

# Strategies of multimodality in communication following traumatic brain injury in adolescence

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## Abstract

The purpose of this study was to explore the multimodal communicative ability of a young survivor of a moderate traumatic brain injury (TBI) in situations involving one or two other speakers.

A single subject design was applied, including a 17 year old adolescent with TBI. The study uses a triangulation of methods, evaluating both quantitative and qualitative data:

1) Analysis of Multimodal Communication Management (MCM) in video-recorded conversations.

2) Assessment of communicative skills in The Communicative Effectiveness Index - CETI (Lomas et al., 1989) by subject and parents.

3) Clinical neuropsychological and speech language assessments.

MCM differed with the number of interlocutors involved. In the two-partite dialogue (TWP), the tempo was lower compared to the three party conversations (TRP) and this facilitated language comprehension and turn-taking for the brain injured adolescent. Analyses in TWP showed frequent use of mutual gaze in collaboration with iconic hand gestures, particularly in moments of impaired word-finding. In TRP, the dominant role for the subject was as a listener since he rarely took turns in the dialogue.

The evaluation of daily communication in the CETI also identified trouble spots in high-speed communicative situations with several people involved. Formal tests verified reduced verbal abilities, corroborating impaired function in situations with high cognitive and communicative load.

## 1 Introduction

Communication problems following a traumatic brain injury (TBI) have been described as manifestations of general impairments to cognitive and executive systems (Ylvisaker and

Feeney 2007) and cognitive-communication disorder the most prevalent form of communication disorders as a consequence of TBI (Sarno 1980). A definition is formulated in a position statement by the American Speech and Hearing Association (ASHA, 2005, p. 1):

*“Cognitive-communication disorders (CDD’s) encompass difficulty with any aspect of communication that is affected by disruption of cognition. Communication may be verbal or nonverbal and includes listening, speaking, gesturing, reading, and writing in all domains of language (phonologic, morphologic, syntactic, semantic, and pragmatic). Cognition includes cognitive processes and systems (e.g. attention, perception, memory, organization, executive function). Areas of function affected by cognitive impairments include behavioural self-regulation, social interaction, activities of daily living, learning and academic performance, and vocational performance.”*

The survival in victims of TBI has increased substantially in recent decades as a result of improved medical treatment methods. However, many survivors are left with lifelong cognitive and communicative impairments as a consequence of the trauma, severely affecting everyday communication skills (Wahlström Rodling et al., 2005).

For the ease of description, the concept “cognitive-communication” will henceforth be referred to as “communication”, unless otherwise noted.

The impact of TBI traumas, especially in the moderate to severe cases, has the nature of a developing “invisible communicative disorder or handicap”, corresponding to the fact that there are few immediately visible or audible external signs of a brain damage in many individuals (Chamberlain 2006). Subjects describe a lack of consistent empathic responses from others during recovery and some experience a difficulty from the environment to adjust and accept them (Rosignano et al., 2011).

The main goal for many adolescents suffering from communicative impairments after TBI is to recover their pre-injury level of functioning to fit in with the social environment they belong to. This may seem like a possible outcome after the conclusion of a period of hospital treatment and clinical assessment. However, it is not until demands are put on the young person to participate in everyday conversations, group dialogues or academic learning setups that the extent of the impediments becomes clear (Hux et al., 2010).

This study explores the use of multimodal communication patterns and how the analysis of such patterns can add to standard test proceedings in creating a more comprehensive description of the subject's communication and identify rehabilitation strategies.

### **1.1 The examination of communication after TBI**

A traditional way to set goals for communicative rehabilitation after TBI is using formal assessment of speech and language to provide an outline for the intervention. When using standard aphasia tests where communication is usually not assessed, for instance in The Western Aphasia Battery - WAB (Kertesz, 1982) up to 30% or 40 % of the patients with TBI will show signs of impaired speech and language skills. These difficulties can consist of anomia expressed in impaired confrontation naming, word-finding, verbal association and comprehension (Ahlsén 2006). However, a conventional investigation of language competence based on phonological, syntactical and semantic skills fails to detect the problems in communication experienced by many individuals (McDonald 2000). Communication impairment after TBI is related to reduced language ability in some cases, like verb retrieval deficits in Broca's aphasia, but it seems that the majority of cases depend on more general cognitive difficulties. Researchers have found problems in the following areas: verbal learning and memory, discourse, meta-linguistic tasks, abstract and indirect language, complex lexical-semantic and morphosyntactic manipulation, theory of mind, social communication, and behavioural self-regulation (Ylvisaker and Feeney 2007).

