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ORIGINAL RESEARCH

Social Cognition Impairments in the Long Term Post Stroke

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Abstract

Objective: To examine the presence of social cognition deficits and the relationship between social and general cognition (eg, attention, mental speed, verbal, visual, or memory abilities) in a large sample of chronic stroke patients and to identify stroke-related factors associated with social cognitive performance.

Design: Inception cohort study in which social cognition was assessed at 3-4 years post stroke.

Setting: Stroke units in 6 general hospitals.

Participants: The data of 148 patients were available. Fifty controls without stroke (consisting of partners of patients and acquaintances of researchers) were recruited (N=198).

Interventions: Not applicable.

Main Outcome Measures: Patients underwent neuropsychological assessment by means of tests for social cognition (emotion recognition, theory of mind [ToM], empathy, and behavior regulation) and general cognition. Subgroup analysis was performed to compare right hemisphere stroke patients with left hemisphere stroke patients. Correlations between general and social cognition tests were assessed. Multiple regression analyses were performed to identify demographic and stroke-related predictors of social cognitive performance.

Results: Patients performed significantly worse on emotion recognition (assessed with the Ekman 60-Faces test on total score as well as on the emotion anger), ToM (assessed with the Cartoon test), and behavior regulation (assessed with the Hayling test). Subgroup analysis revealed no differences between right and left hemisphere patients. Social cognition tests showed significant correlations with each other and with tests for visual perception, language, mental speed, cognitive flexibility, and memory. Older age, low level of education (and for ToM, also female sex) were predictors of worse performance on social cognition tests.

Conclusion: Social cognition impairments are present in the long term post stroke, even in a group of mildly affected stroke patients, which may contribute to their long-term problems. Severity of impairments is determined mainly by demographic factors.

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Cognitive impairment is common post stroke and has a major impact on quality of life.[1] Deficits are most commonly reported in mental speed, attention, memory, and executive functioning.[2] However, studies investigating impairments in social cognition are scarce, and, to date, it is not known whether impairments in general cognition affect social cognitive functioning.

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Social cognition comprises the capacities of individuals to process social information, that is, to understand the behavior of others and to react appropriately in social situations. These capacities involve different but interrelated processes.[3,4] First, social cognition requires the ability to identify and discriminate between the emotional states of others, for example, by recognizing emotional expressions on faces. Second, someone has to be able to form a theory of mind (ToM). This is the ability to infer intentions, dispositions, and beliefs of others and to understand that others have beliefs, intentions, and perspectives that are different from one's own. Furthermore, recognition of other people's emotions needs to be linked to one's own emotional experience, which allows one to empathize with others.[3] A final, important element is the ability to control aspects of the self. This behavior regulation involves the monitoring, control, and inhibition of one's own behavior, emotions, or thoughts in order to adapt them in accordance with the demands of the situation.[5] Collectively, all these skills facilitate appropriate social behavior.

Deficits in separate aspects of social cognition post stroke have been reported, with evidence of more severe impairments in patients with right hemispheric lesions. This was shown in deficits in emotion recognition,[6] ToM,[7-10] and empathy.[11] Unfortunately, sample sizes in all studies examining poststroke social cognition are small, with the largest group consisting of 60 patients.[12] Furthermore, until now, studies have not focused on a comprehensive range of aspects of social cognition, and most studies examined social cognition in the acute or subacute phases post stroke.

Examining deficits in social cognition is complicated. Tests designed to measure emotion recognition, ToM, empathy, or behavior regulation are complex and also appeal to several general cognitive functions, such as attention, mental speed, verbal, visual, or memory abilities. For example, recognizing briefly displayed emotional expressions requires attention to be focused on the relevant features as well as mental speed in order to process all relevant information in time. Accordingly, because deficits in general cognitive domains are frequently found post stroke, an important question is to what extent they influence performance on social cognition tests and consequently whether social cognition tests measure deficits in social cognition exclusively. One study including 44 stroke patients found that impairments in ToM and empathy, measured with 2 screening instruments, could not be explained by general cognitive functioning.[7] A more recent study examined the relationship between general cognition and ToM using a robust neuropsychological examination.[13] This showed that pragmatic competence and, to a lesser degree, executive functions had the strongest contribution to ToM impairments, while attention and general cognitive functioning (consisting of the Similarities, Digit Symbols, Digit Span, and Block Design tests from the Wechsler Adult Intelligence Scale−Revised III measuring verbal comprehension, working memory, perceptual reasoning, and processing speed) did not directly affect mentalizing abilities. However, the sample size was small (58 stroke patients), and measurements were performed only 1 year post stroke.

