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ORIGINAL REPORT

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COMMUNICATION IN CHILDREN AND ADOLESCENTS AFTER ACQUIRED BRAIN INJURY: AN EXPLORATORY STUDY

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Objective: **The usability of the Communicative Effectiveness Index (CETI) in adolescents with acquired brain injury was investigated and compared with linguistic, cognitive and brain injury data.**

Design: **A prospective, longitudinal, between-group design.**

Subjects: **Thirty participants were divided into 2 subgroups: CETI+ and CETI− groups.**

Methods: **Parental CETI ratings of daily communication were compared with linguistic data and IQ test results. Lesion site and aetiology were also studied.**

Results: **The CETI+ group ($n=16$) had a mean score greater than 75 out of 100, while the mean score of the CETI− group ($n=14$) was below 75. Complex daily communication was impaired in both groups, but the CETI− group scored significantly lower on verbal IQ and grammar comprehension tests and had more naming difficulties. A majority of subjects in the CETI− group had a left hemisphere injury. Traumatic vs non-traumatic acquired brain injury did not differentiate the results.**

Conclusion: **Specific complex CETI items provided unique information that is not easily measured by linguistics and cognitive tests for use with the acquired brain injury group. Parental evaluations of communication skills were well reflected in language and verbal IQ test results. Left hemisphere injury was associated with poorer communication outcome.**

Key words: communication functions; acquired brain injury; children and adolescents; parental ratings.

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Acquired brain injury (ABI) in children and adolescents (hereafter termed adolescents) is a major cause of mortality and morbidity, and survivors may experience persistent communication impairments (1–3). For example, follow-up 10 years post-trauma in 53 young adults demonstrated that participants had significantly poorer performance in tests of intellectual function, with lower results in verbal tests compared with matched controls (4). The injuries may have an external cause (traumatic brain injury; TBI), such as a traffic accident or fall, or an internal cause (non-traumatic brain injury; NTBI), such as stroke, brain tumour or brain-related infection, e.g. meningitis (5).

Communication difficulties after ABI are frequently associated with disruption of basic neuropsychological, including linguistic, processes (6). These processes involve verbal and non-verbal intelligence, verbal learning and memory, hearing and visual functions, discourse, meta-linguistic tasks, abstract and indirect language, lexical-semantic and syntactic processing. Other complex skills required for communication involve theory of mind, narrative discourse, behavioural self-regulation, sequencing action, developing resolutions, extracting the moral of a story in discourse and producing gist-based texts on a novel measure of summarization (7–10).

In real-life, communication difficulties can result in deteriorated contacts with friends, as well as poor academic achievement and the need for special education support (11, 12). Understanding the nature of the impairments should therefore be an important priority among practitioners and researchers in the field of paediatric ABI.

It is, at present, unclear to what extent everyday communication functions can be captured with data from tests of language and cognition in a clinical setting. As has been reported previously, participants may be able to collaborate in complex thinking and communication tasks in the clinic, but nevertheless fail to do so in an everyday environment (13). Furthermore, the use of parental evaluations requires further study, since there is increasing evidence that contextualized, family-supported interventions after ABI can be superior to rehabilitation in clinical surroundings (14).

Anterior-posterior pathways

Evaluations of communication outcome could benefit from a comparison with the ABI locations, considering that the injuries frequently affect subcortical pathways connecting frontal cerebral areas to other parts of the brain, involving the inferior fronto-occipital fasciculus (IFOF) (15). Impaired anterior-posterior pathways can result from structural disconnections caused by subcortical lesions or diffuse axonal injury (DAI), which are common after ABI. In particular, the IFOF has been shown to affect the supervision of complex cognitive

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and linguistic processes, since it connects the frontal lobe directly to the postero-lateral temporal, parietal, and occipital lobes (15, 16).