The impact of the cognitive load in a home or school environment may expose difficulties that were just hinted in the clinical setup. A key limitation in clinical assessments is that tests of language functions tend to focus on the impairment perspective, failing to define the

consequences of these deficits on functional communication skills (LaPointe et al., 2010). Standardized tests may be "functional", in the sense that they assess daily functioning, but because of the fact that the administration is standardized, the tests are always limited when it comes to describing the full potential of an individual's communication life (Fyrberg et al., 2007).

Other approaches can address these types of problems more adequately as has been more frequently discussed by researchers in the last two decades. A step away from traditional clinical assessments towards a description of the individual's communication in his/hers own environment may present the best context to understand and rehabilitate communication skills. Applying a social rather than a medical model requires a shift in perspective and in promoting social communication within natural contexts (Simmons-Mackie 2000). This "contextualized observation" is motivated by the fact that subjects with TBI often perform surprisingly better or worse in everyday contexts than can be predicted from standardized test performance (Ylvisaker et al., 2002).

Cognitive ethnography research combines traditional long-term participant observation with the micro-analysis of specific occurrences of events and practices in real life (Alač and Hutchins 2004). Conversation analysis focuses on microanalysis (Atkinson and Heritage 1984) and has been used by researchers to interconnect the data obtained in communication in social contexts with scores on formal language tests (Friedland and Miller 1998). To investigate the details of interaction in dialogues, such as "choice" or "change" functions in communicated messages, a protocol for Communication Management was developed by Allwood et al. (2007). The protocol looks at phenomena such as body gestures, hesitation and self-interruption and their role as "choice" or "change" mediators of an intended message.

The present study adopted the model of Communication Management to explore its relevance in the rehabilitation process of a young person with TBI.

### **1.2 Strategies of multimodality in communication after TBI**

Face-to-face communication is multimodal which is important for the ability to participate in and to manage interaction after TBI. For example, intentional movements of arms, hands and head are used to convey a message; facial

expressions, eye gaze, sounds and body postures are other channels for a subject with a communication disorder to get a message through. Verbal statements can also be illustrated by role-playing. Multimodal communication can comprise prosodic features, pauses, sounds, silences and fragmentary responses in a dialogue and regulates interaction patterns such as turn-taking, feedback and communicative sequencing. Hence, different aspects of multimodality in communication are a focal point when it comes to creating content in a face-to-face interaction (Ahlsén 2003).

Three main components have been described that interact to convey a message in communicative situations: Firstly, factual information is mediated or co-constructed. Secondly, own communication and interaction is regulated and thirdly, emotions and attitudes are communicated (Goodwin 2006). This three-fold content is expressed with different degrees of conscious control and intentionality. On the one hand, the modality that is used to convey a message can require a rather high degree of control, such as in most word-production. On the other hand, a greater proportion of facial expressions, hand gestures and body movements are considered to be mobilized more automatically.

*The type of information* appears to influence the degree of control, in the sense that more of factual information seems to be produced with a greater degree of control and intentionality than most of the regulation of the speaker's own communication and emotions and attitudes (Ahlsén 2006). This implies that the cognitive effort is highly focused on conveying the linguistic part of the message and that the manner of speech, language, face expression and gestures are adapted to the main message on a more intuitive level in most informal face-to-face interactions.

*The type of sign* applied in information sharing will also demand a variation in controllability. Peirce's (1998) description of the triadic relations between the signs icon, index and symbol can further explain some of the multimodal communication patterns.

In a conversation, we typically "symbolically express" factual information while our hands "iconically illustrate" the same thing and our voice and face expressions "indexically" display our opinion of the topic we are speaking about or the person we are speaking to (Allwood 2002). This complex pattern puts high demands on a person with TBI since impaired cognitive

functions will strongly influence the ability to make use of multimodality.