Despite the fact that much research has been done on social cognition impairments post stroke, studies with a large sample size examining a broad range of aspects of social cognition and correlating all these aspects to general cognition are missing. Furthermore, to date, there are no studies in which this relationship has been investigated in the long term post stroke. The aims of the present study were therefore to quantify the magnitude of deficits in a comprehensive range of aspects of social cognition in a large sample of stroke patients in the chronic phase and to examine the relations among the different tests for social cognition and their relations to general cognition measures. Furthermore, because little is known about factors predicting social cognition, determinants of social cognitive performance were studied.

List of abbreviations:

ANCOVA	**analysis of covariance**
BEES	**Balanced Emotional Empathy Scale**
BI	**Barthel Index**
BNT	**Boston Naming Test**
FEEST	**Facial Expression of Emotion: Stimuli and Tests**
MRI	**magnetic resonance imaging**
MS	**multiple sclerosis**
NIHSS	**National Institutes of Health Stroke Scale**
TBI	**traumatic brain injury**
ToM	**theory of mind**
VOSP	**Visual Object and Space Perception**

Methods

Design

The current study is an extension of the prospective longitudinal multicenter Restore4Stroke cohort study, in which stroke patients were followed for 2 years; patients were measured 5 times (T1-T5) during this period.[14] For the present study patients were asked to participate in an extra assessment 3-4 years post stroke (T6). Patients were recruited from stroke units in 6 participating hospitals between March 2011 and March 2013. The T6 measurements were conducted between July 2015 and October 2016. The Restore4Stroke cohort study and the extra follow-up measurements reported here were approved by the Medical Ethics Committees of all participating hospitals.

Subjects

Patients were eligible for this study if they had a clinically confirmed diagnosis of stroke (ischemic or hemorrhagic, judged from a computed tomography scan in the acute phase). All patients had to be $\geq$18 years old. Patients were excluded if they (1) had a serious other condition whereby interference with the study outcomes was expected (eg, neuromuscular disease); (2) were already dependent regarding activities of daily living before their stroke, as defined by a Barthel Index (BI) of $\leq$17; (3) had insufficient command of the Dutch language; or (4) were already suffering from cognitive decline as defined by a score of $\geq$1 on the Heteroanamnesis List Cognition[15] before their stroke. Patients with evidence of visual neglect or language disorder were excluded as well because their results on the social cognition tests might have been influenced by this.

Those without stroke were recruited in 2 ways. First, partners of the participating stroke patients were asked to participate. Second, data from an additional control group, which took part in another study, were added. These controls had been recruited from acquaintances of the researchers. Exclusion criteria were the same as for patients, with an additional exclusion criterion of the occurrence of transient ischemic attack or stroke. Informed consent was obtained from all stroke patients and controls without stroke.

Procedure

The first assessment (T1) consisted of demographic and stroke-related factors, assessed by a trial nurse 4 days post stroke. After 3-4 years (T6) an extensive neuropsychological assessment was conducted by a trained research assistant (graduate neuropsychologist), either in the nearest participating hospital or at home (if patients were not able to travel). Patients performed the total battery of neuropsychological tests, and controls performed only the social cognition test battery.

