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Being with virtual others: Studying social cognition in temporal lobe epilepsy

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Abstract

Social cognitive neuroscience has highlighted the importance of frontotemporal neurocircuitry for social cognition. Temporal lobe epilepsy (TLE) impacts these brain areas and their functional connections and might therefore specifically affect social perceptual and cognitive skills. In the study described here, an established paradigm was used to evaluate the social cognitive skills of female patients with left TLE. Study participants were shown dynamic animations in which virtual characters either looked at the human observer directly or looked away toward someone else, thus manipulating self-involvement. The virtual characters then exhibited different facial expressions that were either socially relevant or arbitrary. Participants were asked to rate the communicative intentions of the virtual character. Patients’ ratings of communicative intent appeared to be linked to their own self-involvement in the interaction, whereas healthy volunteers’ ratings of facial expressions were independent of self-involvement. Potential mechanisms for the observed differences are discussed.

Keywords: Virtual characters; Facial expressions; Social cognition; Temporal lobe epilepsy

1. Introduction

To interact adequately and successfully, individuals must recognize each other as mindful beings and decode relevant social cues to generate adaptive behavior. Social cognition can, therefore, be understood as the group of all processes by which people perceive and make sense of themselves and other persons. Frontotemporal neurocircuitry has been shown to be vital for such social perceptual and cognitive processes [1–6]. In a recent review, Kirsch reported that lesion and functional imaging studies impli-
Cognitive functions, particularly in the domains of language and memory, have been extensively studied in TLE. An increased frequency of comorbid psychiatric conditions, particularly depression, is also well described [14,17,18].

On the other hand, little is known about how TLE may impact social cognition. There is evidence from studies in children and adolescents that epilepsy may impair social competence [19,20]. A recent study suggests that this finding may be more pronounced in girls and young women than in boys [21]. Although the etiology of impaired social competence in epilepsy may be multifactorial, Caplan et al. [22,23] suggested that demographic factors and subtle cognitive problems may be the most important factor influencing the development of social competence in children. Disturbed functional integrity of frontotemporal networks is assumed to contribute to this finding by dysregulating impaired social cognition in TLE. Indeed, Schacher et al. [24] were recently able to demonstrate that MTLE leads to specific impairment of one aspect of social cognition in adults—the detection of a social faux pas.

Another critical aspect of successful social interaction is the correct recognition of communicative intent. Our own recent functional magnetic resonance imaging (fMRI) study investigated this phenomenon in healthy volunteers [1]. Study participants were shown short video sequences in which virtual characters displayed either socially relevant facial expressions or arbitrary facial movements. Interestingly, one of the brain regions that showed differential activity for self-directed social interactions was the left mesial temporal area.

On the basis of this evidence, we hypothesized that patients with left TLE may be particularly impaired in their ability to correctly identify communicative intent. In this study, we were able to make use of our established paradigm, which had been shown to successfully evaluate exactly this aspect of social cognition. As females may be more likely to manifest impaired social competence than males [21], we limited our initial behavioral study to female participants.

### 2. Methods

#### 2.1. Study participants

#### 2.1.1. Patients

Patients were recruited from the epilepsy monitoring unit (EMU) of the Department of Neurology at Johns Hopkins Hospital, as well as from the Johns Hopkins epilepsy outpatient clinics. All patients provided informed written consent for participation in this study.

Ten right-handed females (mean age 36.0, SD 11.6) with a history of complex partial seizures participated in this study. In all of our patients, the epileptogenic focus had been localized to the left temporal lobe via EEG/video/EEG and/or positron emission tomography (PET) studies demonstrating hypometabolism. Magnetic resonance imaging had demonstrated mesial temporal sclerosis (MTS) in 2 of 10 patients, whereas it revealed no structural imaging abnormalities in the remaining 8 patients. All participants had a documented Mini Mental Status Examination (MMSE) within normal limits. Table 1 summarizes information on seizure variables and antiepileptic medications.

Because of the increased incidence of depression in epilepsy [14], participants also completed the Beck Depression Inventory (BDI) to rule out mood disturbance as a possible confound (BDI score 6.6 ± 4.1). A BDI score equaling 16 or higher (mild clinical depression) was used as an exclusion criterion for this study. Two of our 10 subjects had BDI scores of 13 and 14, indicating the presence of a mild mood disturbance; all other participants had a normal score. Therefore, we performed all statistical analyses with and without these two subjects.