### 1.3 Communication management

In the model for Communication Management (CM), the planning of Own Communication Management (OCM) is considered a basic feature in face-to-face interaction. OCM represents a speaker's planning and implementation of an intended message in a dialogue. OCM has also been described in terms of hesitation, planning, disfluency, self-correction, editing and self-repair (Allwood et al., 1990). Another type of communicative mechanism is Interactive Communication Management (ICM), aiming at managing the interaction between interlocutors through systems for turn-taking, feedback and sequencing. To succeed in a dialogue, the speaker will need to plan what to say, as well as when to say it, and he or she will also need to continuously moderate the message depending on the response from other speakers. Consequently, OCM and ICM are closely tied, and in a continuous interactive process with the Main Message (MM). The overall purpose is to share main messages with other speakers and to make communication as smooth and fluent as possible (Figure 1).

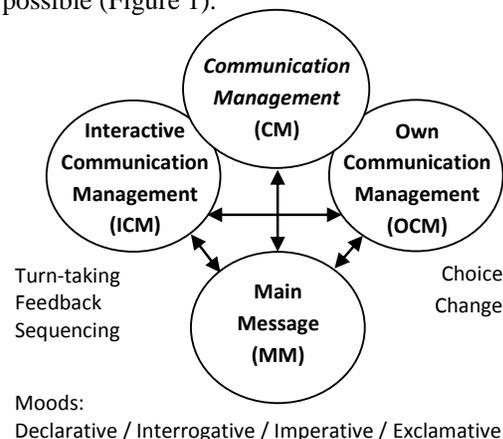


Figure 1. Main functions of Communication. (After Allwood et al., 2007)

Two main features are expressed in OCM - "choice" and "change". Firstly, "choice" phenomena will give the speaker enough time to administer the continuous planning of own content and expression in communication.

Choice can be expressed as tentative word-finding, memory retrieval, hesitation, planning a narrative and keeping the floor. Secondly, "change" features will allow the speaker to alter previously produced content and expressions on the basis of different feedback mechanisms, for

instance by auditive feedback from oneself or from the interlocutor. A change OCM can involve self-repetition and prosodic and/or gestural expressions. However, as Allwood et al. (2007) found in their study of 100 instances of speech based OCM's in informal conversations, OCM functions are often integrated with ICM and MM.

Analyses of gesticulation have been discussed as a method to explore multimodality functions in live communication of persons with aphasia (de Ruiter 2006). In the present study, analyses of OCM and ICM were chosen as methodology to describe multimodal communication in youth with TBI. The study of multimodality in the communication after TBI is a fairly new research area and, to the best of our knowledge, this tool has not been used with adolescents with TBI.

One of the aims of this study was therefore to examine if multimodal aspects supplement formal assessments to create a more comprehensive description of the subject's communication and contribute to identify strategies and goals in the rehabilitation process.

## 2 Method

### 2.1 Subject

The participant was a 16-year old male (PJ) who was found unconscious after a downhill skiing accident. In the medical reports, Loss of Consciousness (LOC) was estimated to approximately 30 minutes, and the Glasgow Coma Score was 9. Post-traumatic amnesia (PTA) prevailed for 2 days. Magnetic Resonance Imaging (MRI) findings of the brain revealed scattered subcortical contusions as well as haemorrhages in the frontal, midbrain and temporal left cerebral regions. There was also evidence of grade 1 DAI injuries (Diffuse Axonal Injury) in the left frontal lobe, indicating a degeneration of white matter in this area. Subsequently PJ was diagnosed with a moderate TBI.

During initial hospitalization PJ regained many of his previous abilities. He appeared to have a fairly relevant self-awareness. Gross and fine motor functions were assessed as intact, apart from a pain and stiffness of the neck. Neuropsychological findings showed normal functions in isolated tasks carried out in quiet surroundings, except for verbal memory capacity.

The speech language report identified adequate language abilities, when performed without time pressure and at a limited level of

abstraction. However, PJ had explicit difficulties to focus his attention to spoken messages and consequently had problems storing the heard information. This resulted in a limited language comprehension in communicative situations, despite age adequate results in single tests.

After discharge from the hospital and acute-care settings he was sent home. Four months later, PJ was again referred to a clinic, this time a rehabilitation centre, after failing to cope with his home and school environment. The medical referral indicates that he exhibited extensive symptoms of anxiety but had declined counselling. Major obstacles when it came to functioning in his previous academic setting concerned initiating, structuring and planning activities and a tiredness that prevented him from participating in class-room activities as before.

During the subsequent 10 month rehabilitation period, data concerning daily communication functioning in the home and school environment was obtained. The report revealed impaired naming, word-finding, verbal memory and a delay in constructing meaningful messages in a conversation.