Measures

Demographic characteristics included sex, age, and level of education. The patients' level of education was recorded according to a Dutch classification system ranging from 1: did not finish primary school to 7: university education.[16]

The hemisphere involved, type of stroke (ischemic or hemorrhagic), and history of previous stroke(s) were obtained from medical charts. The severity of stroke was assessed with the National Institutes of Health Stroke Scale (NIHSS).[17] Activities of daily living were assessed with the BI.[18]

The general cognition test battery consisted of the Visual Object and Space Perception (VOSP) test[19] for higher visual perception, the Bells test[20] for visual neglect, the Boston Naming Test (BNT)[21] for evaluation of aphasia, the Rivermead Behavioural Memory Test story subtest[22] for memory, the Symbol Digit Modalities Test[23] for mental speed, and the Trail Making Test[24] for visual attention and cognitive flexibility.

To measure social cognition, tests were chosen that were designed to measure emotion recognition, ToM, empathy, and behavior regulation.

Emotion recognition

The Ekman 60-Faces test of the Facial Expression of Emotion: Stimuli and Tests (FEEST)[25] was used to examine the recognition of emotional expressions on faces. Sixty faces were shown with expressions depicting the primary emotions: fear, disgust, anger, happiness, sadness, or surprise (10 of each). Stimuli were presented for 3 seconds. The score ranges from 0-60, with higher scores indicating better emotion recognition.

Theory of mind

The Cartoon test[10] is a test for ToM. Subjects have to describe 12 cartoons displaying humorous situations. In half of them, the joke is based on the false belief or ignorance of a character in the cartoon, and the subject needs to form a ToM to understand the joke. The other cartoons require only mental state attribution of the person who drew the cartoon to understand the humorous intention. The score ranges from 0-36 (0-3 per item), with a higher score denoting better performance. The capacity to judge the inappropriateness of behavior in social situations was assessed with a short version of the Faux Pas test.[26] A faux pas occurs when someone says something awkward, hurtful, or insulting to another person, not realizing that one should not say it. Recognizing a faux pas requires belief attribution and inferences about a person's feelings. The task consists of 10 short stories, half of which describe a situation comprising a social faux pas. The Faux Pas Detection score ranges from 0-10 (a higher score indicates better detection).

Empathy

In the 5 faux pas items of the Faux Pas test, participants are asked to describe the feelings of the faux pas recipient. These responses form the Faux Pas Empathy score, ranging from 0-5, with a higher score indicating greater empathic ability. Various aspects of emotional empathy were assessed using the Dutch version of the Balanced Emotional Empathy Scale (BEES).[27] This is a 30-item questionnaire on which subjects rate the extent to which they agree with each statement (ranging from −4 to 4), for example, "Unhappy movie endings haunt me for hours" or "I cannot feel much sorrow for those who are responsible for their own misery" (total score ranging from −120 to 120). Higher scores represent higher levels of emotional empathy.

Behavior regulation and inhibition

The Hayling Sentence Completion test[28] consists of 2 sets of 15 sentences, each of which is missing the last word. In the first section the examiner reads each sentence aloud, and the participant has to simply complete the sentences, yielding a simple measure of response initiation speed. The second part requires subjects to complete a sentence with a nonsense ending word (and suppress a sensible one), giving measures of response suppression ability and thinking time. Total scaled score ranges from 1 (impaired) to 10 (very superior).

Statistical analyses

Descriptive statistics were used to describe patients' characteristics. Chi-square and *t* tests were used to compare demographic characteristics between patients and controls. To determine if the patients included at T6 were a comparable sample of the original cohort, their main demographic and stroke characteristics (including sex, age, education level, NIHSS, and BI) were compared with the characteristics of the patients who refrained from further participation, also using chi-square and *t* tests.

Analysis of covariance (ANCOVA) was used to explore differences between patients and controls on all social cognition tests, in which the selection of covariates was based on demographic differences between groups. Effect sizes (Cohen's d) were calculated using means and standard deviations. Subgroup analysis was performed, in which social cognition test results were compared between right and left hemisphere stroke patients, using *t* tests.

Correlation between social cognition tests was assessed with Pearson correlations. General cognition tests were dichotomized into impaired ($>$1.5 SD under the mean) and not impaired ($<$1.5 SD under the mean). Next, correlations with social cognition tests were assessed.

