Does social cognition differ in patients after epilepsy surgery compared to healthy control adolescence?

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June, 2017

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1. Introduction

Epilepsy is one of the oldest condition known to mankind and still the most common neurological condition which affects individuals of all ages worldwide (Engel, 2013). The disorder is characterized by recurrent seizers (at least two), which are periods of involuntary movements that may involve either a part (partial) or the whole body (generalized) and could be associated with loss of consciousness. Besides the variety of time of a seizure, seizures also vary in frequency happening from less than once a year to several per day (Engel, 2013).

Around 50 million people live with epilepsy worldwide, where the proportion of population with active epilepsy at any given time is between 4 and 10 per 1000 people. However, some studies suggest that in low- and middle-income countries this proportion is considerably higher, between 7 and 14 per 1000 people (WHO, 2017). It is estimated that globally around 2.4 million people are diagnosed with epilepsy each year. Here again, where in high-income countries new annual cases are between 30 and 50 per 100 000 people, in low- and middle-income countries this proportion could be twice as high (WHO, 2017)

Epilepsy is, however, more than only seizures. Though epileptic seizures may be the defining element of having an epilepsy disorder, the disorder is accompanied with many more problems (Stewart, Catroppa & Lah, 2016). So is epilepsy often associated with psychobehavioural and social difficulties. Patients with epilepsy reveal often problems such as depression, anxiety, neuroticism, and social limitations, as well as impaired memory, attention and concentration. Studies also show that patients with epilepsy show executive dysfunction in response initiation an inhibition, as well as cognitive impairment, obsession, and addictive behaviours (Giovagnoli, 2014).

Given the demands on clinical care by epilepsy-related psychobehavioural difficulties, as mentioned above, it is of great interest to learn more about their causes. It is believed that Theory of Mind (ToM), which is an ability to mentally represent one's own and others'

cognitive and affective mental states, may be impaired in patients with epilepsy and therefore those deficits may contribute to the psychobehavioural distress and social cognitive problems (Giovagnoli, 2014). In particular, an impaired capacity to understand mental states and to comprehend interpersonal relations could affect self-appraisal and adaption capacities (Giovagnoli, 2014).

2. Theoretical Framework

The introduction described above mainly focussed on the social impact of epilepsy worldwide. Though Theory of Mind (ToM) is thought to be impaired in patients with epilepsy, it should be mentioned that ToM is part of a bigger concept, social cognition. This part of the theoretical framework will examine both the smaller elements as well as the stages of development of social cognition. Eventually, the theoretical framework will focus on both the method used, the faux pas test, and the disease, epilepsy, which will be linked and investigated during this research.

2.1 Social Cognition

"Humans are social animals and we spend a great deal of time in social relationships. As children develop, they gain a better understanding of peers and adults around them. They become aware that people can differ on what they believe, know, and want. Their values and goals can be different from our own. Some people call this "mindreading other people's mind". Scientists often call this kind of understanding social cognition" (Schick, 2016).

Social cognition focusses on how people process, store and apply information about other people as well as social situations. In other words, social cognition covers emotion perception, theory of mind, and behaviour adjustments (Giovagnoli, 2014). Social cognition focuses on the role that cognitive processes play in our social interactions: the way people think, feel, and interact with the outstanding world. Social cognition therefore encompasses beliefs about individuals themselves, others, people in general, social groups and institutions. The development of social cognition and other forms of social-cognitive understanding, such as theory of mind, are very important aspects of the cognitive development of a human being.

Studies have shown that healthy children develop social cognition gradually, where there is a clear effect of age (Astington, 1993).

Having many sub-topics in child psychology, research in social cognition addresses some issues. Most often, it tries to answer the descriptive question: what exactly does develop and when does it develop? An important challenge to answer those questions is usage of the correct assessment methods for the development in question and identifying interrelations among different forms of understanding. Scientist also try to research the question why certain forms of development occur, in other words what the causal forces are which ensure the shape of social-cognitive understanding of a human being and how social interactions change when those social-cognitive abilities are impaired (Fiske & Taylor, 2013).

As mentioned before, there is existing evidence that healthy children develop social cognition gradually, however, more is known about what exactly develops instead of how it develops over time, i.e., which brain regions are exactly involved and how do they contribute to the overall social cognition. Many theories agree upon the fact that both social experiences, as well as biological maturation, play a role in the development, though theories differ in the relative role how these factors are harmonized (Wyer & Srull, 1994).

2.2 Development of Social Cognition

Social cognition is an umbrella term for different components, such as emotion perception, theory of mind, empathy, faux pas detection and social behavior (Fiske & Taylor, 2013). All these terms occur during the development of an individual starting from infancy on. To examine what happens at each developmental stage, studies have researched every single developmental stage separately. Theory of mind, which is a subpart of social cognition, is the ability of human beings to recognize and attribute to mental states not only in themselves but

also in other individuals. Besides, it is the ability to understand that other humans may have different beliefs and feelings than one itself (Stone, Baron-Cohen, & Knight, 1998).

According to existing studies, the development of social cognition, more specifically theory of mind (ToM), happens over different stages in the development starting around 18 months of age (Stone, Baron-Cohen, & Knight, 1998). Figure 1 represents the development of social cognition over time. Social cognition manifests itself in joint attention which means that a child has the ability to understand that there is a shared focus of two individuals on a specific object (Stone, Baron-Cohen, & Knight, 1998). This stage is closely followed by the so-called proto-declarative pointing where a child uses pointing to alert one's attention to a specific object where the child wants them to pay attention to (Stone, Baron-Cohen, & Knight, 1998). Subsequently, children develop the skill to separate pretend play from reality play which is followed by the skill to understand the mental state of desire (Stone, Baron-Cohen, & Knight, 1998.

