THE SECRET BEHIND THE ACTOR-AND-AVATAR FMRI-STUDY

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Computer-generated faces, or avatars, are often used for commercial purposes in advertising and service industries or scientific applications. Using advanced software, it is possible to create human-like avatars that look and move highly realistic (de Borst/de Gelder 2015). However, we do not know if we perceive human-like avatars in the same manner as other human beings. How does the artificialness of avatars influence brain processes that underlie our behavior towards them? With our research, we work towards closing this knowledge gap and study the difference between the processing of facial expressions shown by human-like avatars or actors. This is realized using a technology called functional magnetic resonance imaging, which is described in the next section.

WHAT IS FUNCTIONAL MAGNETIC RESONANCE IMAGING AND WHY ARE WE USING IT?

Functional magnetic resonance imaging (fMRI) is a variant of magnetic resonance imaging (MRI). Both are imaging techniques that allow us to study the brain from the outside while it is in action. When we are using fMRI, we create images of how the brain is working, what we refer to as *function*. When we are using MRI, we create images of what the brain is made of, what we refer to as *structure*. In combination, both techniques enable us to understand how the brain is working while we perform a cognitive task, experience an emotion, or simply rest and let our thoughts wander (Poldrack 2018). This interest in understanding how the brain works has been the motivation for many fMRI studies, as it is certainly one of the most challenging scientific enigmas to date.

WHAT DO WE MEASURE WITH IT?

Measurements with fMRI exploit the fact that nerve cells in our brain need to be constantly supplied with energy. This energy reaches the nerve cells through the blood vessels in the form of oxygen and sugar. When we perform a cognitive task or experience an emotion, certain regions in the brain become active and the nerve cells in these regions consume more energy than in a state of no activation. This increased energy demand is in turn associated with an increased blood flow, which is measurable with fMRI via the magnetic properties of hemoglobin in the blood (Poldrack/Mumford/Nichols 2011).

HOW IS IT PERFORMED?

In order to create images of how the brain works using fMRI, we need to perform several measurements. In the beginning, we start with a solely structural measurement that maps the shape and structure of the brain. The structural images are needed so that the brain activation, which is measured during the functional measurements, can be overlaid on them to show its location in the brain (Soares et al. 2016).

After the structural measurement, functional measurements are conducted to obtain images of brain activation. Usually, brain activation is measured in two different states: in a state that we want to investigate and, in a state that we want to compare with the state of interest (Poldrack 2018). In our study, we are interested in how the brain is working while people see an avatar's face compared with brain activation while people see an actor's face. When contrasting both conditions, we can see which brain regions are active more strongly in response to an avatar's face or an actor's face.

WHAT DO WE EXPECT FROM OUR FMRI MEASUREMENTS?

In order to understand how the brain is working while people see an avatar or an actor's face, it is important to go back to previous studies investigating brain activation in response to human faces per se. Such studies have revealed that face processing relies on a bilateral network of brain regions in the temporal and frontal lobe of the brain (Duchaine/Yovel 2015, Haxby/Hoffman/Gobbini 2000): the fusiform face area in the fusiform gyrus, the superior temporal sulcus, and the inferior frontal gyrus. In our study, we can also show that these regions consistently become active when participants are looking at the faces of actors. A typical activation pattern is outlined in Figure 1 (showing in color and encircled).