#### 2.1.2. Healthy volunteers

The comparison group consisted of 10 right-handed healthy female volunteers (mean age 32.3, SD 5.9) who were screened for the presence of neurological and psychiatric disorders including depression by means of extensive intake questionnaires. Participants were on no regular medications. These subjects were recruited as part of an ongoing study into social cognition conducted at the Research Center Juelich with approval of the local ethics committee.

#### 2.2. Stimulus material, tasks and study design

##### 2.2.1. General concept

For this behavioral study we used stimuli originally developed for an fMRI study of healthy volunteers [1]. The stimuli consisted of dynamic video animation sequences that had been designed using the software package Poser 4.0 (Curious Lab). These short video sequences depict virtual characters that appear on screen and exhibit dynamic facial expressions as they would appear in real-life approach situations when initiating social interactions [25,26]. The video sequences are systematically varied in the following two respects. First, facial expressions of the virtual characters are socially relevant (SOC) in that they are indicative of variation in communicative intent.
of someone’s intention to establish interpersonal contact, whereas facial movements are arbitrary and socially irrelevant [ARB]. Second, virtual characters shown in the experiment either turn toward and gaze at the human observer directly [ME] (Fig. 1a) or look aside and away from the human observer toward a third person not visible to the study participant but situated at an angle of approximately 30° [OTHER] (Fig. 1b), thus modulating the observer’s self-involvement. The resulting two factors, (1) “social interaction” [SOC vs ARB] and (2) “self-involvement” [ME vs OTHER], thus, constitute a two factorial design (Fig. 1c). As only the second question specifically required the decoding of social cues, our design also allowed us to assess whether subjects were able to simply watch a video clip and answer questions about it.

Condition-specific dynamic changes in facial expression were modeled in accordance with the Facial Action Coding System (FACS) [27]. To this end, the so-called “Action Units” of the FACS were implemented as polygon groups on the virtual characters’ mesh wire structure and manipulated to generate changes in facial appearance. It is important to point out that we did not manipulate the display of facial emotion but focused on facial expressions that, in accordance with human ethology literature, are transculturally known to indicate the intention to communicate and to interact socially [25,26]. Animation of facial motion was realized by interpolating images between the neutral and condition-specific facial expressions/movements, as well as body positions of the virtual character. Video sequences were generated simulating a 100-mm-focal-width camera view. In the video files the virtual characters appeared with a light gray background (Fig. 1a). Overall all video sequences walking direction of the virtual character (from left to right, from right to left), the direction of its gaze (to the left, to the right), its hair color (four different colors), hair style (four different hair styles) and its gender were systematically varied and balanced. Face morphology of the avatars was varied randomly while trying to assemble a neutral and homogenous group of characters. The temporal order of each video sequence adhered to a standardized design. During each clip, subjects saw the virtual character walk into the center of the screen, turn, display a facial expression or facial movement, turn again, and walk off the screen. Following this, two signal words appeared on the screen, shown one after the other. The purpose of each was to prompt the subject to answer two questions about their perception of (1) self-involvement and (2) degree of social interaction in each clip. Each video clip lasted 7.5 seconds and was followed by the presentation of two signal words on screen (shown for 3 seconds each). Participants were instructed to evaluate the video sequence they had just seen via button press. One complete testing session included 100 trials.

2.2.2. Specific instructions

All subjects received standardized instructions on the computer screen prior to the start of the experiment. Study participants were told to consider themselves as part of a virtual scene with two other virtual agents (Fig. 1b), one of which would appear face-to-face throughout the experiment (as in Fig. 1a) and express mimic behavior. The other virtual agent could not be seen on screen at any time from the test subject’s point of view. The subject was instructed to assume that this agent stood close to the participant at an angle of approximately 30° (right or left) (Fig. 1b). No additional explicit instructions concerning this second other were given.

The facial expressions of the virtual character seen vis-à-vis could, henceforth, be directed toward the human observer herself (0°, ME) or toward another virtual other (30°, OTHER). After each stimulus the participant was asked to answer two questions, which were each indicated by a signal word appearing on the screen: (1) Had the character seen vis-à-vis been looking at her or the other agent [WHO]?

