AVATAR'S FACES IN EEG

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In our daily lives *emotions* play an important role in how we think and behave. The emotions we feel can compel us to take action and the recognition of emotions enables us to interact with others and adapt our behaviour to the circumstances. Particularly facial expressions contain a lot of information that allow us to interpret emotions and analysing the brain processes during recognition of different facial emotions (e.g. anger, happiness, fear) can help us to better understand emotion recognition and social cognition.

Sometimes the quality in emotion recognition can be diminished due to neurological diseases like epilepsy. In our study, we plan to compare the reaction towards fearful and neutral faces in actors and computer generated faces, so called avatars between healthy subjects and people who suffer from epilepsy. Our aim is to better understand the processing of emotion recognition in faces in the neural system and the effects of avatars on the quality of emotion perception.

EPILEPSY

Epilepsy is defined as a condition of recurrent unprovoked seizures that start in the brain. These seizures are brief lapses of attention or brief episodes of involuntary movement or sensations that may involve a part of the body, the entire body and are sometimes accompanied by loss of consciousness. Seizures are a result of excessive electrical discharges in a group of brain cells and the characteristic of a seizure depends on where in the brain the disturbance starts, and how far it spreads. The causes can be complex and sometimes hard to identify, but may include a genetic tendency or a structural change in the brain (e.g. a stroke, head injury or tumor). Around 50 million people worldwide have epilepsy, making it one of the most common neurological diseases globally. Usually medication with anti-epileptic drugs is the most important and common treatment, an up to 70% of the people can become seizure-free with medication. Other treatment options are for example brain surgery, deep-brain stimulation, vagus-nerve stimulation or a ketogenic diet.

Deficits in emotion recognition and social cognition are especially reported in people suffering from temporal lobe epilepsy (TLE) (Meletti et al. 2003, 2009, Bonora et al. 2011, Broicher et al. 2012, Amlerova et al. 2014, Steiger/Jokeit 2017). TLE is a chronic disorder characterized by recurrent focal seizures that originate in the temporal lobe of the brain. The primary functions of the temporal lobe are to process sensory information and derive it into memories, language, and emotions. Located within the temporal lobe are the hippocampus and the amygdala, which are part of the limbic system. The hippocampus manages the formation of new memories and communicates closely with the amygdala, which is responsible for the processing of emotions. Parts of the temporal lobe (fusiform gyrus, parahippocampal gyrus) are needed for the processing of visual stimuli to allow us to recognize objects or faces. Our temporal lobes are essential to process emotional information and impairments in these structures seem to be connected to deficits in emotional perception.

ACTOR VS AVATAR

Investigating emotional perception in an experimental environment demands meaningful and realistic stimuli material. The quality of emotional information depends on the pictures and videos presented that contain facial expressions. Recent studies have already shown that it may be helpful to use avatars to examine and possibly enhance emotion recognition in a variety of conditions like autism (Bekele et al. 2014, Hopkins et al. 2011) and schizophrenia (Dyck et al. 2010). However, while emotional faces of avatars have been shown to elicit amygdala activation comparable to that elicited by human faces in healthy participants, responses to human faces in face-sensitive cortical structures were found to be significantly stronger (Moser et al. 2007).

IDEA BEHIND OUR PROJECT

The overall purpose of the EEG study was to learn about the basis of processing of dynamic emotional expressions in human as well in avatars.

In order to achieve this, we compared brain electrical responses elicited by fearful and neutral facial expressions of actresses/actors and their avatars. The evaluation of the difficulties associated with processing of facial expressions makes it absolutely necessary to use valid stimuli that fully capture the facial and emotion related information displayed in a face. However, most studies on the perception and recognition of facial expressions have used static pictures displaying different emotional expressions. Only few studies applied dynamic facial expressions, which are considered to be more ecologic and therefore closer to daily life (Sarkheil et al. 2013). Yet designing and generating dynamic facial stimuli poses the problem of controlling for temporal und figural properties of the face and the developing facial expression. A promising way to bypass this is the use of computer-generated avatars, which allow to form and systematically control important features of the facial expression. We hypothesise that there will be a significant differences in both people with epilepsy and healthy controls elicited by facial expressions of actresses/actors and their avatars.

The secondary objective was to differentiate between brain electrical responses of people with and without epilepsy to fearful and neutral facial expressions. In particular, we invited patients diagnosed with temporal lobe epilepsy to take part in our study. We hypothesise that the responses to fearful facial expressions are significantly reduced in people diagnosed with temporal lobe epilepsy as compared to healthy controls, as it has been shown in earlier functional MRI studies (Schacher et al. 2006, Broicher et al. 2010).