Prior to the age of 3 children do not understand that other people do have other beliefs about the world than themselves From 3 years onwards a child begins to understand that others may not know all things they know and therefore they are referring to a false belief. Tests of false belief are often used to measure ToM (Baron-Cohen, O'riordan, Stone, Jones & Plaisted, 1999). False belief tests consist both of first order and second order false belief tests. The first order belief task holds that a child has the ability to understand that another person may have a belief that is mistaken. The test, therefore, demonstrates that a child is able to represent another’s mental state or beliefs, rather than their own idea of the physical world and state of knowledge (Stone, Baron-Cohen, & Knight, 1998). Later on, children start to understand the second-order false belief tasks, where they understand the belief about belief. In other words, in this case, a child should understand that it is possible to hold a false belief about some else's belief (Miller, 2009).

Even later, between the age of 9 and 11 years, children develop further theory of mind abilities which contribute to their overall social cognition. Research suggest that a child or beginning adolescence should be able to recognize and even understand a faux pas (an unintentional verbal clumsiness) at this age (Stone, Baron-Cohen, & Knight, 1998). To be able to recognize and understand a faux pas, one should be able to correctly socially adept in certain situations. This way of adaptation is the follow up of the second-order false belief tasks, which now requires more and different forms of knowledge about other people different from oneself (Baron-Cohen, O'riordan, Stone, Jones & Plaisted, 1999).

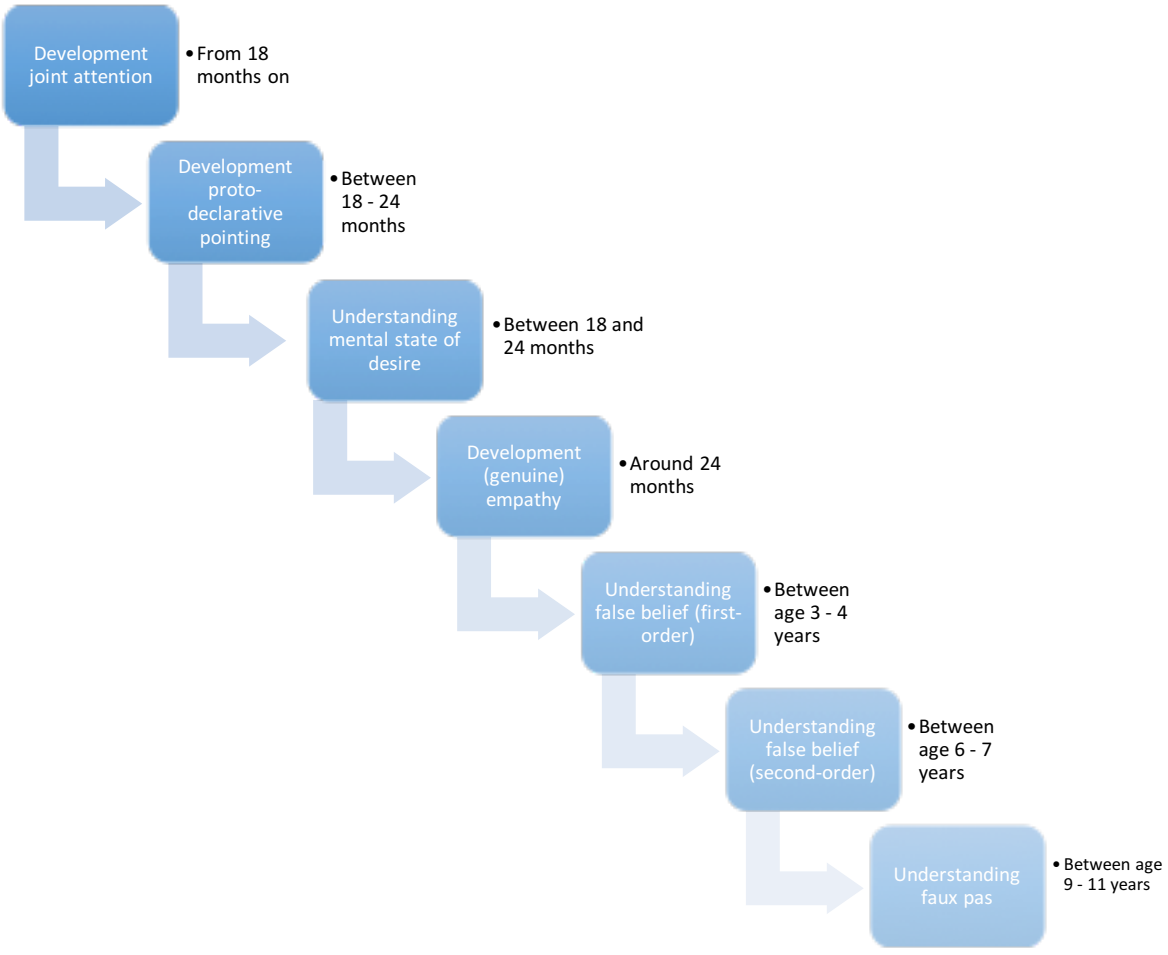

Figure 1: Development social cognition over time

2.3 Faux Pas Task

The Faux Pas Task, other described as a more *advanced* test of theory of mind tests the ability of subjects to recognize "faux pas". Although "faux pas" is hard to define, it literally means 'false step', or an unintended embarrassing or tactless act in a social situation (Stone, Baron-Cohen, & Knight, 1998). The ability of a person to detect a faux pas, or an unintentional verbal clumsiness, is measured by use of the Faux Pas Task.