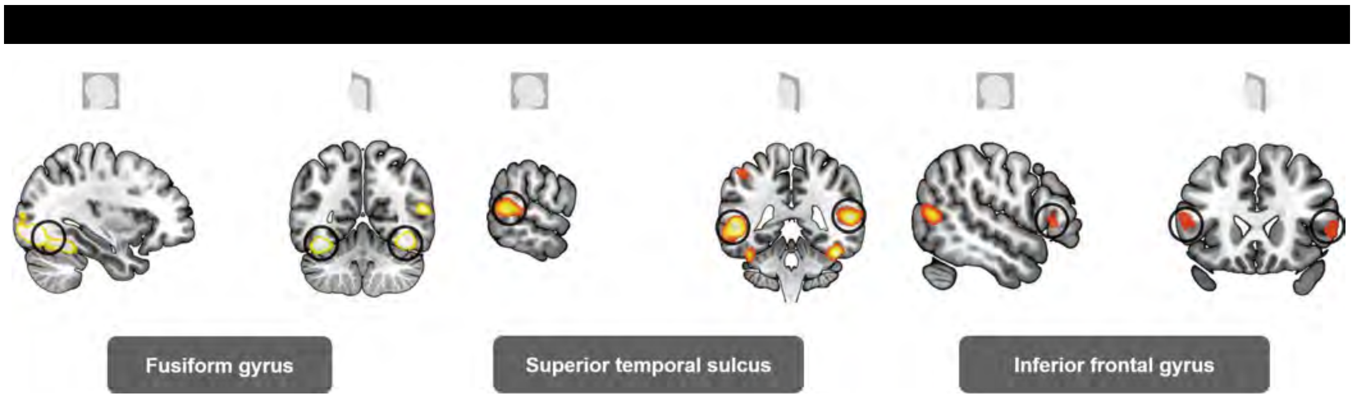

FIG. 1

ILLUSTRATION OF THE TYPICAL BRAIN RESPONSE TO HUMAN FACES. EACH IMAGE SHOWS THE BRAIN ACTIVATION OF ONE PARTICIPANT OF THE FMRI STUDY.

Previous studies have also shown that the amygdala plays an important role while people look at faces, especially when the faces show an emotional expression. The amygdala is essential to people's ability to feel certain emotions and to perceive them in other individuals (Adolphs 2008). Hence, it is bilaterally active in response to faces showing an emotional expression. Such a bilateral activation pattern in the amygdala of one of our participants is outlined in Figure 2.

If the amygdala or other regions in the temporal lobe are altered due to a neurological disease, the entire brain network that is active when people see a face may be affected. Previous studies have shown that this is the case in people with epilepsy that originates in the temporal lobe of the brain (Ives-Deliperi/Jokeit 2019). For example, it was found that the amygdala is less active in response to a human face in the brain hemisphere where the epileptic seizures originate compared with the amygdala in the not affected brain hemisphere (Ives-Deliperi/Butler/Jokeit 2017, Labudda/Mertens/Steinkroeger/Bien/Woermann 2014, Schacher et al. 2006; Toller et al., 2015). Therefore, a further aim of the fMRI study is to compare which brain regions are active while people with temporal lobe epilepsy (TLE) and people without epilepsy look at actor and avatar faces.

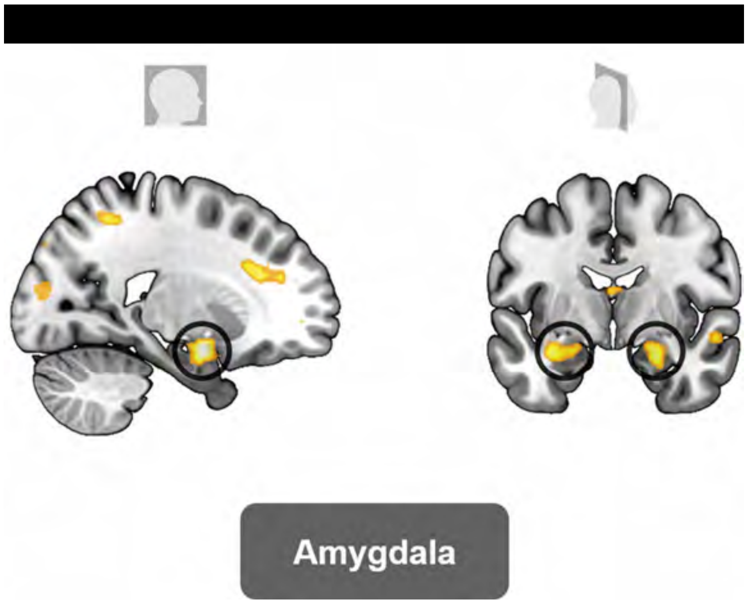

FIG. 2

ILLUSTRATION OF THE TYPICAL AMYGDALA RESPONSE TO HUMAN FACES WITH A FEARFUL EXPRESSION. THE IMAGE SHOWS THE BRAIN ACTIVATION OF ONE PARTICIPANT OF THE FMRI STUDY.