In stroke patients, multiple regression analysis was performed on the social cognition test measures on which they performed significantly worse than the controls. Demographic and stroke-related factors were used as independent variables. Preliminary analyses were conducted to ensure there was no violation of the assumptions of normality, linearity, multicollinearity (correlation coefficient $>$0.7), and homoscedasticity.

The critical value of α was set at 0.05. Analyses were performed with IBM SPSS Statistics version 19.[a]

Table 1 Characteristics of stroke patients (n=148)

	n (%)
Demographic characteristics	
Sex, number of men	103 (69.6)
Age (y), mean ± SD	
T1	63.9±11.3
T6	67.7±11.2
Education level	
Low (1-5)	106 (71.6)
High (6-7)	42 (28.4)
Stroke characteristics	
Type of stroke	
Ischemic	137 (92.6)
Hemorrhagic	11 (7.4)
Location of stroke	
Left	50 (33.8)
Right	62 (41.9)
Vertebrobasilar	36 (24.3)
Recurrent stroke	20 (13.5)
NIHSS score at T1, median ± SD	2.0±3.0
No stroke symptoms (NIHSS 0)	37 (25.0)
Minor stroke symptoms (NIHSS 1-4)	84 (56.7)
Moderate stroke symptoms (NIHSS 5-12)	25 (16.9)
Moderate to severe symptoms (NIHSS>12)	2 (1.4)
Barthel Index at T1, mean ± SD	17.1±4.5
ADL independent (BI 19-20)	87 (58.8)
ADL dependent (BI<19)	61 (41.2)

Abbreviations: ADL, activities of daily living; T1=4 days after stroke.

Results

Subjects

A total of 395 patients were included in the Restore4Stroke cohort study. At T6, a total of 160 of them (40.5%) were included for further testing. With respect to the 235 patients who resigned, 33 patients died, 120 patients refused further participation, 47 patients could not be reached by T6, and it was not possible to conduct the T6 assessment in 35 patients because of their general physical condition. Two patients had evidence of visual neglect according to the results of the Bells test (score >3); 10 patients had evidence of a language disorder according to the results of the BNT (BNT T-score <2 SD) or the clinical judgement of the neuropsychologist. They were excluded, which resulted in a total of 148 patients.

The characteristics of the 148 patients are displayed in table 1. At T6 mean age was 67.7±11.2 years, and mean time since stroke was 3.7±0.6 years. Besides age, no significant differences were found in the characteristics of the 148 patients included at T6 and the 247 patients who resigned. The T6 group was somewhat younger at time of stroke (63.9 years compared with 68.2 years; $t=3.42$; $P=.001$).

Fifty controls (half of which were partners) with a mean age of 65.2±8.1 years were included. Chi-square and t tests showed no significant differences between patients and controls with respect to age ($t=-1.6$; $P=.102$) and education level (high education: controls 40.0% vs patients 28.4%; $\chi^2=2.3$; $P=.126$), while there were more men in the patient group (patients 69.6% vs controls 48.0%; $\chi^2=7.6$; $P=.006$). Therefore, sex was included as a covariate in the ANCOVA.

In table 2 the means and SDs on the social cognition tests are shown for the 2 groups together with the comparisons between the 2 groups. Patients performed significantly worse on the FEEST total score and FEEST emotion anger (emotion recognition), Cartoon test (ToM), and Hayling test (behavior regulation). Subgroup analysis revealed no significant differences between right and left hemisphere stroke patients on any of the social cognition tests.

Correlations between social cognition test measures in patients are shown in table 3. Except for the BEES, almost all social cognition tests showed significant correlations with each other (with the exception of the correlation between the Cartoons and Faux Pas detection).