The faux pas test is designed as a test which goes beyond the 4- to 6-year-old level theory of mind. Detecting a faux pas, in other words, detecting that someone said something he or she could better not have said, requires both an appreciation that there may be a difference between a speaker's state of knowledge and that of their listener, and an appreciation of the emotional impact of a statement on the listener (Baron-Cohen, O'riordan, Stone, Jones & Plaisted, 1999).

Studies also show that the performance on the Faux Pas Task is dependent on the intelligence level (Amlerova, Cavanna, Bradac, Javurkova, Raudenska & Marusic, 2014).

2.4 Epilepsy

As mentioned in the introduction, epilepsy is a chronic disorder which affects people of all ages worldwide (Engel, 2013). This disorder is characterized by unprovoked seizures which happen by the occurrence of sporadic electrical storms in the brain. Patients suffering from epilepsy have more than one type of seizure and also have other symptoms of neurological problems. A person is diagnosed with epilepsy when one has experienced one or more seizures that were not caused by a known and reversible medical condition. The location, the spreading, and the duration of the seizures all have profound effects. All those factors determine on the severity of a particular seizure and therefore the impact of the seizure on the individual (Engel, 2013).

There are three main types of seizures: generalized seizures, partial or focal seizures, and absence seizures. When all areas of the cerebral cortex are involved, one is referring to a generalized seizure or a grand mail seizure. Patients with this kind of seizure will commonly experience stiffening of muscles for several seconds to a minute, followed by rhythmic movements of arms and legs. Commonly, a patient is confused after such a seizure as abnormal activity spreads through a large part of the brain (Engel, 2013). When only a part of the cortex is involved, one is referring to a partial or focal seizure. Depending on the part of the brain which is involved in the seizure, symptoms may differ. Due to the fact that various brain areas are involved, there is not one common seizure (Seneviratne, Woo, Boston, Cook, & D'Souza, 2015). The third type of seizure is called the absence or petit mal seizure. When one is suffering from this kind of seizure, one experiences loss of consciousness resulting in a brief period of blankly staring. Patients may experience more of these seizures in a day and these are most common in childhood (Miao, et al., 2014).

Seizures are the first symptoms one experiences having epilepsy, however, seizures can also dramatically affect one's social cognition, such as emotion perception, interaction, relationships etc. (Stewart, Catroppa & Lah, 2016). Besides those effects, patients with epilepsy could experience problems within the field of language, where they have difficulties finding words, within the field of memory, where information may be stored but disorganized due to seizures and within the field of executive functioning, where the ability to organize one's own thoughts are weakened and where it is harder to interact with other people as attention may drift way sooner (Lunn, Lewis, & Sherlock, 2015). Studies have shown that patients with epilepsy have more lesions in the brain parts which are related to social cognitive functions, i.e. temporal or frontal lobe epilepsies. However, different forms of lobe epilepsy result in different form of impairments. So is memory loss related to epilepsy in both the temporal lobe as well as the hippocampus, the language problem related to epilepsy

occurring in the left hemisphere, and executive functioning related to epilepsy in the frontal lobe (Lunn, Lewis, & Sherlock, 2015).

Accordingly, there have been studies which demonstrated the impairments in social cognition in patients with epilepsy involving tasks measuring theory of mind as well as emotional recognition. Often, a patient perceives its neurological impairment in their life as a bigger problem than the actual seizures (Broicher & Jokeit, 2011).

3. The social relevant problem in adolescence with epilepsy

Due to the fact that there are still insecurities around the subject of how social cognition develops over time as many different brain regions are involved, it will make it even more difficult to understand the impairments of social cognition in patients with mental diseases, for instance, epilepsy (Broicher & Jokeit, 2011).

Patients with epilepsy experience cognitive and behavioural problems, such as disturbances in relationships, attention and memory. As mentioned before, for many patients these impairments are a bigger problem than the seizures itself, especially due the possible consequences of the disorder at school, work or social relationships. In clinical practice, it is often difficult to determine the cause of cognitive disorders because of a large number of factors which may play a role. These factors include the aetiology of epilepsy, the characteristics of epilepsy (the type, the duration, the debut age and the localization of the epileptic seizure), and the behavioural problems which arise, such as anxiety and depression (Lunn, Lewis, & Sherlock, 2015).

Research in the field of ToM has traditionally been conducted in children and has therefore investigated the key moments of the developing child using the false belief tasks. As mentioned earlier, interest in theory of mind abilities beyond childhood have increased and have therefore been investigated using a wide and more variable set of tasks which differ from the false belief tasks. This faux pas task is used to test the advanced ToM abilities which evolve after infancy and childhood.

Thus, despite an extensive already existing literature on the development of social cognition from infancy to childhood, only a few studies have been carried out to specifically explore the social cognition in healthy adolescence. Furthermore, studies have investigated social cognition in children with mental disorders, such as autism, however, not enough research has been performed on social cognition in patients with epilepsy, especially in

adolescence with epilepsy. So, as there is an upcoming interest for researching ToM in adolescence, it also reflects on the major changes in the cognitive, socio-emotional, and relational domains adolescence happening during this period of life. This time of development is also referred to as puberty.