METHODS OF THE FMRI STUDY

For the study, we used a set of videos that have been developed in a four-step process in cooperation with the Zurich University of the Arts:

1. Fearful and neutral facial expressions were recorded from female and male actors.
2. For two female and to male actors, a customized avatar was created by a graphic artist to match their appearance.
3. By motion tracking, the actors' recorded expressions were conveyed onto their avatar faces.
4. The recorded material was divided into single videos of three seconds duration and the best 128 videos were selected to show during the fMRI measurement.

26 participants without epilepsy and 17 partcipants with epilepsy took part in the fMRI measurements. They were scanned with an MRI scanner of the Medizinisch Radiologisches Institut located at the Schulthess Clinic in Zurich. When lying in the MRI scanner, participants watched the videos of actor and avatar faces via a back-projection that was visible by a mirror above their eyes (see Figure 3; the table with the participant is positioned outside

the tube of the MRI scanner for illustration purposes). While images of the brain were created, participants were required to lie as motionless as possible inside the MRI scanner. The measurement took around 35 minutes. Before each video, a fixation cross was presented, so participants knew where the video would appear. After each video, a black screen was presented until the next fixation cross appeared announcing the subsequent video (see Figure 4 for illustration).

FIG. 3

THE FMRI SETTING AT THE EPILEPSY CENTER AT KLINIK LENGG, ZURICH.

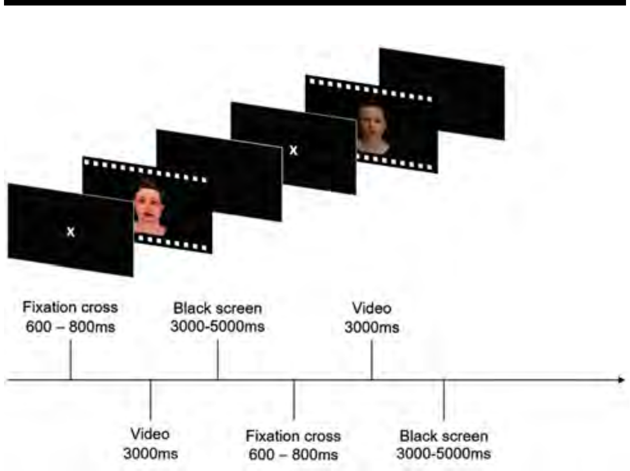

FIG. 4

ILLUSTRATION OF THE PROCEDURE OF THE FMRI STUDY

RESULTS OF THE FMRI STUDY

Before the results are outlined in detail, we want to summarize our three main findings. The first two findings are based on the results found in participants without TLE and the third finding is based on the comparison between participants with and without TLE:

1. While participants look at avatar faces with a neutral expression, the brain is active in a similar manner than when people look at faces of actors with a neutral expression.
2. While participants look at avatar faces with a fearful expression, certain brain regions are less active than when participants look at faces of actor with a fearful expression.
3. The difference in response to fearful avatar faces and fearful actor faces is smaller in participants with TLE than in participants without TLE.

Concerning the second finding, an activation difference between fearful expressions of avatars and actors emerges in the superior temporal sulcus and the inferior frontal gyrus. Both regions are sensitive to human faces and human facial motion, which also has been shown in previous studies (see again Figure 1; Duchaine/Yovel 2015, Haxby et al. 2000). In other words, avatar faces do not seem to activate these brain regions in the same way as their human counterparts. However, as the first finding shows, this difference between avatar faces and faces of actors is only present if the faces show an emotional expression.

When comparing the brain activation in participants with TLE to participants without TLE, we see that several regions that are associated with the processing of faces are less activated in participants with epilepsy. For example, the amygdala (see again Figure 2) of participants with TLE shows a smaller response to avatar faces and faces of actors with a fearful expression than the amygdala in participants without TLE.

SUMMARY AND OUTLOOK

In summary, some regions in our brain work differently when we look at actor faces than when we look at avatar faces. Furthermore, if epilepsy is present, it influences these brain activation patterns. It is likely, that these differences in response to avatar faces also have an influence on our behavior during interactions with avatars. This has important consequences for the use of avatars in various commercial and public applications and research. Interestingly, avatars and computer-generated characters in general are increasingly being used in diverse fields. As a result, with every day we become more experienced with such characters. How will this increasing exposure with computer-generated characters influence our behavior towards them? How will our brain adapt to this? At this point, we note that we currently have no answers to these questions and are in need of future studies to address this.

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