Inclusion of adolescents with non-traumatic brain injury

Impaired cognition and related communication problems are not restricted to participants with TBI, since NTBI is also known to induce communication disorders (17). In addition, there appears to be an increasing number of participants with NTBI related to different aetiologies. The improved survival rates for young people with brain cancer and stroke (18, 19) as well as the constantly changing epidemiological profile of survivors of meningitis all have a role to play in this increase in injuries (20). Moreover, as has been previously pointed out, the heterogeneous profile of adolescents with ABI may be the cause of their under-representation in the research literature, which is unfortunate (21). To recruit an acceptable number of participants within each of the NTBI aetiologies for meticulous group-design studies might be practically unfeasible, as a result of the low incidence within specific aetiologies. In conclusion, both subgroups were included to explore differences as well as similarities, which can be useful in developing communication interventions in the entire ABI group.

Aims of the study

The overall aim of the study was to examine the usability of the Communicative Effectiveness Index (CETI) through parental evaluations of communication in 30 adolescents, compared with linguistic, cognitive and brain injury data.

In addition, the study also checked how information from the parental communication ratings and linguistic/cognitive tests relates to background data on lesions to cerebral networks and aetiology, i.e. (*i*) whether adolescents with particularly poor communicative outcome in real-life situations have injuries located in the left hemisphere, and (*ii*) whether there were any differences in results depending on aetiology of the injuries or (*iii*) demographic factors.

METHODS

Participants

Thirty consecutive participants (18 with TBI and 12 with NTBI) were recruited from a regional rehabilitation centre. Out of 32 selected families, one family declined to participate in the study. Another participant was excluded due to interruption of the clinical evaluations, on the family's own initiative. The final sample included 19 males and 11 females who all had neurologically assessed complex clinical pictures. Mean age at injury was 12.7 years (SD 3.2, range 2.6–17.5 years). All participants but one were aged 8 years or above at time of injury. The assessments were concluded in a mean of 16 months post-injury. Mean age at assessment was 14.2 years (SD 2.7, range 8.6–17.8 years). The inclusion criteria were: no previous history of neuropsychiatric disorders, neurological deficits, language delays, autism, intellectual disability and Swedish as a first language. In participants with reported hearing and visual impairments, compensatory strategies and/or devices were applied (n=29). Data on injury locations were obtained through available medical records.

Severity

The severity of TBI was determined by on-scene paramedics or scored using the description at the time of presentation in the emergency room. The Glasgow Coma Scale (GCS) (22) or the Swedish equivalent, the Reaction Level Scale (RLS 85) (23), were used, to evaluate the same basic information (response to speech, touch and pain), making comparison of injury severity possible (24). TBI was considered mild if the GCS was 13–15, moderate if the GCS was 9–12 or severe if the GCS was <9. Furthermore, estimates of post-traumatic amnesia (PTA) were a primary source of information in 8 participants (25). Injury severity was considered mild if PTA< 1 h, moderate if PTA was 1–24 h, severe if PTA was 1–7 days or more (26). The collected injury data for the participants were converted into a 3-graded scale, where 1=mild, 2=moderate and 3=severe injury. The total results of the neurological ratings of injury severity were: 14 severe, 9 moderate and 7 mild.

The severity of NTBI was scored after admission for assessment to the rehabilitation centre. Participants with no records of amnesia or reduced levels of consciousness (n=6) were scored in accordance with the model proposed in the Modified Rankin Scale (mRS) (27), as follows:

- Mild injury: minor motor limitations and problems with communication (mRS 0, 1).
- Moderate injury: mild motor impairments and/or mild problems with communication (mRS 2, 3).
- Severe injury: severe motor impairments and/or severe problems with communication (mRS 4, 5).

Causes

The aetiology of the injuries was heterogeneous; however, multifocal injury location was common (n=25). For TBI the following causes of injury were recorded: (*i*) traffic accident, (*ii*) sports accident, and (*iii*) physical assault. For the NTBI the following causes of injury were recorded: (*i*) tumour, (*ii*) intracranial arteriovenous malformation, (*iii*) anaesthesia-related morphine overdose, (*iv*) stroke, and (*v*) meningitis or encephalitis (Table I).