Though more studies on social cognition in patients with epilepsy will not only reveal answer to questions as how social cognition may be affected compared to healthy controls, it will also provide patients and families with answers about the disorder. Where nowadays epilepsy patients experience seizures and suffer from cognitive and behavioural problems, further studies might answer the question whether those impairments could be explained by the deficits originated from the seizures. More research might explain this question and therefore this paper will examine how social cognition is affected in adolescence after epilepsy surgery compared to healthy control subjects.

4. Methods

The controlled study was part of a countrywide project addressing cognitive, affective, and psychosocial functioning of adolescents after epilepsy surgery. All patients received epilepsy surgery at the Wilhelmina Children's Hospital (WKZ) and were acknowledged for neuropsychological investigations. Besides surgery, more instruments were added to the standard neuropsychological investigation, such as the faux pas task as well as the intelligence test. The Institutional Review Board of the University Medical Centre Utrecht approved the study. Parents of all children and also all children above the age of 12 years provided informed consent. Only a few subjects rejected and did not participate in this research.

4.1 Subjects

A total of twelve patients were selected on the basis of assessment date in relation to the correct version of faux pas task completed. All patients selected were assessed at four different time intervals: pre surgery, 6, 12, and 24 months after surgery. However, as all patients completed different versions of the faux pas task on different time intervals, patients were selected on basis of the correct faux pas version completed as their matching control at the same time interval. As all patients were independent of each other, where there is no scientific evidence of a difference on social cognition over time after surgery, they were merged to create a bigger sample. Table 1 demonstrates participant characteristics of patients used 12 and 24 months after surgery, and the given average of those separate groups [(n = 12); mean age = 15.29 (sd = 2.33) years; 7 girls, mean TIQ = 98.33 (sd = 20.23)].

For every individual patient, age- and sex-matched controls without a neurological history, were included. All patients assessed 12 months after surgery were matched to two different age- and sex-matched controls, where the average of both has been taken into calculation, where patients assessed 24 months after surgery had one age- and sex-matched

control which was taken into calculation. So, of the total of the 7 controls (assessed at same time as their matching patients at 12 months after surgery) and 5 controls (assessed at some time as their matching patient at 24 months after surgery), the average was taking into calculation [mean age = 15.48 (sd = 2.27) years; 7 girls, mean TIQ = 116.92 (sd = 14.99)] (Tabel 1). All control adolescents were recruited from regular schools in Arnhem, the Netherlands, which were located in different neighbourhoods with diverse socioeconomic backgrounds. All controls were assessed at similar intervals as their matching patient, i.e. same date interval as the patient was assessed, as there was no significant difference on social cognition over time after surgery. All control adolescents did complete the same version of the faux pas task and intelligence test at their matched patient.

Table 1
Participant characteristics

	Patients - 12 months after surgery (n = 7)	Patients - 24 months after surgery (n = 5)	Patients - total average (n = 12)	Controls (n = 12)
Demographic characteristics				
Female n (%)	4 (57 %)	3 (60 %)	7 (58%)	7 (58%)
Age (years) at assessment (mean ± SD)	15.01 ± 2.05	15.69 ± 2.89	15.29 ± 2.33	15.48 ± 2.27
Cognitive characteristics				
TIQ (mean ± SD)	97.71 ± 15.28	99.20 ± 27.81	98.33 + 20.23	116.92 ± 14.99
Clinical factors				
Age (years) at epilepsy onset (mean ± SD)	8.06 ± 4.16	7.04 ± 3.15	9.32 ± 3.53	-
Seizure frequency (median; mean ± SD) [a]	0.00; 0.00 ± 0.00	0.00; 0.00 ± 0.00	0.00; 0.00 ± 0.00	-
Side of surgery (n) [b]	3; 4; 0	0; 5; 0	3; 9; 0	-
Area of surgery (n)				
Hemispherectomy	0	0	0	-
Temporal	3	3	6	-
Frontal	1	1	2	-
Central	1	0	1	-
Parietal	1	1	2	-
Occipital	0	0	0	-
MST; multiple	1 (45; parietocentral)	0	1 (45; parietocentral)	-
AED use (n) [c]				
Monotherapy	3	1	4	-
Politherapy	3	2	5	-
None	1	2	3	-

Abbreviations: n = number; SD = standard deviation; TIQ = total intelligence quotient; AED = antiepileptic drugs

[a] Seizure frequency as reported by parents: 0 = less than 1/year; 1 = ≥ 1year; 2 = ≥ 1/month; 3 = ≥ 1/week; 4 = ≥ 1/day; 5 = ≥ 1/hour; 6 = continuously; 9 = extremely variable

[b] Side of surgery: right; left; both

[c] AED use at the time of the assessment, as reported by parents

4.2 Neuropsychological instruments

4.2.1. Faux pas task

The advanced ToM was evaluated using the Faux Pas Task (Stone et al., 1998). The faux pas task can be performed successfully by subjects aged >10-11 years, and is sensitive to subtle deficits in epilepsy patients.

The faux pas task requires the recognition or exclusion of a social faux pas in 10 short stories (i.e., 5 stories with a faux pas and 5 without), including the same six question in every single story. Besides detection of the faux pas, the task also involves the identification, comprehension of intention, and the general comprehension of the faux pas story. In this way the faux pas task measures cognitive advanced ToM.