Correlations between general cognition tests and social cognition tests are shown in table 4. Only the VOSP test and the BNT showed correlations of medium strength with some of the social cognition measures: the VOSP test correlated significantly

Table 2 Social cognition test results at T6

Test Measures	Stroke Patients (n=148) Mean ± SD	Controls Without Stroke (n=50) Mean ± SD	ANCOVA F	ANCOVA P Value	ANCOVA Effect Size
FEEST total score	42.63±6.2	45.02±6.2	4.64	0.033	0.39
FEEST-anger	6.69±2.2	7.79±1.9	8.73	0.004	0.54
FEEST-disgust	6.78±2.4	7.27±2.1	0.61	0.438	0.22
FEEST-fear	4.74±2.2	4.81±2.5	0.29	0.594	0.03
FEEST-happiness	9.76±0.6	9.79±0.5	0.00	0.988	0.05
FEEST-sadness	6.00±2.1	6.50±1.8	2.20	0.140	0.26
FEEST-surprise	8.66±1.6	8.85±1.2	0.54	0.465	0.13
Cartoon test	21.28±6.8	22.75±5.9	4.16	0.043	0.23
Faux Pas detection	9.25±1.0	9.12±0.7	0.79	0.375	-0.15
Faux Pas empathy	3.00±1.2	3.28±1.2	1.19	0.276	0.23
BEES	32.06±22.5	35.60±26.1	0.03	0.861	0.15
Hayling	3.13±1.8	4.65±1.4	29.3	<0.001	0.94

NOTE. FEEST: higher score means better emotion recognition; Cartoon test: higher score means better ToM; Faux Pas detection: higher score means better ToM; Faux Pas empathy: higher score means higher level of empathy; BEES: higher score means higher level of empathy; Hayling: higher score means better behavior regulation.

Table 3 Pearson correlations between social cognition tests in patients

	FEEST	Cartoon Test	Faux Pas Detection	Faux Pas Empathy	Hayling
Cartoon test	0.471*				
Faux Pas detection	0.221‡	0.148			
Faux Pas empathy	0.180‡	0.264†	0.243†		
Hayling	0.319*	0.433*	0.243†	0.234†	
BEES	0.060	−0.016	0.017	0.075	0.098

* $P<.001$.
† $P<.01$.
‡ $P<.05$.

with the FEEST ($r=0.357$) and the Hayling test ($r=0.309$); the BNT correlated significantly with the Cartoon test ($r=0.326$).

In multiple regression analyses (table 5), demographic and stroke-related factors explained 16.2% of the variance in the FEEST total score ($P=.002$), 37.9% of the variance in the Hayling test ($P<.001$), and 33.3% of the variance in the Cartoon test ($P<.001$). Younger age and a high level of education were predictors of higher scores on the FEEST total score, the Hayling test, and the Cartoon test. In all 3 tests, age was the strongest predictor (FEEST: $\beta=-0.355$; Hayling: $\beta=-0.511$; Cartoon: $\beta=-0.452$). For the Cartoon test, male sex was also a significant predictor of higher scores ($\beta=-0.244$).

Discussion

Our study showed that in the long term post stroke, patients performed significantly worse on emotion recognition (assessed with the Ekman 60-Faces test of the FEEST, on total score as well as on the emotion anger), ToM (assessed with the Cartoon test), and behavior regulation (assessed with the Hayling test). Multiple regression analyses showed that these impairments were more severe in older and lower educated patients (and for ToM also in female patients), while stroke-related factors were not found to be significant determinants of social cognition impairments. Except for the BEES, almost all social cognition tests showed significant (small to medium) correlations with each other (only the relation between the Cartoon test and the Faux Pas detection was not significant), indicating that there is some overlap between the various tests, suggesting the tests share a common aspect of social cognition.

The majority of our patients (81.7%) suffered a minor stroke (NIHSS<5). Still, social cognition impairments were found in this relatively nondisabled patient population. It could, however, explain why we did not find differences between right and left hemisphere stroke patients. Deficits in social cognition are associated with lesions in the right prefrontal cortex, the right superior temporal gyrus, and the temporoparietal junction.[29] Generally, minor strokes do not affect these areas because most of them are lacunar infarcts involving small penetrating arteries in the deep areas of the brain. In many studies comparing social cognition in right and left hemisphere strokes, lacunar infarcts were excluded or comprised only a small amount of all strokes.[6] It could also explain why we did not find significant differences between patients and controls on the domain of empathy. Hillis et al[11] described how focal lesions affect emotional empathy. In summary, the right amygdala, the right temporal pole, the right anterior insula, and the right anterior cingulate cortex are most responsible for impairments in empathy. In addition, Yeh et al[7] concluded that empathy scores were significantly lower in right hemisphere stroke patients compared with controls, but not in left hemisphere patients. Because we did not find differences between right and left hemisphere patients, this could explain why we also did not find significant differences in empathy scores between patients and controls.