Materials and methods

Oral and written information about the study was provided to the parents of the participants, at the beginning of a 4–6-week clinical assessment period. Parents were assured that the research data would be handled confidentially and anonymously. The adolescents' communication functions were rated by parents on the CETI (28) in collaboration with the researcher, who was a licensed speech-language pathologist. Assessments were also carried out on data from a selection of tests of language and cognition for use with adolescents with brain injuries, and on data regarding lesion site and aetiology. The feasibility of conducting specific tests measuring language production was

Table I. Characteristic data from the patients with acquired brain injury

Case	Sex	Age at test	Years since injury	Aetiology	Injury severity	Lesion site according to magnetic resonance imaging or computerized tomography findings	AI	VI
1	M	16.4	2.3	Motor vehicle accident	2	Occipital lobe	1	1
2	F	11.3	1.0	Tumour	2	Occipital lobe	1	0
3	F	16.5	2.4	Motor vehicle accident	3	Thalamus/basal ganglia	0	1
4	M	15.8	2.2	Motor vehicle accident	2	Left frontal and temporal lobes, occipital lobe	1	1
5	M	11.7	2.1	Tumour OCR	2	Occipital lobe	1	1
6	M	13.8	1.6	Tumour OCR	2	Cerebellum, pineal gland	1	1
7	M	8.6	6.0	Anaesthesia-related morphine overdose	3	No findings	1	1
8	M	16.8	0.4	Stroke	3	Subarachnoid haemorrhage	1	0
9	F	11.4	2.5	Tumour OCR	2	Right frontal and parietal lobes	1	0
10	M	12.1	0.3	Motor vehicle accident	2	Right parietal and occipital lobes	1	1
11	M	12.4	0.0	Motor vehicle accident	1	Diffuse axonal injury, splenium and mesencephalon	1	0
12	M	17.3	1.5	Motor vehicle accident	3	Left temporal and parietal lobes, corpus callosum, semi oval centre	0	0
13	M	17.6	3.3	Motor vehicle accident	3	Right temporal lobe, bilateral parietal lobes	1	0
14	M	16.0	1.3	Motor vehicle accident	3	Left frontal and temporal lobes	0	1
15	F	16.7	1.4	AVM	3	Right frontal, temporal and parietal lobes	1	1
16	M	13.9	3.7	Motor vehicle accident	3	Bilateral left frontal lobes, left ventricles	1	0
17	M	16.4	0.2	Motor vehicle accident	1	Right frontal lobe, left parietal lobe	1	0
18	F	13.4	0.4	Stroke	2	Left temporal lobe, bilateral parietal lobes	1	0
19	M	9.3	0.3	Infection	1	Left frontal and parietal lobes, right parietal lobe, occipital lobe	1	1
20	F	12.7	1.4	Sport	1	Right temporal lobe	1	0
21	M	12.3	0.2	Motor vehicle accident	3	Left frontal lobe, right temporal lobe, left internal capsule, diffuse axonal injury	1	1
22	F	16.5	2.5	Sport	1	No findings	1	1
23	M	17.8	0.3	Sport	3	Bilateral frontal lobes, occipital lobe	1	1
24	F	15.8	0.3	Motor vehicle accident	1	Occipital lobe, basal ganglia, cerebellum	1	1
25	M	16.2	0.4	Physical assault	3	Left frontal, temporal and parietal lobes; occipital lobe	1	1
26	F	14.8	0.5	Sport	3	Corpus callosum, bilateral diffuse axonal injuries, brain stem	1	1
27	F	10.5	1.0	AVM	3	Central deep brain structures	1	1
28	M	11.0	0.2	Stroke	3	Occipital lobe, thalamus	1	1
29	M	17.0	0.6	Sport	1	Bilateral frontal lobes, temporal left lobe	1	0
30	F	12.2	0.10	Stroke	2	Left basal ganglia, left temporal lobe	0	1

AVM: intracranial arteriovenous malformation; OCR: operation, chemotherapy, radiation; grades of severity: 1 = mild, 2 = moderate, 3 = severe; AI: auditory impairment; VI: visual impairment.

restricted due to overall impairments; for example, extensive speech production difficulties related to general fatigue, motor speech disorder or executive problems as a result of frontal lobe injury. These difficulties made it impossible for many of the subjects to complete these tests. Nineteen out of 30 adolescents completed the Boston Naming Test (BNT) (29). However, since the participants in the study are fairly representative/typical of the relevant population, we concluded that it was important to include the available BNT results as a measure of expressive language ability. These results were deemed particularly relevant to further understanding the daily communication results obtained with the CETI.