After each story, the subject has to state whether a faux pas – verbal clumsiness – was present in the story after the following question was being asked, "Did anyone say something they shouldn't have said?". Subjects were awarded points when they correctly answered the detection question: in faux pas cases the answer 'yes' is awarded with one point, in non faux pas cases, the answer 'no' is awarded with one point. As there are 10 stories being told, the subject can score a total of 10 points on the detection question.

Regardless of whether a story contains a faux pas or not, two control questions are asked at the end of the questionnaire. The control questions are asked at the end of each story to verify that the subject has kept in mind the contextual details and is not guessing al questions asked before. If a subject has an incorrect response to one of the two control questions, or both, all answers to the questions of that particular story were awarded zero points to avoid any possible guessing.

Besides the five questions which measure the cognitive advance ToM, every story, regardless the presence or absence of a faux pas, also contained an empathy question. This empathy question, phrased as "How did X feel?" tests the respondent's empathy for the story characters who is being hurt. Again, this response, when answered correctly, is awarded with one point, resulting in a total of 10 point per subject for the empathy question. In this way, the faux pas task also measures affective advanced ToM.

4.2.2 Total Intelligence

As different studies show the dependence of performance on intelligence level, the total intelligence quotient was measured. The intelligence level was assessed using two different instruments as related to age. Both the Wechsler Intelligence Scale for Children – III (WISC-III^{NL}) and the Kaufman Adolescent and Adult Intelligence Test (KAIT) were used as subjects were divided over the two different intelligence tests due to age – the WISC-III^{NL} test covers children aged between 6 and 17 years, and the KAIT test covers adolescents and adults aged 11 – 85+. Of both tests the total intelligence quotient (WISC-III^{NL}: total IQ; KAIT: total IQ) was used for analysis.

The average IQ measured for both patients and controls describes the average IQ between 12 and 24 months after epilepsy surgery. As controls were only matched on age and gender, taking the average of the intelligence level is not allowed. Therefore, all controls, either matched to their patients 12 or 24 months after surgery were assessed separately, leaving with a total population of controls of 20. As the total IQ score is a calculation of both the verbal IQ and performance IQ, we calculated those two variables separately as well.

For this study we did set the norm of minimum IQ at 80 points as having a IQ lower than 80 points one is said to be subnormal. When having an IQ lower than 80 points there is no certainty the participant is be able to understand to faux pas task in general. Because of this norm, two patients and one control in total were excluded.

	Total IQ	Verbal IQ	Performance IQ
Patients (n = 10)	104.20 ± 16.12	97.10 ± 12.14	111.70 ± 19.67
Controls (n = 18)	119.33 ± 13.77	112.67 ± 14.99	122.11 ± 13.27

4.3 Data management and analyses

For all data management and analyses SPSS version 14 was used. To display the descriptive characteristics such as the mean (± standard deviation), median, range, minimum and maximum of all separate datasets to get a clear overview of the descriptive statistics and frequencies of those particular datasets SPSS was used as well.

To test whether there is a difference in performance on the faux pas task between the healthy subjects and patients, the Mann-Whitney U (exact, two-tailed) test was conducted. As the number of patients and controls are relatively small, a nonparametric test should be used as we cannot assume the data has a normal distribution. Besides the fact of conducting a nonparametric test, we should also consider an unpaired test as both the patients and subjects are independent of each other. To take into account these aspects, we therefore used the Mann-Whitney U test.

For any correlations between the results given by the Mann-Whitney U test, the Spearman's rank correlation coefficient (exact, two-tailed) was used. This correlation coefficient is again a nonparametric measure of a rank correlation which means it is the statistical dependence between the ranking of two variables.

5. Results

5.1 Group comparisons

For all analyses within the group comparisons, a criterion *p* value of 0.05 was used to establish statistical significance. Table 2 displays the outcomes of the Mann-Whitney U test including the descriptive statistics of the particular datasets.

Statistical analyses revealed no statistically significance for the Total Faux Pas Task (p = 0.070). Although a *p* value of 0.070 is not said to be significant, the outcome could be relevant when we take a closer look. For the Total Faux Pas Task there is a mean ranking of 9,88 (patients) compared to 15,13 (control) on a total of 24 subjects. In other words, patients (mean ± SD; 39.33 ± 6.27) and controls (mean ± SD; 43.67 ± 5.16) differ in mean value of approximately 4.34 (excluding SD) within a range of 20, with a tendency towards better performance by controls. The Total Faux Pas stories, i.e., the total amount of points awarded to all questions of the faux pas stories, with a maximum of 25 points in total which could be achieved, did not show a significant result p = 0.600. The Faux Pas Q1, which means the total amount of points awarded to the first, detection, question – with a maximum of 5 points – of every faux pas story did not show a significant result either (n = 0.759). For the Total Non Faux Pas stories, i.e., the total amount of points awarded to all questions of the non faux pas stories, with a maximum of 25 points points which could be achieved, did show a statistically significant result (p = 0.037). The Non Faux Pas Q1, which means the total amount of points awarded to the detection question of every non faux pas story, with a maximum of 5 points which could be achieved, did show a statistically significant result (p = 0.026) as in line with the total non faux pas stories.

The Faux Pas Q6, which means the total amount of points awarded to question 6 , the empathy question, of all faux pas stories, again with a maximum of 5 points, did not show any statistical significance (p = 0.716).