EEG: WHAT CAN YOU MEASURE?

At the root of all our thoughts, emotions and behaviours is the communication between neurons within our brains. The billions of nerve cells in your brain produce very small electrical signals that form patterns called brain waves while they communicate with each other. An 'electroencephalogram' (EEG) is a test used to evaluate the electrical activity in the brain and is considered by many to be one of the most efficient and relatively inexpensive methods for examining activity in the brain. It provides excellent time resolution, allowing us to detect activity within cortical areas, even at sub-second timescales. It tracks and records these brain wave patterns of varying frequency and amplitude, measured in voltage. These EEG waveforms are generally classified according to their frequency, amplitude, and shape, as well as the sites on the scalp at which they are recorded.

Our brainwaves change according to what we're doing and feeling. When slower brainwaves are dominant we can feel tired or dreamy. The higher frequencies are dominant when we are alert and awake. Altered brain waves can be measured in several types of brain disorders. For example, when epilepsy is present, seizure activity can appear as rapid spiking waves on the EEG. The EEG test can also be used to diagnose other disorders that influence brain activity, such as Alzheimer's disease or sleep disorders. Electrical activity in the brain can also be measured as a response to an external stimulation of e.g. sight, sound, or touch in an experimental condition. These are called evoked potential studies.

HOW IS IT USED?

A varying number of small flat metal discs called electrodes are attached to the scalp with a conductive gel, paste or dry. The majority of signals captured by EEG represent the summation of cortical pyramidal cells in the upper layer of the brain. The electrodes on the scalp are very sensitive and they detect these dipoles formed by ten to fifty thousand neurons. EEG poorly measures neural activity that occurs below the upper layers of the brain (the cortex). The charges picked up by the electrodes are amplified and send to a computer that records the results.

The electrical impulses in an EEG recording look like wavy lines with peaks and valleys (fig. 1). Analysing these data can get quite challenging. Signal processing, artefact detection and attenuation, feature extraction, and computation of mental metrics such as workload, engagement, drowsiness, or alertness all require a certain level of expertise and experience to properly identify and extract valuable information from the collected data.

FIG. 1

EXAMPLE OF EEG SIGNALS. EACH LINE REPRESENTS THE SIGNAL MEASURED AT A SPECIFIC ELECTRODE LOCATION ON THE SCALP.

THE STUDY

We invited 10 healthy controls and 10 TLE subjects to participate in our study. Subjects sat in front of a screen in a comfortable position, watching videos and pictures of the actresses/actors and avatar stimuli material while continuous EEG signals were recorded with twenty-one sintered Ag/AgCl scalp electrodes that were placed on the head of each subject (fig. 2).

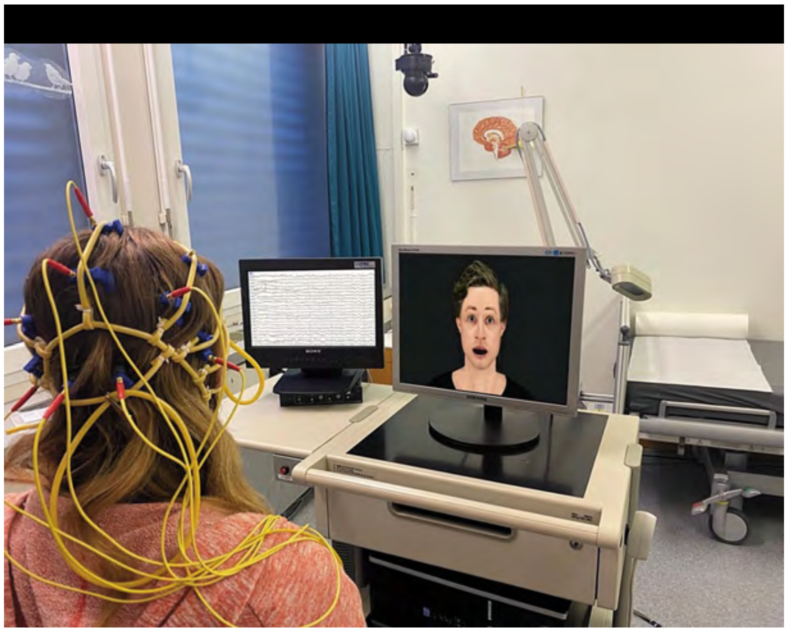

FIG. 2
EXPERIMENTAL SET-UP AT THE EPILEPSY CENTER AT KLINIK LENGG, ZURICH.