Associations between expressive language and comprehension of grammar and words have been found in previously language-disordered adolescents, who did poorly on both the Test of the Reception of Grammar (TROG) and the Peabody Picture Vocabulary Test (PPVT) tests (30) and correlations between PPVT and Verbal IQ in typically developing school-aged participants indicated "rather strong evidence that PPVT-III is an effective screening device for verbal ability" (31, Examiners manual, p 57). Hence, to investigate aspects of expressive speech and language comprehension in the participants in this study, the chosen linguistic and cognitive tests battery comprised: TROG (32), Peabody Picture Vocabulary Test III (PPVT III) (31), BNT, and the Wechsler Adult Intelligent Scale (III) (33)/Wechsler Intelligent Scale for Children III/IV (34, 35).

Communicative Effectiveness Index

The CETI questionnaire was chosen to evaluate daily communication functions because: (*i*) it covers a range of communicative behaviours associated with ABI; (*ii*) it is well known in the domain of acquired communication disorders; (*iii*) it is based on descriptions by significant others of daily communication situations in persons with ABI; and (iv) it is easy to administrate by the participants. In the CETI, 16 everyday communicative

Table II. Parent evaluations of preserved communication function on Communicative Effectiveness Index (CETI) items 1–16 in the full study group ($n = 30$). Range 0–100%

Items (n=16)	Min–Max	Mean (SD)
1. Getting somebody's attention	7–100	87.82 (20.65)
2. Getting involved in group conversations that are about him/her	0–100	66.58 (28.39)
3. Giving yes and no answers appropriately	0–100	84.70 (26.96)
4. Communicating his/her emotions	0–100	75.76 (26.25)
5. Indicating that he/she understands what is being said to him/her	17–100	80.10 (22.27)
6. Having coffee–time visits and conversations with friends and neighbours (around the bedside or at home)	0–100	73.13 (30.98)
7. Having a one-to-one conversation with you	0–100	83.63 (27.58)
8. Saying the name of someone whose face is in front of him/her	0–100	76.40 (34.63)
9. Communicating physical problems such as aches and pains	7–100	82.50 (27.91)
10. Having a spontaneous conversation (i.e. starting the conversation and/or changing the subject)	0–100	71.58 (34.28)
11. Responding to or communicating anything (including yes or no) without words	9–100	82.67 (25.51)
12. Starting a conversation with people who are not close family	0–100	67.27 (34.33)
13. Understanding writing	0–100	62.77 (37.53)
14. Being part of a conversation when it is fast and there are a number of people involved	0–100	46.20 (37.96)
15. Participating in a conversation with strangers	0–100	65.10 (36.63)
16. Describing or discussing something in depth	0–100	56.91 (37.82)

SD: standard deviation.

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functions are surveyed through individual ratings (Table II). The assessments are made on a 100-mm visual analogue scale (VAS), where 100="As able as before the injury" and 0="Not at all able". The ratings can be used qualitatively, visualizing the results for each situation to reflect perceived improvement or impairment. They can also be converted into a score by laying a template marked with 1-mm divisions over the 10-cm VAS and reading off a value between 1 and 100. The CETI has previously shown a high validity in assessment of functional communication in adult participants of different language backgrounds (36, 37).

Linguistic and cognitive measures

The Swedish versions of PPVT III, TROG and BNT were applied to provide information about the participants' general receptive and expressive vocabulary.

The neuropsychological assessments were carried out by a licensed neuropsychologist, applying the WAIS III or the WISC III/IV, depending on the participant's age at assessment. Differences associated with chronological age at injury, chronological age at time of assessment and gender distribution were statistically analysed.