Table 2
Descriptive statistics of Total Faux Pas Task; Total (Non) Faux Pas stories; (Non) Faux Pas Q1; Faux Pas Q6

	Mean (± SD)	Median (range)	*p* values
Total Faux Pas Task[a]			
Patients (n = 12)	39.33 (6.27)	38.50 (30 - 50)	0.070
Controls (n = 12)	43.67 (5.16)	44.50 (32 - 50)	
Total Faux Pas stories[b]			
Patients (n = 12)	20.33 (3.94)	21.50 (14 - 25)	0.600
Controls (n = 12)	20.83 (3.76)	20.00 (13 - 25)	
Total Non Faux Pas stories[c]			
Patients (n = 12)	19.00 (4.29)	18.00 (15 - 25)	0.037
Controls (n = 12)	23.13 (3.08)	24.50 (14.5 - 25)	
Faux Pas Q1[d]			
Patients (n = 12)	4.25 (0.87)	4.50 (3 - 5)	0.759
Controls (n = 12)	4.42 (0.70)	4.75 (3 - 5)	
Non Faux Pas Q1[e]			
Patients (n = 12)	3.67 (0.89)	3.00 (3 - 5)	0.026
Controls (n = 12)	4.58 (0.73)	5.00 (3 - 5)	
Faux Pas Q6[f]			
Patients (n = 12)	2.17 (1.34)	2.00 (0 - 4)	0.716
Controls (n = 12)	2.46 (1.22)	2.25 (1 - 4)	

Abbreviations: n = number; SD = standard deviation; range = minimum - maximum
[a] Total points on both faux pas and non faux pas stories (10 stories, 5 questions each story)
[b] Total points on faux pas stories (5 stories, 5 questions each story)
[c] Total points on non faux pas stories (5 stories, 5 questions each story)
[d] Total points on question 1 (detection) of faux pas stories (5 stories)
[e] Total points on question 1 (detection) of non faux pas stories (5 stories)
[f] Total points on question 6 (empathy) of faux pas stories (5 stories)

5.2 Relationship performance faux pas task and intelligence level

As showed in earlier studies, intelligence level on subjects seemed to be a predictor for the performance on the faux pas task (Amlerova, Cavanna, Bradac, Javurkova, Raudenska & Marusic, 2014). Therefore, this study also conducted several correlation analyses in relation to the intelligence level to consider any relationships between those variables.

As all patients and controls were double matched on age and gender, no correlation was tested for these variables. Within the group comparisons we used all 12 patients and 12

controls as they were double matched on age and gender, and were therefore allowed to be compared. As mentioned earlier, both patients and controls were not matched on IQ score and therefore it was not allowed to take the average of all two double-matched controls of 12 months after surgery. We, therefore, calculated the average of the 5 controls matched to patients 24 months after surgery, and the matched two times matched controls to patients 12 months after surgery, which leads to an average of a total of 19 controls.

For this study used the norm of a minimum IQ score of 80 points to exclude participants who are said to be subnormal, i.e., retarded. In total two patients and one control were excluded. The correlation between total IQ and performance on the different versions of faux pas task was calculated with in total the average of 10 patients and 18 controls.

As the total IQ score is a calculation of both the verbal IQ and performance IQ, we calculated, figure 2 displays the difference on IQ patients compared to controls.

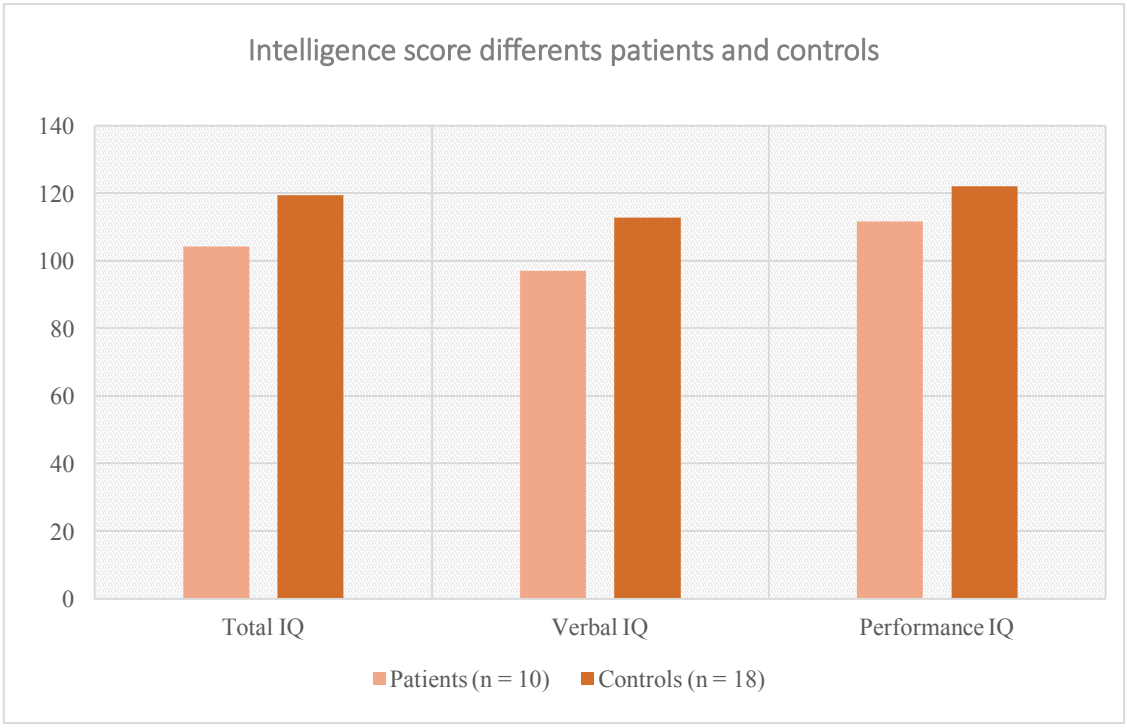

Figure 2: Difference in Total IQ, Verbal IQ, and performance IQ between patients and controls