### 2.2 Procedure

#### **Multimodal Communication Management**

**measures:** Two live conversations were recorded on videotape at the conclusion of the treatment period. Both recordings involved an unstructured dialogue between the subject and one or two interlocutors (Figure 2 and 3). None of the participants had met previously.

The instruction for the bi-partite conversation (figure 2) was to talk freely for 10 minutes in a "first acquaintance conversation".

In the tri-partite talk (figure 3), the participants agreed on a common topic of conversation, "travelling", for an informal talk. Subsequently, an investigation of communication functions in the two videotapes was made according to multimodal communication analyses (Allwood et al., 2007). The choice of analysed aspects was made according to two main functions: Own Communication Management (OCM) and Interactive Communication management (ICM).

In these two contexts, hand gestures, gaze and head movements as well as smiles and non-verbal sounds perceived as communicative were registered. Articulated words or sentences in conjunction with the gesture were also accounted for. The relations between the vocal-verbal and the gestural production were explored.

Findings in patterns for turn-taking and questioning were linked to PJ's self-confrontation and evaluation of the video-recordings.



Figure 2. The bi-partite conversation. Faces are blurred to secure anonymity.



Figure 3. The tri-partite conversation. Faces are blurred to secure anonymity.

Self-confrontation of live conversations in video transcripts was applied to clarify the interplay between the vocal and the gestural modalities. **The CETI:** The Communicative Effectiveness Index (Lomas et al. 1989) was originally developed for persons with stroke. It is a 16-item questionnaire for estimation of functional

communication based on daily communicative functions. Examples of described functions are: "Getting somebody's attention", "Having a one-to-one conversation" and "Being part of a conversation when it is fast and there are a number of people".

For the purpose of this study it was translated into Swedish and used for evaluation of communication by PJ as well as his parents.

**Formal tests:** Traditional neuropsychological assessments as well as a speech language evaluation were made in clinical surroundings at the beginning of the treatment period.

### 2.3 Ethical considerations

The study was approved by the Regional Ethical Review Board.

## 3 Results

### 3.1 Multimodal Communication Management Results

The outcome of the two live conversations was very different concerning PJ's vocal-verbal participation. In the first conversation with one interlocutor, he contributed substantially more to the conversation than in the second talk with two speakers.

His role talking to two people was more as a listener than an interlocutor. Tables 1 and 2 show the occurrences of interrupted turn-taking, completed turn-taking and instances of asked questions for PJ and the interlocutors in the bi-partite and the tri-partite conversations.

The attempts to initiate turn-taking in the tri-partite conversation were trouble spots since they were delayed and consequently ignored by the other speakers who had already moved on to a new topic. The overall impression was that the other participants interacted partly as interviewers and that PJ was excluded from the turn-taking as the tempo was perceived higher and he had difficulties keeping up with the turns.

Interrupted turn-taking		Completed turn-taking		Asking questions	
<i>Other speaker</i>	<i>PJ</i>	<i>Other speaker</i>	<i>PJ</i>	<i>Other speaker</i>	<i>PJ</i>
3	15	15	10	34	9

Table 1. Frequency of turn-taking and questioning in the bi-partite conversation N=2

Interrupted turn-taking		Completed turn-taking		Asking questions	
<i>Other speaker</i>	<i>PJ</i>	<i>Other speaker</i>	<i>PJ</i>	<i>Other speaker</i>	<i>PJ</i>
–	3	17	–	19	1

Table 2. Frequency of turn-taking and questioning in the tri-partite conversation N=3

However, PJ had better chances of taking initiative when talking to one person, due to a slower speech rate in the conversation and less competition for the turn.

His turns were longer and more elaborated compared to in the three party conversations where his contributions consisted of mainly one sentence utterances. The phrases were essentially answers to asked question from one of the other participants in the three party talks and not results of PJ's own turn-taking initiative. Hand gestures were frequently used as OCM in

the bi-partite conversation (Example 1 and Table 3).

*Example 1.* The interaction of OCM, hand gesture and gaze in an utterance (// signifies a prolonged silent pause).