Although extensive research on location-symptom mapping has been performed in the field of social cognition, study results do not always show a 1:1 relationship between lesion location and social cognition impairments. In a recent study examining emotion recognition, ToM, and empathy after aneurysmal subarachnoid hemorrhage, the authors did not find a relationship between social cognition impairments and the location of

Table 4 Pearson correlations between social cognition and general cognition tests in patients

	SDMT	TMT-B/A Ratio	RBMT Stories Immediate Recall	RBMT Stories Delayed Recall	VOSP	BNT
FEEST	0.066	0.147	0.038	0.088	0.357†	0.205‡
Cartoon test	0.100	0.061	−0.029	0.181‡	0.284†	0.326*
Faux Pas detection	0.144	0.162	0.052	0.180‡	0.191	0.204‡
Faux Pas empathy	0.240†	0.030	0.108	0.168	0.126	0.156
Hayling	0.205‡	0.216‡	0.009	0.130	0.309†	0.244†
BEES	0.090	0.175	0.038	0.098	0.039	−0.050

Abbreviations: RBMT, Rivermead Behavioural Memory Test; SDMT, Symbol Digit Modalities Test; TMT, Trail Making Test.
* $P<.001$.
† $P<.01$.
‡ $P<.05$.

Table 5 Multiple regression analyses of independent variables and FEEST, Hayling, and Cartoon test scores

Factors	Measure	FEEST		Hayling		Cartoons	
		β	*P* Value	β	*P* Value	β	*P* Value
Demographic factors							
Sex (female)		0.031	.720	−0.049	.489	−0.244	.001*
Age		−0.355	<.001*	−0.511	<.001*	−0.452	<.001*
Education (high)		0.168	.048*	0.327	<.001*	0.175	.017*
Stroke-related factors							
Side of stroke (right vs left+vertebrobasilar)		0.038	.647	0.051	.461	0.027	.708
Severity of stroke	NIHSS	−0.127	.162	−0.082	.269	0.016	.836
ADL (independent)	BI	−0.056	.545	−0.028	.708	−0.016	.835
Recurrent stroke(s)		−0.070	.408	−0.032	.651	−0.110	.130
		$R^2=0.162$		$R^2=0.379$		$R^2=0.333$	

Abbreviation: ADL, activities of daily living.
* $P<.05$.

aneurysmal subarachnoid hemorrhage.[30] They compared frontal lesions with nonfrontal lesions (based on magnetic resonance imaging [MRI]) and concluded that it does not matter whether there is an aneurysm in the anterior circulation or whether there is frontal damage (like ischemia) visible on MRI. One of their explanations is that the frontal cortex is part of a larger network subserving social behavior, in which other cortical and subcortical areas also participate. Consequently, lesions in all different areas that are part of these networks can affect social cognition. It is well known that stroke affects not only local connectivity but can also cause remote brain changes, as shown by functional MRI and diffusion tensor imaging studies.[31] A recent study showed that brain connectivity measures predict applied cognitive functioning 6 months post stroke.[32] The Prediction of Cognitive Recovery After Stroke investigators are currently investigating whether diffusion tensor imaging−based measures of brain connectivity predict social cognition.[33]

It is particularly interesting to find that social cognition impairments are still present so long post stroke, even in a group of patients with mostly minor strokes. Three to 4 years post stroke, patients may have at least partially recovered from the initial impairments caused by the lesion. On the one hand, the length of our follow-up and the mild nature of the stroke might explain why effect sizes in our study are relatively small in comparison with other studies. On the other hand, even patients with a relatively favorable outcome (in terms of stroke severity) can have long-term problems in participation and quality of life.[34] The presence of social cognition problems may contribute to these findings. We have these data available and will analyze these associations in another study because this is beyond the purpose of the current study.