Table 4 shows all results regarding the correlation between the different items of the faux pas task in relation to the full scale, total IQ score. Although the total IQ score consist of both the verbal as well as the performance IQ score, neither the verbal or performance IQ score showed any statistical significance in performance on any of the different faux pas tasks. They are therefore not included in table 4, where only the total IQ score is demonstrated.

According to table 4, there is little statistical significance at the level of 0.05. Only for patients (n = 10) the Non Faux Pas detection question, question 1, was significantly correlated with the total IQ score (p = 0.044). Although not statistically significant, the patients' Total Faux Pas Task was close to a level of significance where according to the correlation coefficient interpretation guideline a coefficient around 0.600 is referred to be in between moderate and a strong correlation. This argument yields the same for the patient's Total Faux Pas stories, however, this time negatively correlated instead of positively.

Table 4

Correlations between Total IQ and performance on different versions of faux pas tasks on basis of different group settings

	Patients (n = 10) TIQ (CC; *p* value)	Controls (n = 19) TIQ (CC; *p* value)
TFPT [a]	0.585	-0.113
	(0.075)	(0.726)
TFPs [b]	-0.599	-0.494
	(0.067)	(0.103)
TNFPs [c]	-0.125	-0.302
	(0.730)	(0.340)
FP Q1 [d]	0.447	-0.106
	(0.195)	(0.744)
NFP Q1 [e]	0.645*	-0.032
	(0.044)	(0.922)
FP Q6 [f]	0.504	0.082
	(0.138)	(0.800)

Abbreviations: n = number; cc = correlation coëfficient (Spearman)

* Correlation significant at 0.05 level

[a] Total points on both faux pas and non faux pas stories (10 stories, 5 questions each story)

[b] Total points on faux pas stories (5 stories, 5 questions each story)

[c] Total points on non faux pas stories (5 stories, 5 questions each story)

[d] Total points on question 1 (detection) of faux pas stories (5 stories)

[e] Total points on question 1 (detection) of non faux pas stories (5 stories)

[f] Total points on question 6 (empathy) of faux pas stories (5 stories)

Referring to the control group, all correlations could be interpreted as weak correlation to no correlations. Remarkably are the negative correlations of the control group, where only

the empathy question of the faux pas stories has a positive correlation, which in turn can be interpreted as almost no correlation.

5.3 Relationship performance faux pas task and area of surgery

As all patients (n = 12) have had surgery in different areas of the brain, we also investigated if there is any relation between the area of surgery and the performance on the Total Faux Pas Task score. Of the 12 patients who received surgery, 6 of them received temporal lobe epilepsy surgery, 2 frontal lobe epilepsy surgery, 1 central lobe epilepsy surgery, 2 parietal lobe epilepsy surgery and 1 multiple lobe epilepsy surgery (parietocentral).

Although there are many varieties in the area of surgery and amount of patients who received the surgery, i.e., one patients received central lobe epilepsy surgery versus six patients received temporal lobe epilepsy surgery, figure 3 shows the performance on the total faux pas task in relation to the are of surgery. Patients who underwent parietal lobe epilepsy surgery had the worst performance compared to the patient who had the best score and received multiple lobe epilepsy surgery.

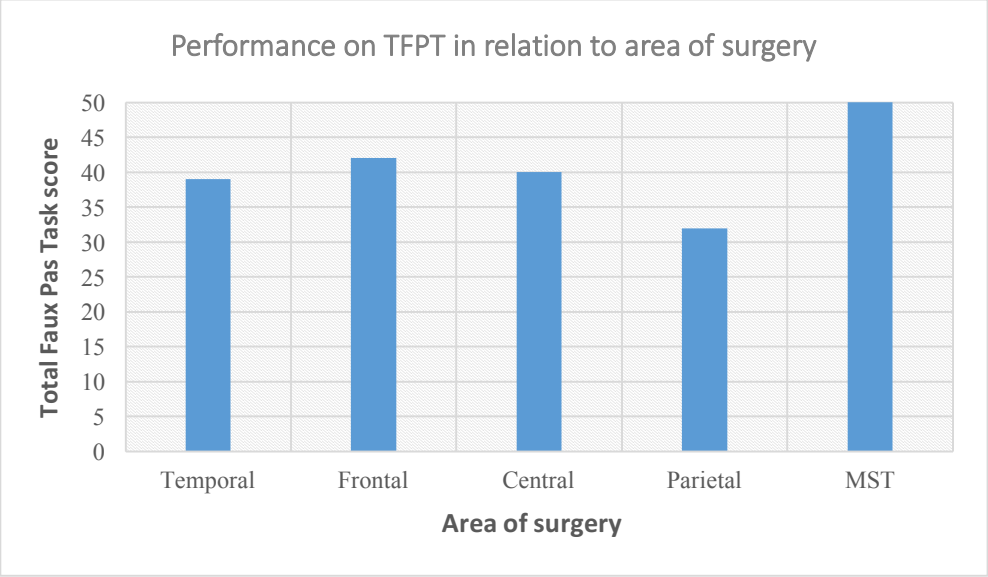

Figure 3: Performance on Total Faux Pas Task in relation to area of surgery

6. Discussion

This study is not only of relevance for advancing understanding of its underlying neural network, but also for its clinical care. As the faux pas task measurement is said to be sensitive to subtle deficits in epilepsy patients, where literature review shows patients with epilepsy may experience cognitive and behavioural problems, such as disturbances in relationships, attention and memory, the faux pas task might show to what extend ToM is affected in patients with epilepsy.

