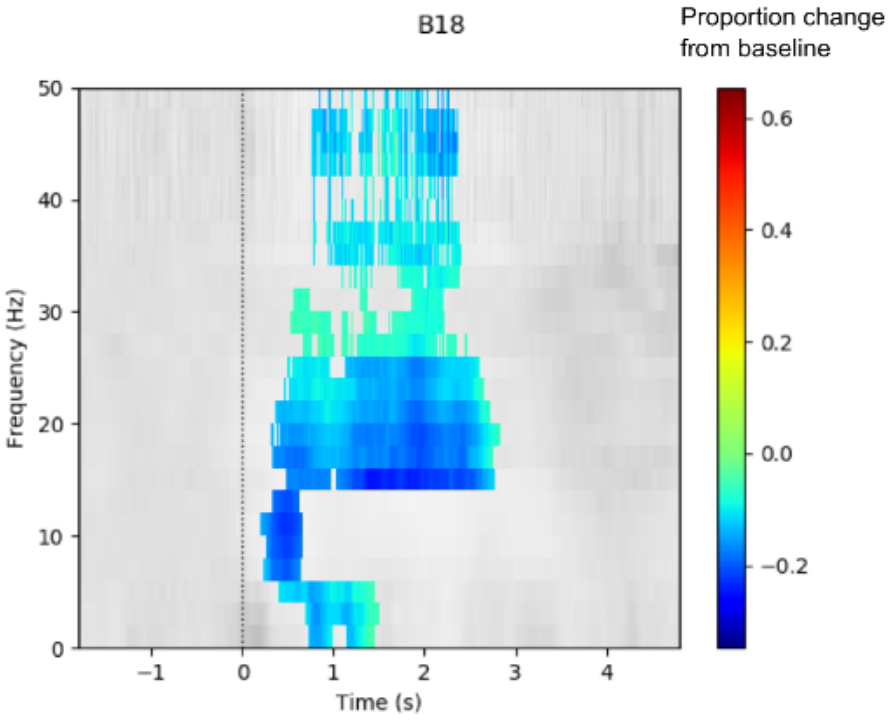
Figure 1. ***A****, time-frequency images from electrode B18 near the contralateral S1. The figure depicts changes in power from the baseline over frequencies from 0 - 50 Hz. Changes are expressed as a proportions of the baseline value.* ***B****, as in A for electrode D19 over the ipsilateral S1.*

Cluster-based statistics on the electrode level

The first step of statistics performed on the group average TFR-plots was cluster based permutation tests on an electrode level. This revealed only the beta ERD as significant for a substantial time and space. This is illustrated in the previously shown B18 electrode (Fig.

2A). The duration here is approximately from 0.2 to 2.8 seconds. In several other electrodes most of the ERD started at around 1.2 seconds (fig. 2B).