Our study is the first study investigating the relationship between general and social cognition in stroke patients. In the recent literature, reviews have been written about impairments in social cognition and their relationship with general cognition in several neurologic disorders, such as multiple sclerosis (MS),[35] traumatic brain injury (TBI),[36] and amyotrophic lateral sclerosis.[37] In TBI no significant correlations were found.[38] In amyotrophic lateral sclerosis there was a significant relationship between social cognition and executive dysfunction.[37] In MS inconsistent associations were found between studies.[35] In our study of stroke patients, poor performance on the social cognition measures appeared to be partly associated with deficits in visual perception (for emotion recognition and behavior regulation) and language (for ToM), albeit with small-medium strength correlations. Some correlations could be explained by similar task demands, for instance, the correlation of the Cartoon test with the BNT, requiring sufficient language capacity, and of the FEEST with the VOSP, requiring complex visual perception. However, this did not apply to several other significant correlations, for instance, the VOSP with the Hayling test and the Faux Pas detection test as well as the Cartoon test with the Symbol Digit Modalities Test and Rivermead Behavioural Memory Test stories. Because of our assumption that the communality would be related mainly to severity of stroke causing deficits in various cognitive domains that might be in themselves unrelated, we performed some additional analyses (results not shown). We used *t* tests to compare the social cognition performances of patients who had impaired scores on the general cognition tests with patients with nonimpaired scores and found that the social cognition tests also differed significantly, confirming our hypothesis.

As in our study, older age was a predictor of greater deficits in emotion recognition in MS patients.[35] Also in accordance with the results in our study, no disease-related predictors were found in MS patients. In a study of TBI patients, longer posttraumatic amnesia duration and a lower Glasgow Coma Scale score (ie, more severe TBI) were predictors of poor facial emotion recognition (assessed with the FEEST).[38] They found that a longer duration of posttraumatic amnesia is associated with a greater likelihood of having prefrontal damage. Because patients in our study were less likely to have prefrontal damage, this might explain why stroke-related factors could not be identified as significant predictors of social cognition impairments. Another explanation may be that patients with moderate to severe stroke were underrepresented. Therefore, it is too simplistic to conclude that severity of stroke is not related to social cognition impairments.

Study limitations

Some limitations of our study should be mentioned. First, no brain imaging characteristics were assessed in our study, which could have told us more about lesion sites. Second, a disadvantage of examining social cognition in the long term post stroke is that only the most motivated patients are willing to participate in extensive neuropsychological assessment. The fact that only 37.5% of the original cohort participated in the final assessment at 3-4 years post stroke could indicate that there was a selection bias, with only the "better" patients remaining. Nevertheless, no significant differences were found in stroke characteristics between the 148 patients left at T6 and the 247 patients who resigned. Third, we included only demographic and stroke-related characteristics in the multiple regression analysis, while such factors as depression, pain, and fatigue might also influence social cognition. Future research must focus on these factors. Furthermore, because effect sizes of the significant results in the ANCOVA are relatively small, our results should be interpreted with caution. It would be interesting to measure clinical significance because the assessment of clinical relevance can facilitate the interpretation of the research results into clinical practice. Unfortunately, we do not have the minimally clinically important difference of the tests available. However, because we found statistical significant differences on social cognition performances between patients and controls, our findings open the field of future research on this topic. Finally, except for the FEEST, there are no norm scores for the social cognition measures used in this study. Therefore, unfortunately, it is not possible to present prevalence rates of social cognition impairments in stroke patients.

Conclusions

Stroke is associated with significant deficits in facial emotion recognition, ToM, and behavior regulation, even in the long term post stroke and in a group of mildly affected stroke patients. Although it is likely that these deficits have behavioral implications and negative effects on quality of life, this is a topic for further investigation.

Supplier

a. IBM SPSS Statistics, version 19; IBM.

Keywords

Cognition; Social behavior; Stroke; Rehabilitation

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