Regarding the group comparisons, 12 patients and 12 controls were compared on basis of performance on different kinds of faux pas task, i.e. different items of the faux pas task. For the total faux pas task, no significant difference on performance was found on a level of 0.05. As explained already in the results section, though this performance is not statistically significant, the p value of 0.07 contains information which should be discussed. So, for the Total Faux Pas Task there is a mean ranking of 9.88 (patients) compared to 15.13 (control) on a total of 24 subjects. In other words, patients (mean ± SD; 39.33 ± 6.27) and controls (mean ± SD; 43.67 ± 5.16) differ in mean value of approximately 4.34 (excluding SD) within a range of 20, with a tendency towards better performance by controls. Performing the same research with another sample, or a bigger sample, might provide significance at a level 0.05 as the value is already pretty close. It could also turn the other way around, where the mean ranking would be closer to each other resulting even in less significance. This answers to the overall performance on faux pas, and therefore the difference between the patient and control group is of high relevance for further studies as well as for clinical care.

Moreover, no significant difference was found either on the Total Faux Pas stories or the detection question, question 1 of all faux pas stories. As the p value was pretty high ($p = 0.600$ and $p = 0.759$), further studies should investigate whether this outcome is due to the small sample size, random variety or selection bias, or that further studies would be consistent

having the same outcome of no difference in performance. However, this might be contradicting as previous study show patients with epilepsy are doing worse than their controls on performing the faux pas task. Here again, this research did include patients who have had surgery, where other patients of different studies were mostly only treated with medicines. Further studies should also investigate the impact of surgery on performance on the faux pas task between patients.

Furthermore, both the Total Non Faux Pas stories and the detection question of the faux pas stories showed significant results at a level of 0.05 ($p = 0.037$ and $p = 0.026$). Referring to the mean values the performances by patients were worse than controls. Although in first instance this may sounds contradicting as epilepsy patients show deficits and may show problems in either recognizing the faux pas than the non faux pas, as recognizing a faux pas is thought of to be the problem, recognizing a non faux pas also means having knowledge of what a faux pas is. In other words, although recognizing or detecting a faux pas should be the harder assignment to complete, to be able to recognize a story does not contain a faux pas, one should also know exactly what the idea of a faux pas is. It could also be argued that epilepsy patients might be too influenced by their own securities, so when they believe no faux pas is present in a story, they might to start doubting themselves and second guess their own opinion, leaving eventually with the wrong answers.

The faux pas task also includes an empathy question which measures how well the participant can empathy the feelings of the story character who is being hurt. Referring to the results, both patients and controls did not perform really well. Patients scored an average of 2.17 correct answers per 5 questions, where controls scored an average of 2.46 correct answers per 5 questions. Though they performed both pretty worse, there was not a statistical significant result in one performing better than the other ($p = 0.716$). As the other questions of the faux pas task are easier to score, i.e. the answers is either correct or wrong, the scoring of

the empathy question is more a subjective one. As describing one's feeling in one word, the performance is dependent on their vocabulary. Though there was not a correlation between performance on the empathy questions and the verbal IQ, it should be considered to score the empathy questions by another person as well to have a second opinion to prevent any biases.

As previous studies show a dependency on performance on the faux pas task and intelligence, the correlation coefficient was calculated to test this finding on our study as well. The p values of the correlation coefficients do not show much of significance, and therefore this study is not able to support the finding of dependency of intelligence on performance on the task. For the patients' group there was only one significant result where total intelligence would correlate with the performance on the detection question of the non faux pas stories. Within the control group, there are pretty much no moderate or strong correlations, and where almost all correlations show a negative relationship meaning having a lower total intelligence score would result in better performance on the test. This particular finding should be re-tested on another sample to provide any solid conclusions, as no solid arguments can be given for this particular finding.

6.1 Limitations

As mentioned throughout the discussion, this study consisted of a sample size of 24 participants, i.e. 12 epilepsy patients and 12 controls. Those 12 patients were selected from a bigger sample of 73 patients. However, not all of these 73 patients did meet the requirements for this particular study, as all patients needed to complete the same version of the faux pas test to avoid any other biases regarding different versions completed. Moreover, patients' matched controls also should have completed the same version at the same time interval. In other words, selection bias is one of the limitations of this study as well as the small sample size.

Besides the sample size, patients were only assessed after surgery, where there is no visible overview of their performance over time, i.e., before surgery and time following after surgery.

6.2 Future studies

Future studies should focus on the development of a patient with epilepsy over time, to be able to judge their performances over a certain timeframe – before and after surgery. Moreover, the study should be conducted with another sample, as selection bias was present in this study. Another study including more participants could also give more information about the patient and control group as not much is known yet about the advanced ToM attributions during adolescence time.

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