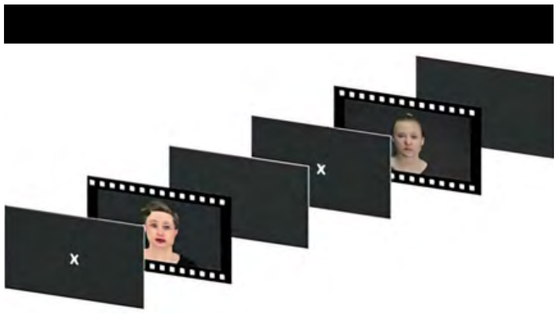

FIG. 3
STIMULI ITERATION. EACH SINGLE ITERATION OF A FIXATION CROSS FOLLOWED BY THE VIDEO/PICTURE FOLLOWED BY A BLANK SCREEN IS LABELLED AS A TRIAL.

PROTOCOL

In the first part of the experiment subjects watched 120 brief videos (2–3 sec) of faces of actresses/actors and their avatars showing neutral as well as fearful faces on a computer screen in randomized order, separated from each other respectively by 4sec of blank screen with a fixation cross in the middle of the screen (fig. 3).

Afterwards subjects did a second round with the same sequence but videos were replaced with pictures that have been taken from each clip. To keep subjects engaged, they were asked to perform an attentional task by pressing a button during a specific control condition.

RESULTS

For analysing the EEG datasets, the trials for each condition (ACTOR neutral, ACTOR fear, AVATAR neutral, AVATAR fear) are averaged and the signal is processed.

Is there a difference in the brain electrical response between watching actresses/actors and their avatars?

EEG signals were measured while subjects watched subsequent pictures of actors and their avatars with neutral and fearful facial expressions. The trials of each condition (i.e. actor or avatar with neutral/fearful faces) were then averaged to measure the specific brain response to the different faces, this response is called an event-related potential (ERP).

As an example, the measured EPRs to the four different conditions of 5 healthy volunteers are shown in fig 4. The waveform represents the time locked reaction of the brain (measured over CZ) within 1000 ms after the pictures are presented. The blue waves show the reaction to faces of actors with neutral (light blue) and fearful (dark blue) expression, the red curves the reaction to faces of avatars with neutral (light red) and fearful (red) expression.

We can see a fast reaction to the different stimuli within only 100–200 ms after presentation and the waveforms seem to differ after 200 ms dependent on whether the picture of an actor or avatar is presented. A more long-lasting change between the different curves is seen after 300 ms.

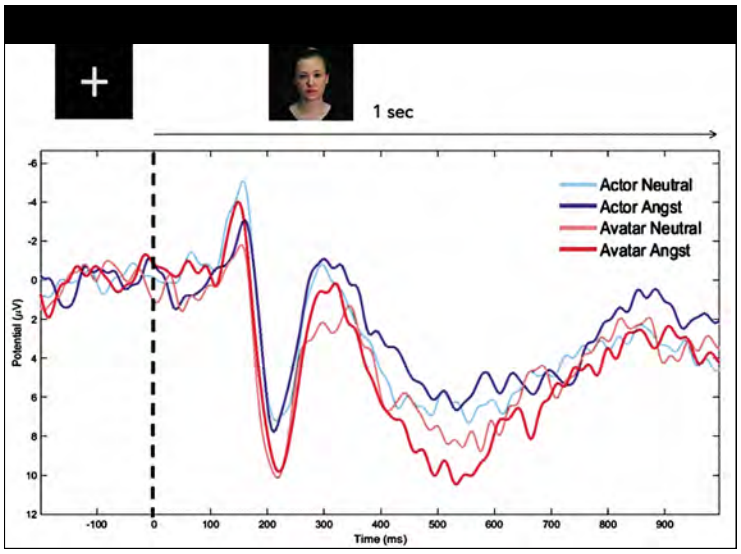

FIG. 4

EPRS TO THE FOUR DIFFERENT CONDITIONS ANALYSED FOR 5 HEALTHY VOLUNTEERS.

Is there a difference between brain electrical responses of people with and without epilepsy to fearful and neutral facial expressions?

EEG signals were measured while subjects watched the 120 video clips and subsequently the trials of each condition were averaged. Afterwards a so-called time-frequency spectrum (fig. 5) was computed, where we calculated the intensity of power (dB) in each frequency over the period of time while the subjects watched the videos. As an example, we can have a closer look on the condition ACTOR fear. The more activated the brain, the more power is produced and the more intense the colours of the heat map become. The intensity of activation is more pronounced in healthy subjects compared to the epilepsy subjects in our study.