A



B

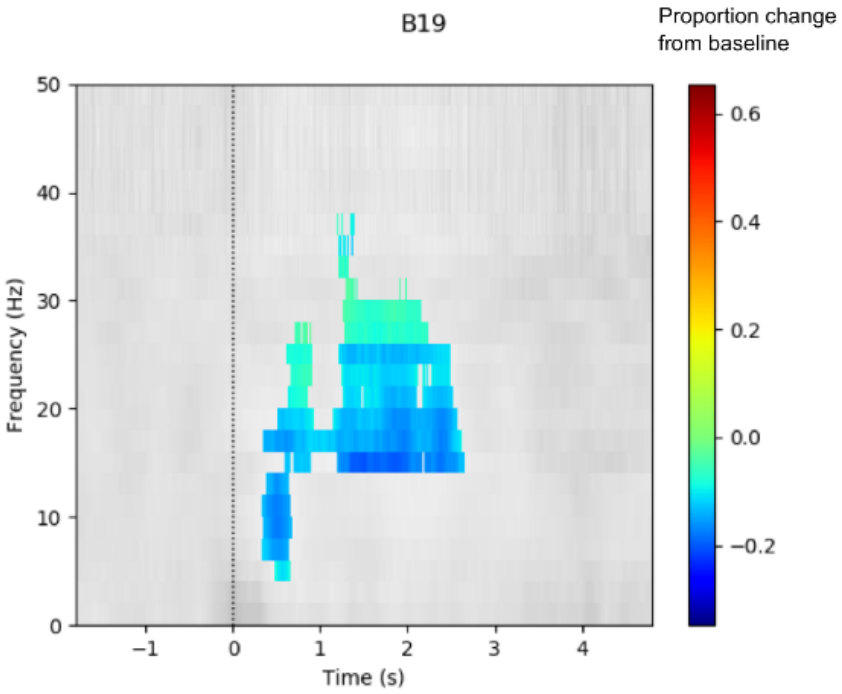


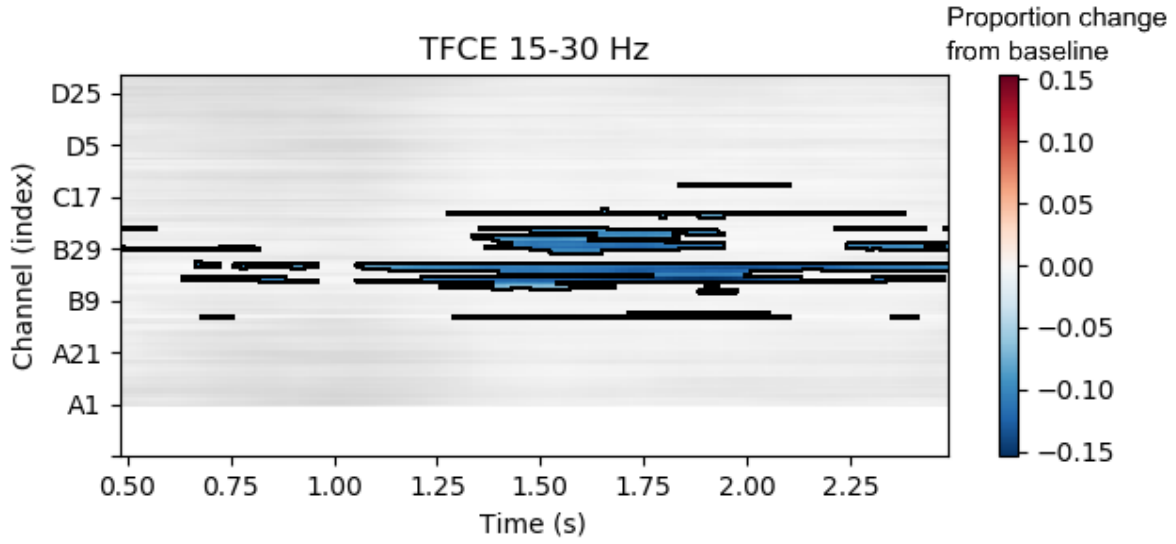
Figure 2. Time-frequency images obtained from cluster-based permutation testing for two electrodes over the contralateral S1. Highlighted areas represent the statistically significant ($p<0.05$) change in power from baseline over 0-50 Hz. Numbers reflect the proportion of change from baseline. ***A****, electrode B18.* ***B****, electrode B19.*

Threshold-free cluster enhancement (TFCE)

When performing TFCE on all of the data, the only significant oscillatory modulation was in the beta frequency. The results were visualized in an overview of the electrodes across time, in this case in the time window 0.5 to 2.5 seconds (fig. 3A). This shows beta ERD in a few electrodes at 0.5 seconds and in several more electrodes after 1.25 seconds. In order to better

visualize the localization of this modulation, topographical plots marking the significant electrodes at specific time points were made. This is exemplified with one plot at 0.8 (fig. 3B) and one at 1.6 seconds (fig. 3C). At 0.8 seconds there was an initial ERD that is localized in proximity to S1, which at 1.6 seconds was spread to a wider area, more frontally and towards the frontal midline.