(2) Did she feel that the

Fig. 1. (a) Exemplary picture of a male virtual character as seen by test subjects during the experiment (here: SOC_MEO). (b) Virtual scene as shown in the instructions. (c) Two factorial design.
virtual character tried to greet and initiate any kind of interpersonal interaction with whomever he or she was looking at (CONTACT)? Concerning the latter question, they were explicitly instructed to judge the interaction from the point of view of the person addressed, that is, their own point of view or the other’s point of view. The former question had to be answered using two buttons, the latter by indicating the level of social relevance on a 4-point scale (1 = high, 2 = rather high, 3 = rather low, 4 = low). Subjects were instructed to respond as quickly as possible after the display of each signal word. Nonetheless, all responses were non-speeded responses because there was a delay of >4 seconds from the presentation of the facial expression/movement to the display of the first question. Reaction times were therefore not recorded.

2.3. Statistical analysis

Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS for Windows; Version 12.0) and consisted of two-tailed analyses at a significance level of $P < 0.05$. To ensure that significant results are not due to multiple comparisons, we further adjusted the $\alpha$ level in accordance with the number of tests. Results that reach a level of $P < 0.0125$ can be regarded as significant also at this corrected, more stringent statistical threshold. Dependent variables were overall accuracy (percentage of correct responses across conditions) and ratings of social relevance. Means and SD of test results from the control and TLE groups are reported in Tables 2 and 3.

Nonparametric statistics (Mann–Whitney U test for between-group comparisons, Friedman and Wilcoxon signed ranks tests for within-group comparisons) were performed because some of the variables failed to approach a normal distribution and because of the small sample size [28].

3. Results

As expected, healthy control participants did not have difficulties in using eye gaze and body posture information to decide who was addressed by the virtual character, resulting in a correctness score of $99.3 \pm 0.7\%$ in response.

Table 2

<table>
<thead>
<tr>
<th>Control subject</th>
<th>Gender</th>
<th>Handedness</th>
<th>Age</th>
<th>Correctness score (ME vs OTHER)</th>
<th>Individual response averages/condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) S.A.</td>
<td>F</td>
<td>R</td>
<td>27</td>
<td>100%</td>
<td>1.79</td>
</tr>
<tr>
<td>(2) S.W.</td>
<td>F</td>
<td>R</td>
<td>27</td>
<td>99%</td>
<td>1.57</td>
</tr>
<tr>
<td>(3) B.J.</td>
<td>F</td>
<td>R</td>
<td>28</td>
<td>99%</td>
<td>1.44</td>
</tr>
<tr>
<td>(4) A.M.</td>
<td>F</td>
<td>R</td>
<td>28</td>
<td>99%</td>
<td>1.83</td>
</tr>
<tr>
<td>(5) S.N.</td>
<td>F</td>
<td>R</td>
<td>28</td>
<td>100%</td>
<td>1.28</td>
</tr>
<tr>
<td>(6) S.R.</td>
<td>F</td>
<td>R</td>
<td>29</td>
<td>98%</td>
<td>1.58</td>
</tr>
<tr>
<td>(7) N.L.</td>
<td>F</td>
<td>R</td>
<td>37</td>
<td>99%</td>
<td>1.33</td>
</tr>
<tr>
<td>(8) M.E.</td>
<td>F</td>
<td>R</td>
<td>38</td>
<td>100%</td>
<td>2.21</td>
</tr>
<tr>
<td>(9) S.S.</td>
<td>F</td>
<td>R</td>
<td>40</td>
<td>99%</td>
<td>1.46</td>
</tr>
<tr>
<td>(10) M.Z.</td>
<td>F</td>
<td>R</td>
<td>41</td>
<td>100%</td>
<td>1.58</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
<td></td>
<td>99.3%</td>
<td>1.61</td>
</tr>
<tr>
<td>SD</td>
<td>5.89</td>
<td></td>
<td></td>
<td>0.28</td>
<td>0.25</td>
</tr>
</tbody>
</table>

Note. SOC_ME, perception of self-directed, socially relevant facial expressions; SOC_OTHER, perception of other-directed, socially relevant facial expressions; ARB_ME, perception of self-directed, arbitrary facial movements; ARB_OTHER, perception of other-directed, arbitrary facial movements; SD, standard deviation.