It was essential to include all consecutive participants in the study so that the assessments were based on a representative sample of the ABI population. Those who could not complete the formal assessments ($n=7$) were assigned a standard score of 40 as an indicator of level of cognitive functioning. The score of 40 was chosen based on the stipulated floor score of 40 of the PPVT-III, and also to correspond to a level below the lowest rated Full Scale IQ (FSIQ) result in this study. This method was applied in the VIQ and/or PIQ evaluations in participant numbers 4, 13, 14, 25, 26 and 27. It was also applied in the PPVT and/or the TROG, where participant numbers 14, 25, 26 and 27 were assigned a floor score of 40, since they could not fully partake in the assessments.

The BNT was administered to measure the adolescent's verbal communication skills. Participants are allowed 20 s to respond to each picture according to the standard test procedures, which was a challenge for a majority of the adolescents due to delayed response time as a result of the brain injury. In these cases, the response time was extended to capture the naming ability and not the processing speed capacity in the test situation. Furthermore, instructions for each of the test items in the language tests were repeated if necessary, to minimize the influence of symptoms such as visual and auditory disabilities or memory and attention problems, on the test performance.

Statistical analysis

The data were computed in the Statistical Package for the Social Sciences (SPSS), version 20.0 for Windows. The level of significance was set as $p<0.05$ (2-tailed).

Cronbach's alpha was calculated to examine the internal consistency of all the 16 parameters in the CETI. There were a total of 9 missing values on the CETI (out of a total of 480 assessed items, i.e. less than 2%) and these were imputed using the mean value for the item in question. The internal consistency on the CETI proved to be excellent with a Cronbach's alpha of 0.97, both with and without imputation of missing values.

A cut-off was established for severely impaired communication outcome on the CETI scale, motivated by a combination of clinical experience with the scale (parents to adolescents with more severe communication difficulties tend to choose evaluation scores below 75 on the CETI) and for analytical purposes. This cut-off created 2 almost equally sized groups: the CETI+ group with a score above 75 ($n=16$) and CETI− group with participants who were assigned a score below 75 ($n=14$).

Group comparisons were conducted with non-parametric Mann–Whitney U tests (U) for continuous variables, and χ^2 tests for categorical variables. Furthermore, the CETI+ and CETI− groups were compared with respect to lesion location and aetiology.

RESULTS

Communicative Effectiveness Index

The items measuring communication functions with the 6 highest mean ratings for the whole group were: *#1 Getting somebody's attention, #3 Giving yes and no answers appropriately, #5 Indicating that he/she understands what is said to him/her, #7 Having a one-to-one conversation with you, #9 Communicating physical problems such as aches and pains, and #11 Responding to and communicating anything (including yes or no) without words.* These items received high parental ratings: over 80% functional communication out of 100%. They represent very basic communicative functions and seemed relatively well preserved in the participants.

The items with the absolutely *lowest* mean ratings for the whole group were *#14 Being part of a conversation when it is fast and there are a number of people involved* and *#16 Describing or discussing something in depth* (both below 60% preserved functional communication). Other problematic items were *#15 Participating in a discussion with strangers, #12 Starting a conversation with people who are not close family, #2 Getting involved in a group conversation which is about him/her, and #13 Understanding writing*. All of these are more complex, in different ways, but essential for managing everyday communication in different real-life activities (Table II)

Item 14, *Being part of a conversation when it is fast and there are a number of people involved,* received the lowest mean rating, indicating relatively severe impairment in 21 participants. Concerning uniqueness of information obtained by the CETI ratings, there were adolescents who showed no obvious signs of communication problems in the tests of language and cognition, but who had problems when interacting in the home environment. For example, participant #29, a 17-year-old male, received scores above 90 on the FSIQ, VIQ and PIQ tests. The speech and language assessments showed no clear evidences of difficulties in verbal comprehension at word and sentence level, but the BNT test score revealed a somewhat limited expressive function. The result, 47/60 correct responses, corresponded to a mean level of confrontation naming capacity in 9th grade adolescents (the oldest age group in the Swedish standardization of the BNT). The parents' ratings in the CETI revealed a 30% reduced ability in the adolescent to manage daily conversations.