A



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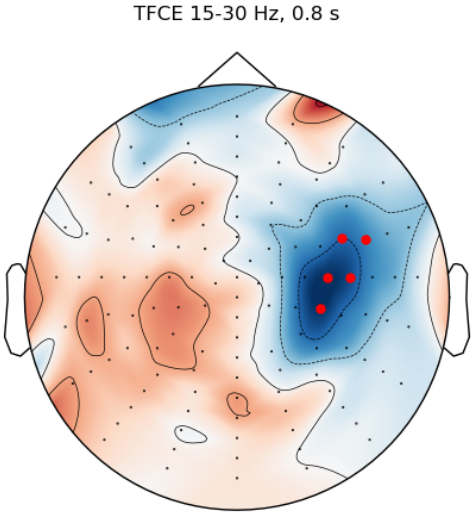

C

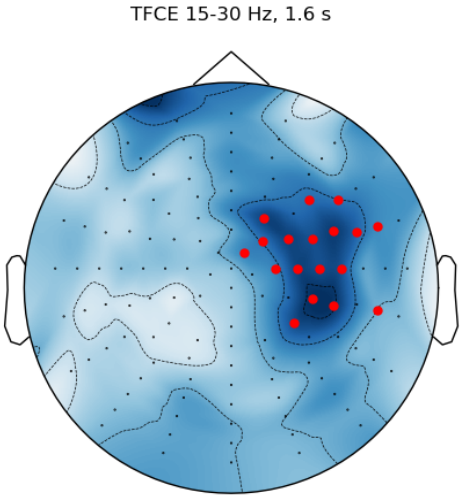

*Figure 3. **A**. An image of the statistically significant changes in power from baseline obtained from TFCE analysis on the beta frequency band, 15-30 Hz,. The figure depicts all electrodes over time, and electrodes that presented significant ERD ($p<0.05$) are highlighted. **B**. Topographical visualization of the data presented in A. Electrodes with significant ERD at 0.8 s are marked with a red dot. **C**, as in B at 1.6 s.*

Discussion

Using a slowly moving brush stimulation and EEG, we wanted to investigate oscillatory changes elicited by gentle touch. Especially brain activation, detected by ERD/ERS, after 1 second was of interest, since the low peripheral conduction velocity of CT-afferents means that any resulting brain activation will start no earlier than about 0.6 - 0.7 seconds after the onset of the stimulus. What we saw was a beta ERD which started around the primary somatosensory cortex, and spread to frontal and midline areas after 1.2 seconds.

The oscillatory modulations that could be discerned from the time frequency images, matched the findings of previous research on sensory stimulation. Even though out of these, only the beta ERD turned out significant, all might be relevant to mention in order to underline the solidity of the results. The modulations found around primary somatosensory cortex were alpha ERD, beta ERD and beta rebound, all of which have been previously reported (Cheyne et al., 2003; Ackerley et al., 2013; Eriksson Hagberg et al., 2019). Furthermore, the finding of alpha ERS in midline and ipsilateral hemisphere simultaneous with alpha ERD in

contralateral somatosensory cortex, supports the idea of activated areas synchronized with inhibition of inactive cortical areas (Neuper and Pfurtscheller, 2001).

The late wave of beta ERD has on the other hand not been reported before. Starting at 1.2 seconds, it had the same timing as the theta ERS that Ackerley et al., 2013 suggested to represent input by CT-afferents. Since ERS represents an inactivated cortical area, whereas ERD represents an activated, this finding might be interesting in the search for the cortical projections of CT-afferents.

The localization of the late beta ERD was frontal and midline electrodes. EEG and MEG activity in these areas can originate from insula and cingulate cortex (Ackerley et al., 2013; Eriksson Hagberg et al., 2019). These areas have also been suggested to receive input from CT-afferents (Olausson et al., 2002; Morrison et al., 2011b Gordon et al., 2013).