Table 3

<table>
<thead>
<tr>
<th>Patient</th>
<th>Gender</th>
<th>Handedness</th>
<th>Age</th>
<th>BDI</th>
<th>Correctness score (ME vs OTHER)</th>
<th>Individual response averages/condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) N.F.</td>
<td>F</td>
<td>R</td>
<td>28</td>
<td>14</td>
<td>82%</td>
<td>1.25</td>
</tr>
<tr>
<td>(2) C.F.</td>
<td>F</td>
<td>R</td>
<td>48</td>
<td>1</td>
<td>98%</td>
<td>1.25</td>
</tr>
<tr>
<td>(3) K.V.</td>
<td>F</td>
<td>R</td>
<td>25</td>
<td>13</td>
<td>93%</td>
<td>1.27</td>
</tr>
<tr>
<td>(4) S.D.</td>
<td>F</td>
<td>R</td>
<td>36</td>
<td>3</td>
<td>96%</td>
<td>1.74</td>
</tr>
<tr>
<td>(5) D.R.</td>
<td>F</td>
<td>R</td>
<td>46</td>
<td>4</td>
<td>96%</td>
<td>1.17</td>
</tr>
<tr>
<td>(6) D.L.</td>
<td>F</td>
<td>R</td>
<td>44</td>
<td>7</td>
<td>93%</td>
<td>1.74</td>
</tr>
<tr>
<td>(7) R.M.</td>
<td>F</td>
<td>R</td>
<td>55</td>
<td>6</td>
<td>96%</td>
<td>1.17</td>
</tr>
<tr>
<td>(8) T.B.</td>
<td>F</td>
<td>R</td>
<td>20</td>
<td>5</td>
<td>92%</td>
<td>1.26</td>
</tr>
<tr>
<td>(9) B.D.</td>
<td>F</td>
<td>R</td>
<td>28</td>
<td>6</td>
<td>100%</td>
<td>1.16</td>
</tr>
<tr>
<td>(10) K.M.</td>
<td>F</td>
<td>R</td>
<td>30</td>
<td>7</td>
<td>98%</td>
<td>1.40</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>94.00%</td>
<td>1.34</td>
</tr>
<tr>
<td>SD</td>
<td>11.60</td>
<td></td>
<td></td>
<td></td>
<td>0.22</td>
<td>0.51</td>
</tr>
</tbody>
</table>

Note. SOC_ME, perception of self-directed, socially relevant facial expressions; SOC_OTHER, perception of other-directed, socially relevant facial expressions; ARB_ME, perception of self-directed, arbitrary facial movements; ARB_OTHER, perception of other-directed, arbitrary facial movements; SD, standard deviation; Correctness score, percentage of correct answers to the question of whether the virtual character had looked at the participant (ME) or the other agent (OTHER); BDI, Beck Depression Inventory.
to the question “Who?” This is comparable to a group of male healthy control persons as described in Schilbach et al. [1]. Ratings of social relevance revealed significant condition-specific differences: Control participants rated facial expressions (SOC_ME, SOC_OTHER) significantly more social than facial movements (ARB_ME, ARB_OTHER; all: Z = −2.8, P ≤ 0.005) (Fig. 2). Importantly, ratings of social relevance were independent of the factor “self-involvement”: There was no significant difference in the scores when comparing SOC_ME and SOC_OTHER (Z = −0.98, P = 0.33) or when comparing ARB_ME and ARB_OTHER (Z = −1.28, P = 0.20).

Patients with TLE also succeeded at indicating whether the virtual character looked toward themselves or toward someone else. This result is reflected by a mean correctness score of 94.4 ± 5%. Similar to the control group, there were significant differences between conditions in terms of social relevance ratings: Patients also rated facial expressions as significantly more social than facial movements (SOC_ME vs ARB_ME: Z = −2.81, P ≤ 0.005; SOC_OTHER vs ARB_OTHER: Z = −2.70, P ≤ 0.007). In contrast to the control groups, however, we found that a statistical interaction of both factors varied in the patients group: Patients with TLE rated conditions always as significantly more socially relevant when they were themselves addressed by the virtual character (SOC_ME vs SOC_OTHER: Z = −2.80, P ≤ 0.005; ARB_ME vs ARB_OTHER: Z = −2.50, P ≤ 0.012) (Fig. 2).

Two of our patients with TLE had a BDI score > 10, indicating some mood disturbance. Importantly, the findings did not change when the two patients with the elevated BDI score were excluded from the analysis (SOC_ME vs ARB_ME: Z = −2.38, P ≤ 0.017; SOC_ME vs SOC_OTHER: Z = −2.52, P ≤ 0.012; ARB_ME vs ARB_OTHER: Z = −2.24, P ≤ 0.025).

Our patients were not a homogenous group with respect to their seizure frequency, age at the time of seizure onset, or antiepileptic medication at the time of the study (see Table 1). Nonetheless, they all exhibited the same trend toward rating an interaction more socially relevant if there was greater self-involvement. Unfortunately, our sample size was too small to do further subgroup analyses.