Linguistic and cognitive measures: TROG, PPVT, VIQ, PIQ and BNT

The CETI results were compared with the test scores, to determine if there were any differences in communication outcome that could be clarified in the results. Data showed that this was the case (Table III).

Specifically, participants in the CETI− subgroup scored significantly lower on the TROG and VIQ tests. Differences in PPVT or on PIQ between the 2 subgroups did not quite reach significance, although the trend was similar. However, it is noteworthy that both subgroups tended to score low on the WISC, including verbal as well as perceptual results. Data measuring visual confrontational naming test ability obtained in the BNT was scored in 19 adolescents (63%) who managed to carry out the evaluations. As a result of the rather high attrition rate, a statistical comparison with other clinical test data was rejected. Instead, an examination of the BNT data was conducted to examine associations between individual stanine scores, compared with the parental evaluations of the participants' daily communication. Stanine scores were chosen as norm-referenced scores to estimate the individual results compared with the performance of other adolescents of the same age. The examination of the data in the light of daily communication skills was motivated by reports from the participants of frequent problems related to verbal vocal production in everyday situations. The available BNT results showed very low – low mean results in 7 adolescents (stanine 1–4); mean results (stanine 5–6) in 10 participants, and 2 adolescents who performed above average – very high (stanine 7 and 9). A closer inspection of the data revealed that a small majority of those who performed very low – low average results, and those who had not been able to participate in the BNT test at all, belonged to the CETI– group ($n=12$), while a clear majority of those who completed the BNT with average results or above belonged to the CETI+ group ($n=9$).

Injury severity and demographic measures

The groups did not differ on overall injury severity. They also did not differ with regard to chronological age at injury, chronological age at time of assessment, gender distribution or in family constellation.

Injury localization measures

The 2 subgroups differed in terms of localization of the brain injury. A majority (9 out of 11 participants) with left temporal and/or frontal injuries belonged to the CETI− subgroup. A χ^2 test with the left temporal-frontal hemisphere group vs the right hemisphere group vs "other" localizations (e.g. central) over communicative effectiveness group was significant, and adolescents in the CETI− subgroup scored significantly lower on the TROG and VIQ tests. Inspection of adjusted standardized residual in the cells suggested that the high proportion of CETI− in the "left temporal/frontal group" and the low proportion of CETI− among those with pure right hemisphere injury were both major contributors (i.e. >1.96) to this overall significant result.

Aetiology measures

No differences were found between aetiology and (*i*) communicative ability according to the CETI ($p>0.2$), (*ii*) cognitive or linguistic test results ($p>0.5$), or, (*iii*) lesion site data ($p>0.3$).

Table III. Subgroup comparison

Measure	Group CETI+ ($n=16$)	Group CETI− ($n=14$)	Statistical comparison
Chronological age at injury, mean (SD)	12.41 (3.53)	13.26 (2.56)	$p=0.82$, ns
Chronological age time at CETI assessment, mean (SD)	13.94 (2.78)	14.37 (2.65)	$p=0.64$, ns
Gender distribution, female/male, *n*	6/10	5/9	$p=1.0$, ns
Severity rating, mean (SD)	2.12 (.89)	2.42 (.76)	$p=0.40$, ns
Intact families, *n*	15	11	
Localization: Left temporal-frontal/Right only/"other", *n*	2/6/8	9/0/5	$\chi^2=11.06$, $p=0.004$
Type of injury, traumatic/non-traumatic, *n*	8/8	10/4	$p=0.28$, ns
PIQ, mean (SD)	83.06 (17.83)	71.43 (28.13)	$p=0.21$, ns
VIQ, mean (SD)	84.87 (14.67)	65.14 (25.80)	U=161, $p=0.043$
PPVT, mean (SD)	103.19 (11.03)	81.14 (34.60)	$p=0.22$, ns
TROG, mean (SD)	98.75 (13.79)	70.43 (32.77)	U=164, $p=0.028$
BNT*	$<$mean: $n=9$ (56%)	$>$mean: $n=12$ (86%)	

*Statistical comparison was rejected, see below for the chosen calculation of the available BNT data.
CETI: Communicative Effectiveness Index; SD; standard deviation; PIQ: Performance IQ; VIQ: Verbal IQ; PPVT: Peabody Picture Vocabulary Test; TROG: Test of the Reception of Grammar; BNT: Boston Naming Test.