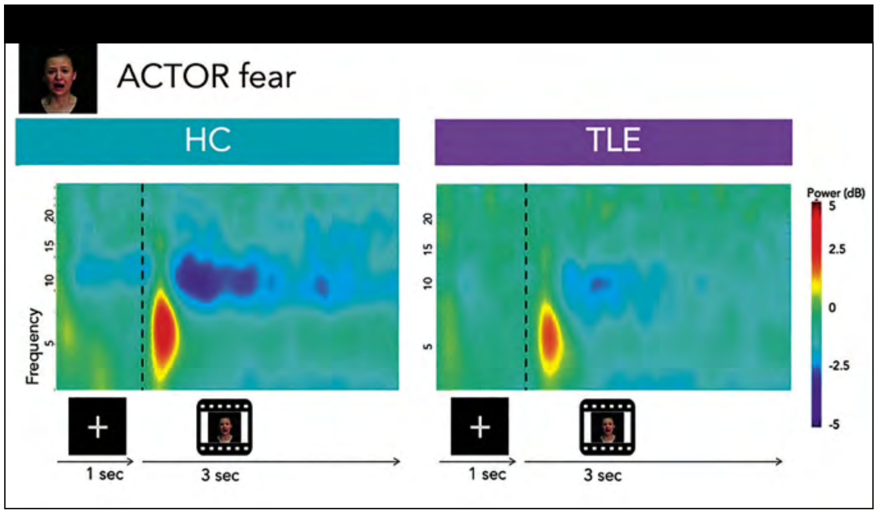

FIG. 5

TIME-FREQUENCY SPECTRUM OF POWER AT A CENTRAL ELECTRODE.

HC= HEALTHY CONTROL GROUP, TLE = SUBJECTS WITH TEMPORAL LOBE EPILEPSY. THIS IMAGES WERE CALCULATED FOR ELECTRODE POSITION C4.

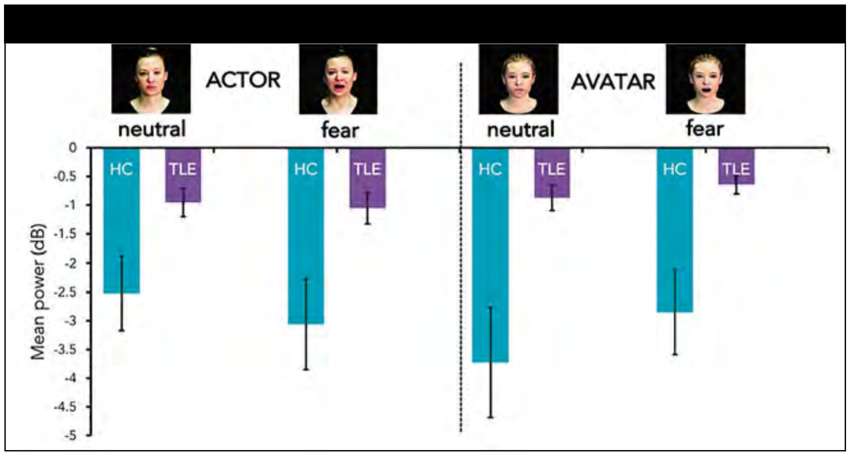

FIG. 6

POWER VALUES OF ALL CONDITIONS FOR HEALTHY AND TEMPORAL LOBE EPILEPSY SUBJECTS.

THE VALUES WERE MEASURED FOR A TIME WINDOW OF 500–2000 MS IN THE FREQUENCY RANGE FROM 8–13 HZ.

In a second step, we are able to transform the values of these heat maps into a numeric value during a specific time window (500–2000 ms) and frequency range (8–13 Hz) for all conditions. These values of power reflect the intensity of electrical response and the results are depicted in fig. 6. The responses to fearful facial expressions seem to be reduced in people diagnosed with temporal lobe epilepsy as compared to healthy controls.

CONCLUSION

So far the EEG measurements suggest that the faces of actresses/actors are perceived different than faces of avatars not dependent on a fearful expression. Fear in faces of actors seem to affect us different than in faces of avatars although further analysis is needed.

In previous studies a reduction in brain electrical activity during emotional perception could be seen in epilepsy patients (TLE). Our preliminary results are reinforcing these findings for fearful facial expressions. In total, we are aiming for a group size of 26 subjects to have statistically meaningful results. Measurements are ongoing and results will be shared with the academic community by publishing an article in a topic related scientific journal.

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