3.1. Between-group comparisons

Between-group comparisons revealed significant differences between the patients and controls: Compared with controls, patients rated self-addressed facial expressions (SOC_ME: U = 16, P ≤ 0.009; based on mean rank of 7.1 for the patients vs mean rank of 13.9 for the controls) and self-addressed facial movements (ARB_ME: U = 15, P ≤ 0.007; patients’ mean rank = 7, controls’ mean rank = 14) as more socially relevant. Thus, patients seem to have difficulty differentiating between facial expressions and facial movements when they themselves are directly addressed (Fig. 2).

Again, these results remained significant when performing the analyses without the two patients with higher BDI scores (SOC_ME: U = 16, P ≤ 0.034; ARB_ME: U = 13, P ≤ 0.016).

4. Discussion

Using an established paradigm [1], we tested the performance of female patients with left TLE who were asked to assess someone else’s (i.e., a virtual character’s) communicative intention. We found that patients, unlike healthy controls, rated the social relevance of a facial expression differently depending on their own self-involvement: Facial expressions directed toward the patient were regarded as significantly more socially relevant than those directed toward someone else. Additionally, patients interpreted arbitrary facial movements directed toward themselves as significantly more socially relevant than arbitrary facial movements directed toward someone else.

Female patients with left TLE showed comparable-to-normal ability when deciding whom the virtual character on the screen was addressing. Except for the one patient with the highest score on the BDI, all patients achieved
>90% accuracy on the part of the task that did not involve social judgments. This suggests that differences in ratings of social relevance are not caused by alteration of more basic perceptual processes.

Unfortunately, our sample size did not allow us to perform subgroup analysis with respect to seizure variables like age at the time of seizure onset, seizure type, or seizure frequency. Larger studies are needed to address this issue.

It is well known that antiepileptic drugs (AEDs) cause a number of cognitive side effects [29]. Typically, different types of medications have different effects and cause different degrees of cognitive impairment. Our patients were on a variety of different AEDs (see Table 1). Again, because of our sample size constraint, subgroup analyses could not be carried out. Interestingly, however, all patients as a group showed the same trend in their rating of social intent, regardless of the numbers and types of AEDs they were taking. Although we cannot completely rule out that all AEDs have this same effect, our results more likely suggest that our patients’ difficulty in correctly interpreting communicative intent is related to their underlying illness rather than to the fact that they take seizure medications.

Overall, our findings might be taken to suggest that patients with TLE react more easily to self-directed, face-based social cues constituting an increase in interpersonal reactivity. Conversely, and more likely, this could represent a compensatory mechanism for deficits in social cognition. Patients may use self-involvement to guide them in making decisions about the communicative intentions of others because they have difficulty interpreting facial expressions in terms of their underlying mental states (in our study, the intention to initiate social contact). This might be understood as an “egocentric bias” by which stimuli are judged as more meaningful when directed toward oneself, whereas healthy controls can consistently perform a more “objective” assessment (i.e., judgment from someone else’s point of view) of the stimuli. Although controls seem to have no difficulty in adopting someone else’s perspective—thereby “suppressing” their own egocentric perspective—patients appear not to be able to do so consistently.

Ethological studies suggest that facial expressions of emotion are innate, automatic, and of critical importance in social behavior [30]. Recent evidence has emphasized the importance of contributions from both frontal and temporal lobes, and of critical importance in social perception and cognitive processes [1–6]. Our results suggest that the interpretation of facial expressions or movements with respect to their underlying mental states is impaired in female patients with left TLE. How exactly MTLE affects the complex processes of social cognition remains unclear at this point.

Functional magnetic resonance imaging using our paradigm in healthy controls had demonstrated involvement of the left medial basotemporal lobe [1], which is in accordance with other imaging studies that identified the medial temporal lobe as one of the key components of the neural system suberving social cognition [6]. The amygdala, in particular, has recently been implicated in the evaluation of social interactions: Spezio et al. were able to show that complete amygdala lesions result in a severe reduction in direct eye contact during conversation [31]. A similar, but milder, effect causing abnormalities in social gaze may have contributed to our results. Future eye tracking studies using our paradigm may be able to evaluate this further.