Since there is no way of activating CT-afferents in healthy individuals without also activating Aβ-afferents, another explanation of the late beta ERD is that it is caused by Aβ-input. The late activity might therefore have been caused by Aβ-input spreading from primary somatosensory, indicating either further processing in that area or in insular and cingulate cortices. Selective stimulation of Aβ-afferents has caused activation in insula (Sanchez Panchuelo et al., 2016). In a MEG study with tactile stimulation, Eriksson Hagberg et al., 2019 detected an activation in the insula and cingulate cortex that was too early to be due to CT-input.

One might ask why out of all the different observed oscillations, only the beta ERD was found to be statistically significant. In summary, this was the one that showed least individual variation, with 11 out of 14 subjects presenting it. The alpha oscillations showed both ERD and ERS in different subjects, likely rendering them not significant. The beta rebound was too weak to turn out significant, due to stronger ERS in frontal and occipital electrodes at the same time. This was likely due to activity in the primary visual cortex and artifacts such as EMG from eye and neck musculature.

The stimulation that was used was in this study was within what has been defined as optimal for activating CT-afferents (Vallbo et al., 1999; Löken et al., 2009). This provides confidence that we have in fact stimulated CT-afferents. One important difference from previous research by Ackerley et al., 2013, was the use of 128 electrodes instead of 64. This provided a higher spatial resolution, which might explain why the late beta ERD was seen in this case and not in that study.

The number of participants in this study was in the same range as the in published articles in the research field. Ackerley et al., 2013 used 16 and Eriksson et al., 2019 used 15 subjects. But since many of the observed oscillations in this study turned out not significant, one might nonetheless wonder whether a larger sample size would have prevented this. This is however not necessarily the case. In some subjects they are strong enough to be seen on an individual level, and some subjects present the complete opposite pattern. Strong artifacts in one or a few individuals can also make a pattern that was seen in most individuals not significant, which was the case with the beta rebound.

The statistical methods that we have used are quite strict, and we can therefore have quite strong confidence in our findings. One disadvantage with the cluster based statistics is that the significant cluster might be the peak of an outstretched activity that in reality has a longer duration. This could mean that the late ERD we have seen is a part of an activity that actually started earlier. However, when using the TFCE method, we calculate the significance of each individual time point, while correcting for the multiple-comparison problem. We can thus assume that the TFCE-detected activity at any time point actually reflects the time when it starts being significant.

Conclusions

We have used a soft brush stimulus optimal for CT-afferents, while recording EEG. Time-frequency analysis has been performed on the data, in order to detect oscillatory modulations in response to the stimulus. What we discovered was a beta ERD that started around 0 seconds in close proximity to the primary somatosensory cortex, before spreading to frontal and midline areas at around 1.2 seconds. This matches the long latency at which CT-input is expected to reach the brain. Since these experiments were conducted with 128-electrode EEG, they had a higher spatial resolution than previous research, which can explain why this activity has not been detected before. In order to conclude which region is responsible for the beta ERD, and consequently gain further knowledge of the importance of this finding, the next step in this research will be to use source localization analysis. This is a method that uses an MRI image of a subject's brain in order to calculate the sources of the EEG signals recorded on the scalp. Nevertheless can we with this study present a new possible

representation of the cortical processing of gentle touch: a late beta ERD. This might be one step further towards an understanding of our perception of pleasant touch and in what ways it affects our behavior.

Populärvetenskaplig sammanfattning på svenska

Synkronisering och desynkronisering - Hur människans hjärna bearbetar lätt beröring

Hos människan finns det två typer av sensoriska nerver som på huden registrerar lätt beröring. Dessa två kallas Aβ- och CT-afferenter. De registrerar när något rör vid huden och skickar då elektriska impulser upp till hjärnan, vilket leder till känslan av beröring. Aβ-afferenter leder elektriska impulser snabbt och har funktioner såsom att avgöra objekts lokalisering och rörelse över huden. CT-afferenter leder elektriska impulser långsamt och har endast receptorer belägna i behårad hud. Deras funktion är ännu inte helt känd, men det finns forskning som indikerar att de är viktiga för hur behaglig vi upplever att en beröring är. Man vet heller inte vart i hjärnan de impulser de skickar till slut hamnar. Detta har lett till att mycket forskning har gjorts på detta, för att få en större förståelse för hur behaglig beröring bearbetas i hjärnan och i slutändan hur den skulle kunna påverka vårt beteende.