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DISCUSSION

The results of this study add to the existing small body of knowledge relating to the usability of the CETI in the daily communicative interactions of adolescents with ABI. Three major findings are discussed below.

First, associated with evaluations of real-life communication skills, the analysis showed that there were specific items in the CETI that provided unique information that is not easily available from other linguistic and cognitive tests for use with the ABI group. The most notable item was *Being part of a conversation, when it is fast and there are a number of people involved,* but other items dealing with talking to strangers, initiating conversations and other complex interaction phenomena were also challenging for many of the participants. These complex interactions received low ratings in a majority of all participants in the ABI group. Hence, complex communication difficulties seemed to occur independently of the participants' aetiology.

Secondly, the test results showed that the overall IQ scores were low, both in the CETI+ group, and in the CETI– group. However, further analyses demonstrated that adolescents with more communication impairments, the CETI− group, scored significantly lower on tests that measure grammar comprehension and VIQ and had more naming problems, compared with those with less impaired communication, the CETI+ group. A conclusion might be that tests of grammar comprehension and vocal-verbal ability are particularly well reflected in parental evaluations of communication in daily contexts. Another conclusion is that poor VIQ results may indicate general vocal verbal production difficulties found in daily communicative situations.

Thirdly, the left hemisphere injury locations were associated with pronounced difficulties in complex communicative situations, as reflected in parental evaluations. Closer examination of the cerebral networks in the CETI− group revealed a high proportion of adolescents with left temporal and/or frontal brain injury having difficulties, suggesting that participants with lesions to the left temporal-frontal cortex, i.e. areas including classic language regions, experienced worse communicative outcomes, whereas those with a selective right hemisphere injury had the least impairments (38).

Even if the language and communication difficulties appeared to be more pronounced in the group with left hemisphere injury, other participants also experienced challenges in complex daily situations. Twenty-one participants in the total study group had a score below 75 in item 14 in the CETI: *Being part of a conversation when it is fast and there are a number of people involved*. The results indicate that this is one of the most challenging interactions after ABI, including adolescents with injury to the left hemisphere as well as those with right hemisphere injury. The task involved frequent use of communication at a rapid speech rate, which was associated with expressive language problems and reduced processing speed mirrored in the BNT test results.

In conclusion, it may be argued that complex communicative situations are particularly demanding for the brain's network, since it requires simultaneous activation of a large number of skills, e.g. attention (sustained and shifting), rapid turn-taking, pragmatic skills, language comprehension, and topic-related manoeuvres. Also, the speed of the activations is supposedly high, since several speakers are simultaneously involved in the conversational task, which increases demands on focus of attention related to frontal lobe activity. Associated with the participants' auditory and visual impairments, the reduced cognitive and linguistic skills probably contributed to the communication difficulties discovered by the parents in everyday situations.

Study limitations and future directions

This study has a number of limitations and the results must therefore be interpreted with caution. More significant findings might have been obtained if more participants with ABI had been available. A comparatively small sample size of 30 adolescents may have hidden differences between subgroups. Restricted data on expressive speech production associated with difficulties in participating in vocal verbal test procedures may have limited the findings. Furthermore, given the specialized environment of the centre where the study was conducted, there may have been a bias towards more severely injured participants in the sample. The educational and socioeconomic status of the parents were only partly accounted for in this study.

In conclusion, the comparison of communicative evaluations obtained in real life assessments with linguistic and cognitive data obtained in clinical environments appears to be useful. Future research should include more trials in real-world settings to further investigate the usability of the CETI in adolescents with ABI. A new clinical test, the S-FAVRES, may provide useful information about communication potentials (39). Self-awareness and social skills are additional areas of particular importance to explore in participants with communication problems after ABI (40).

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