**Speaker PJ:** // *Silverringen* // *üum.. de..e..* // *en lägenhet där* //

(// The Silver Ring // *ehum.. it.. is..*// an apartment there //)

<i>Speech</i>	//	The Silver Ring //	ehum	it	is //	apartment
<i>Type</i>	silence	noun	OCM word	pronoun	adjective	noun
<i>Gesture</i>	Palm down, fingers spread circular, illustrating a ring. Gaze at interlocutor (IL).	Palm still down, fingers spread circular, illustrating a ring. Gaze at IL.	Fingers collected, index finger pointing down. Gaze at IL.	Continued hand movement with index finger making a circular movement. Gaze to side.	Hand and fingers collected. Gaze still to side.	Hand closed. Gaze at IL.
<i>Duration</i>	2 secs	2 secs	3 secs			3 secs

Table 3. The interaction of OCM, hand gestures and gaze in an utterance.

In the above example, PJ answers the question “Where do you live?” and the hand gesture is accompanied by gaze direction at interlocutor. The gestures occur before the elicited content-bearing word and appear to serve the main purpose to trigger word-finding.

The duration of the interval by which the stroke of the gesture preceded the target word corresponded to the duration of the gestures. The gestures continued after the onset of articulation of the lexical affiliate.

This touches on the findings in a previous study by Morrel-Samuels and Krauss (1992) that showed how gestures help speakers access and retrieve lexical items from their mental lexicon. The researchers found that the less familiarity can be assumed in the lexical affiliate, the greater the interval by which the gesture precedes it.

Furthermore, the familiarity of the lexical affiliate was also related to the gesture's duration: the less familiar, the longer the duration of the associated gesture.

In the case of PJ's performance, one might argue that his impaired naming and word-finding as well as a reduction of verbal processing speed and verbal memory creates a similar condition, where verbal functions appear elusive and unfamiliar and require prolonged time to emerge

in live conversations. In the research area of expressive gesture abilities in individuals with aphasia, persons with Broca's aphasia were found to be slow to initiate movement, have long pauses but also to have frequent use of iconic gestures and beats (Duffy et al., 1984). The speech related to Broca's aphasia is characterized by a slow and effortful articulation with no significant disturbance in language function. The condition resembles the expressive language difficulties experienced by PJ, as well as the site of the lesion in his left frontal lobe which is similar to the neurological basis for Broca's aphasia.

PJ used gestures to manage the communication. However, the number and the nature of the gestures varied with the number of completed turn-takes. When talking to two persons, PJ used no gestures of the hand to manage the conversation.

Instead he closed his eyes and smiled while struggling with word-production in the one case of gestural OCM (Table 5). During a major part of the conversation, he acted as a listener to the other two speakers and held his hands clasped in front of him, at the sides of the body or the arms held behind his back. However, smiling and using other ICM strategies to demonstrate

participation were frequent and adequate, despite a partial absence of own verbal contributions (JP's comparison and analyses of the dialogues are reported in the end of this section). Tables 4 and 5 contain PJ's distribution of different gesture types in OCM and ICM in the two conversations.

Gesture	OCM	ICM
Hand gesture	8	–
Gaze down	4	1
Head shake	1	–
Gaze up	2	1
Gaze to side	8	3
Head nod	–	1
Smile	3	24
Non-verbal sounds	7	30

Table 4. **The bi-partite conversation:** PJ's production of gestures in OCM and ICM

Gesture	OCM	ICM
Closed eyes	1	–
Smile	1	15
Non-verbal sounds	–	32

Table 5. **The tri-partite conversation:** PJ's production of gestures in OCM and ICM

<i>Speech</i>	ehum..ehum	//	two weeks
<i>Type</i>	OCM word	silence	noun phrase
<i>Gesture</i>	Gaze to side.	Lifted collected hand, index finger making two circular movements. Gaze to side.	Gaze at IL.
<i>Duration</i>	3 secs		

Table 6. The interaction of OCM, hand gestures and gaze in an utterance.

Comprehension was also reduced by unknown topics in the talk. Turn-taking and initiative was managed more easily in the bi-partite dialogue as the speech rate of the interlocutor was lower here. PJ did not want to laugh so much during the conversations and had wanted to use his hands more for gesturing. When unable to understand, he did not ask for a clarification. His overall feeling was that new people do not regard him as being serious and avoid his eye-contact. This statement was, however, not confirmed in the analyses of the video-recordings.

### 3.2 The CETI results

The ratings on the CETI made by the parents and PJ occurred at the beginning of the rehabilitation period, six months post trauma. Repeat test scores were recorded 10 months later, at the

In the bi-partite conversation, gestures for word-finding describing spatial location and action were used in eight cases of completed turn-taking. This was clearly expressions of OCM performed at a lower pace when PJ talked only to one person. In this situation, he had enough time to use the gesture during silent pauses to trigger a delayed word-finding during his turn (Example 2 and Table 6).