Our patients’ difficulty in judging facial expressions may also have resulted from impairment of temporal regions other than the amygdala. The fusiform face area is known to be important in facial recognition [32]. However, areas involved in viewing faces in the context of social interaction likely differ from those involved in facial identification. In the former context, the superior temporal sulcus has been demonstrated to be involved in attention to gaze direction and facial movement [33]. A follow-up experiment by Haxby et al. [34] indicated that the bilateral parietal cortices and also the left superior temporal sulcus (STS) were activated when subjects viewed images of faces with averted gazes. STS is known to be modulated via connections with medial temporal regions [35]. Neurofunctional alterations of medial temporal lobe structures could, therefore, result in the modulation of activity in STS. Future investigations employing neuroimaging techniques could include analyses of functional connectivity to formally investigate such interactions and how they contribute to patients’ difficulty in correctly judging the social intent of a virtual character dependent on its direction of gaze.

Damage in MTLE may not be limited to the medial temporal lobe structures themselves. Diffusion tensor imaging (DTI) has revealed extensive extratemporal white matter abnormalities in patients with TLE, indicating the involvement of larger networks [36,37]. Functional magnetic resonance imaging using our paradigm in healthy controls had demonstrated not only involvement of left medial basotemporal and right superior temporal cortex, but also ventromedial prefrontal lobe activation when participants viewed the socially relevant clips [1]. Of course, medial prefrontal cortex along with areas of temporal cortex have been established as part of the complex network underlying social cognition and Theory of Mind, the ability to understand that others have beliefs, desires, and intentions that are different from one’s own [1–3,38,39]. It is therefore conceivable that impaired frontotemporal connections contribute to the deficits seen in our patients.

The importance of contributions from both frontal and temporal lobes and frontotemporal connections to social cognition has also been recognized by Kirsch [7], who suggested that anterior temporal lobectomy may have an effect on higher-order social behavior by altering efferents to frontal regions. Waites et al. recently [40] presented evidence of how TLE can disrupt temporofrontal connectivity. This seems to be a theoretically plausible mechanism by which TLE might also interfere with social cognitive functioning, giving rise to “pseudo-frontal” symptoms.

Given the self-involvement bias our patients exhibited when judging the communicative intent of the virtual character, it is possible that impairments of inhibition of their
self-perspective caused our patients to overrate communicative intent when they were directly addressed. Recently, Samson et al. [41] have been able to isolate different components of Theory of Mind. They could show how “other-perspective taking” may depend on the inhibition of self-perspective and that this phenomenon may rely on frontotemporal neuroanatomy. This may be relevant to our findings, as our patients may suffer from an impaired inhibition of self-perspective. In the case of patients with TLE, this might be due to dysfunction of the temporal lobe and its connections feeding into prefrontal cortex, rather than a dysfunction of the frontal lobes themselves. It should therefore be interesting to systematically study patients with TLE with the tools developed by Samson et al. [41] and assess their ability to process different mental states in an effort to determine whether possible alterations may be domain specific [42].

On a more speculative note, we suggest that the “ego-centric bias” exhibited by patients with TLE patients may also be associated with alterations of the so-called “default mode of brain function” [43,44]. This default activity of the brain has been related to shifting between “internal” or stimulus-independent and “external” or stimulus-dependent states. Remarkable overlap also exists between activation patterns elicited by social cognitive paradigms and the resting state activity. Most interestingly, recent evidence shows that this “default mode of brain function” might be disturbed in TLE, giving rise to the possibility that this may be a potential mechanism of altering social experiences in these patients [45].

Clearly, our study has limitations. Based on evidence from the literature and on data from our previous fMRI study in healthy volunteers, we tested only female subjects with left TLE. Our aim in this small pilot study was to test a subgroup of patients with TLE that would allow us to validate our hypothesis that TLE impairs specific aspects of social cognition. Studies in male patients and in patients with right TLE are needed and are underway. Nonetheless, we were able to demonstrate an intriguing impairment of one aspect of social cognition in female patients with left TLE. The purely behavioral nature of our study does not allow us to provide concrete answers concerning the underlying functional neuroanatomy. However, given that we were able to demonstrate the usefulness of a paradigm originally developed for an fMRI study, we opened the door to performing functional neuroimaging of social cognition in TLE.

We therefore feel that our interesting results contribute as a pilot study to the understanding of patients with TLE and their social cognitive competence and point to the importance of further research into impairments of social cognition in this patient group.

5. Conclusion

Social competence contributes significantly to quality of life. However, the study of social cognition in epilepsy has thus far been neglected. This is likely due to the fact that self-administered quality-of-life questionnaires do not specifically target patients’ social role and limitations [7]. Furthermore, patients may not even be aware of their deficits and therefore cannot report them. Our report, along with very few others [e.g., 24], underscores the need for the further study of social cognition in epilepsy.

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References