En av de metoder som har använts för att studera hur lätt beröring bearbetas i hjärnan är elektroencefalografi, förkortat EEG. Den fungerar genom att man placerar elektroder på huvudet hos en försöksperson. Dessa elektroder kan registrera de spänningsskillnader som uppstår när nervcellerna i hjärnan skickar elektriska impulser mellan varandra. Detta kan dels ses som positiva eller vågor eller som en synkronisering eller desynkronisering av nervcellernas impulser, vilket innebär att impulser vid vissa frekvenser ökar eller minskar.

Synkroniseringen anses stå för en del av hjärnan som är inaktiv, medan desynkronisering anses stå för en del av hjärnan som aktivt bearbetar information.

Vid en tidigare EEG-studie på lätt beröring såg man två positiva vågor, en tidig och en sen. Tidpunkten för den första var då man förväntar sig att impulser från Aβ-afferenter når hjärnan, och tidpunkten för den andra var då man förväntar sig att impulser från CT när hjärnan. Denna sena våg såg man däremot inte när man gjorde ett liknande experiment med Magnetoencefalografi (förkortat MEG, en metod som registrerar magnetfält som uppstår av de ovan nämnda spänningsskillnaderna i hjärnan). Syftet med denna studie har därmed varit att med EEG vidare undersöka aktivitet som uppstår i hjärnan vid lätt beröring, med en fokus på eventuell sen aktivitet. Detta för att få en större förståelse för hjärnans bearbetning av lätt och behaglig beröring. En väsentlig skillnad från tidigare den EEG-studien är att vi har använt oss av en EEG-inspelning med 128 elektroder, istället för 64. Detta för att få en högre precision för var i hjärnan vi ser aktivitet och för att eventuellt se något man inte tidigare kunnat se. Den typ av aktivitet vi har letat efter i detta arbete är synkronisering och desynkronisering av nervcellernas impulser. Det frekvensintervall vi främst tittat på kallas beta, vilket innebär impulser mellan 15 och 30 Hz.

EEG spelades in på 14 försökspersoner, samtidigt som de stimulerades med en mjuk borste på överarmen 200 gånger, på ett sådant sätt som definierats som optimalt för att aktivera CT-afferenter. Med hjälp av medelvärdet för de 200 stimuleringarna utfördes så kallad tids-frekvensanalys. Med denna metod räknade man ut synkronisering och desynkronisering av nervcellsimpulser efter stimuleringstillfället.

Det mest framstående resultat vi fick var en desynkronisering i mittlinjen av hjärnan efter 1,2 sekunder. Eftersom vi såg en desynkronisering kan vi anta att detta representerar en del av hjärnan som aktivt bearbetar information. Den sena tidpunkten för denna aktivitet stämde överens med då man kan förvänta sig att impulser från CT-afferenter når hjärnan. Man har tidigare sett aktivitet i mittlinjen när man har studerat lätt beröring med EEG och MEG, men inte i form av en desynkronisering vid denna sena tidpunkt. Därmed anser vi att vi har hittat en ny möjlig representation av hjärnans bearbetning av lätt och behaglig beröring. Vi tror att den sena aktiviteten beror på både impulser från CT- och Aβ-afferenter, vilket stämmer överens med tidigare slutsatser om att båda typerna av afferenter är viktiga för upplevelsen av beröring som behaglig. Vidare forskning krävs för att utreda betydelsen av den sena desynkroniseringen, och den fortsatta planen inom forskningsgruppen är att räkna ut vilka anatomiska strukturer i hjärnan som gett upphov till denna aktivitet.

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