*Example 2.* The interaction of OCM, hand gesture and gaze in an utterance ( // signifies a prolonged silent pause).

#### Speaker PJ:

*eller jag börjar om... um um // två veckor*

(that is, I start in... ehum.ehum // two weeks)

PJ's qualitative description of the video-recordings confirmed a clear discrepancy in the experience of communication management depending on the number of speakers involved. Speech rate in one of the interlocutors in the tri-partite conversation was perceived as high by PJ which further limited his overall language comprehension of the dialogue.

closure of the period. In both the initial test score as well as in the repeat score, PJ evaluated his own communicative ability "as able as before the brain injury" (score = 100) in a total of 9 communicative situations. Four of these 100 % items were rated before onset of the treatment period, and a further 5 items were registered at follow-up. Apparently PJ experienced 4 communicative functions as being completely unaffected by the trauma and additional 5 functions as being recovered to present status at the end of the treatment period.

The parents, however, did not on any given occasion perceive their sons communication as "as able as before the brain injury", a fact that was mirrored in their estimations. Their highest points of registration were between 75 % and 98 % (12 items) with six of these ratings occurring before the treatment period and six items after.

However, in these ratings, there are two items, 11 and 13, "Starting a conversation with people who are not close family" and "Understanding writing" that indicate a major change over time, of a 50 (51) % improved capacity. For the other ratings, there is no major change of performance registered.

### 3.3 Formal test results

The subject performed seemingly well on all tests in the WAIS-III. Full Scale IQ-results of 101 indicate an average cognitive level of functioning. However, a discrepancy of 25 IQ points between the verbal and visual domains, with limitations in verbal functions, was apparent.

## 4 Discussion

In the videotaped interactions of Multimodal Communication Management, PJ was the more passive vocal-verbal interlocutor in both dialogues. However, he managed to interact using multimodal expressions, a great proportion of all instances of communication management was judged to be expressions of ICM, thereby upholding the interaction non-verbally. In the case of OCM, hand gestures and gaze down were the most frequent gestures. This is consistent with the findings by Allwood et al. (2007) in their study of Communication Management in conversations between healthy subjects.

Furthermore, gestures preceded the affiliated word in most cases and the delay between gesture and target word was 2-4 seconds. Morrell-Samuels and Krauss (1992) found that the onset of gestures usually precedes the target word. The researchers also found that the less familiar a word is, the larger is the time interval by which the gesture that precedes the speech. This might explain the interval between PJ's gesturing and naming in the conversations, since delayed and tangential word-finding as well as verbal memory limitations were trouble spots after the trauma.

During the rehabilitation period PJ elaborated the use of multimodal cues to participate in conversations, despite persisting problems with verbal comprehension and expressions. From a communication treatment perspective, the cognitive functioning of the adolescent allowed a development of insights in the possibilities and obstacles in communicative situations. By using gaze, smiles and postural techniques, he was able to participate as a teammate even in the instances of reduced language comprehension. To appreciate the role

as a listener and the importance of this stance in the joint creation of meaning-making proved an important technique to uphold a conversation and, above all, to save face in moments of comprehension difficulties.

The results on the CETI are consistent with previous findings in investigations of Health Related Quality of Life (HRQL) after TBI (Stancin et al., 2002). Specifically, the researchers found that parents rated their children's HRQL less favourably than the young person did themselves. This implies that adolescents might be inclined to underestimate the impact of their own health and functioning and hence report higher HRQL compared to their parents.

Conventional MR images are poor predictors of functional outcome in patients with TBI. However, as in the case with the adolescent in this study, neurological findings helped explain some of the core deficits underlying the difficulties experienced after a brain injury. The DAI-lesions in the left frontal lobe of PJ reflected a slower rate of processing speed and initiative. Damage to the left temporal lobe corresponded to the word-finding problems, the reduced processing of auditory input and to the verbal memory limitations. In functional communication, this may have affected the impaired language comprehension ability, as was documented in the video-taped conversations.

## 5 Conclusions

The results in this study support the notion that a triangulation of methods is a fruitful approach to investigate and treat consequences of communication impairment after TBI. Future research should include trials in more persons with TBI, and an extension of the method to compare more recorded situations of multimodal communication management during the rehabilitation period.

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