CHAPTER 1
General introduction
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Traumatic brain injury

Traumatic Brain Injury (TBI) refers to a blunt, penetrating and acceleration or deceleration force-derived injury that most commonly results from motor vehicle accidents, assaults or falls. The brain may suffer contusions at the point of direct impact and at the site directly opposite this point. It also occurs due to oscillation of the brain on the inside of the cranium. The resulting changes in the anatomy and neurophysiology of the brain disrupt multiple cerebral networks. Areas of particular vulnerability include the orbital frontal and temporal cortices, frontal poles, corpus callosum and sub-frontal white matter.

There are three generally acknowledged levels of severity of TBI: mild, moderate and severe. The focus of this dissertation is on patients with moderate to severe TBI. The diagnosis moderate TBI is based on a period of unconsciousness of 30 minutes to 24 hours, an initial Glasgow Coma Score of 9-12, and a post traumatic episode of amnesia lasting 24 hours to seven days. Severe TBI is determined by a period of unconsciousness of longer than 24 hours, an initial Glasgow Coma Score of 3-8, and a post traumatic amnesia episode of more than seven days.

Worldwide, an estimated 69 million individuals suffer a TBI each year, of which 13 million within the category moderate to severe. In people under 40 it is even the leading cause of disability, and it is expected to become the third largest cause of global disease burden by 2020. TBI causes persistent functional impairments and psychosocial problems leading to significant socio-economic costs.

TBI: social behavioral problems and consequences

Behavioral problems are common in patients with moderate to severe TBI which are frequently experienced to be more distressing than cognitive or physical disabilities. Patients with moderate to severe TBI may have problems dealing with a wide range of complex behaviors, such as, being mindful of personal distance, initiating, keeping up with or ending conversations, conforming to social rules, avoiding inappropriate topics and jokes, as well as social problem solving and anger management. Social and interpersonal difficulties have been found to be a serious impediment to societal integration and employment in patients with TBI. Studies have reported that behavioral changes have a negative impact on family life and long-term outcome. The lack of concern or empathy in the person with TBI in particular proved harmful to their family’s life satisfaction.

Social cognition: definition

Potentially relevant for social functioning and outcome following TBI are the proposed social cognition processes underlying social behavior. Social cognition is an umbrella term encompassing several cognitive processes, having been defined as “the way in which people make sense of other people and themselves”. In the definitions by Adolphs, social cognition is directly linked to behavior. Adolphs distinguishes “the processes that sub-serve behavior in response to conspecifics”, and “the ability to construct representations of the relationship between oneself and
others and to use those representations flexibly to guide behavior.\textsuperscript{22,23} Several mental processes are involved in social cognition. These processes can be categorized in three general stages: perception of emotions, interpretation of social cues, and adjustment of behavior in accordance with the social context.\textsuperscript{22} The first stage, emotion perception, encompasses the recognition of basic emotions, namely anger, sadness, happiness, fear, disgust and surprise.\textsuperscript{22-24} The second stage (getting perspective on and understanding social information) refers to interpretative processes, judging complex mental states, desires and beliefs, all of these also referred to as theory of mind (ToM).\textsuperscript{25} The third stage (basic and goal directed social behavior) refers to the regulating responses to these inferences to guide social behavior.\textsuperscript{26}

**Social cognition in TBI**

Deficits in each of these social cognition stages have been found following moderate to severe TBI.\textsuperscript{27,28} Impaired recognition of facial emotion has been found in various studies.\textsuperscript{28-30} A meta-analysis by Babbage and colleagues (2011)\textsuperscript{31} estimated 13 to 39 percent of persons with moderate to severe TBI to have significant difficulties recognizing facial affect. Also, several studies have demonstrated impairments in ToM following TBI.\textsuperscript{32-34} Further, up to 70% of the patients with TBI reported reduced levels of empathy.\textsuperscript{35-37}

**Neurobiology of social cognition**

Studies have identified a complex network of cortical and sub-cortical brain areas involved in social cognition.\textsuperscript{22,38} This network includes the prefrontal, temporal and parietal cortices and the limbic system.\textsuperscript{22,38} Lesions in the orbitofrontal cortex, for instance, impair intuitive reflexive social behaviors and the ability to self-monitor in everyday functioning.\textsuperscript{3} In addition, damage to the frontal-subcortical circuits reduces higher-order intellectual function, and emphatic, motivated and subtle behavior.\textsuperscript{3} Subcortical structures such as the amygdala, dorsomedial nucleus of the thalamus, ventral striatum and the anterior insula, are important for detecting emotional information.\textsuperscript{39}

**Neuropsychological rehabilitation**

Neuropsychological rehabilitation is concerned with the assessment and treatment of cognitive, emotional and behavioral impairments following TBI. It can be described as a series of interventions enabling patients and their relatives to cope with, by-pass, reduce and come to terms with cognitive deficits.\textsuperscript{40} Neuropsychological rehabilitation interventions may be broadly divided into two approaches: restorative and compensatory. The restorative approach aims at reinforcing, strengthening or restoring a specific skills. It includes repeated training of specific cognitive processes to improve the underlying cognitive impairment. The compensatory approach teaches ways of bypassing the impaired function. It includes training to establish new patterns of cognitive activity through direct instructions, as well as supplying internal compensatory strategies (e.g., self-instructions, visualization) or external compensatory mechanisms such as phone reminders and
According to the widely used International Classification of Functioning, Disability and Health (ICF) framework (How to use the ICF: A practical manual for using the International Classification of Functioning, Disability and Health. Exposure draft for comment), the ultimate goal of neuropsychological rehabilitation is to maximize societal participation and quality of life. In terms of the ICF classification, poor social cognition is an impairment, while poor social or behavioral skills refer to limitations in activity and poor social functioning is described as a restriction of participation.

Assessment of social cognition

So far, assessment of social cognition has not been a widespread element in neuropsychological examination. Recently, Kelly and colleagues (2017) have shown that 78% of the clinicians working in brain injury rehabilitation have never or infrequently used a standardized test to assess social cognition. The main reason for this seems to be the unavailability of reliable tests.

There are several tests available for evaluating aspects of social cognition, that consist mainly of static stimuli: pictures of faces, text-based stories or cartoons. In general, such measures have, to some extent sensitivity to the effects of brain injury, yet their sensitivity to real-life errors has so far been largely unknown. Overall, there is now an urgent need for ecologically validated social cognition tests that can predict everyday functioning with robust psychometric properties which can easily be administered in clinical practice.

Treatment of social cognition

Research on the treatment of deficits in social cognition following TBI has been sparse so far. In the few available randomized controlled trials, only isolated aspects of social cognition appear to have been targeted. A few studies show that treatment of emotion recognition can be effective in persons with TBI, however, improvements in emotion recognition was not automatically accompanied by improved social behavior. In a case study on perspective training for controlling anger problems, decreased aggression was demonstrated besides improvement in perspective taking, according to relatives. Also, interventions that targeted on several aspects of communication after TBI could be found, that were shown to be effectively improving ToM. In a pilot study, positive changes were reported with regard to emotional self-awareness and emotion regulation after treating alexithymia post-TBI. Besides these, a number of studies show that interpersonal interventions are effective in modifying partner-related behaviors, such as reduced ego-centrism and appropriate contributions to conversations.

According to Driscoll (2011), the available studies on social cognitive and behavioral interventions in persons with TBI show methodological shortcomings, such as the inclusion of relatively small-sized samples, no control group included or a non-existent follow-up. Moreover, studies on social cognition treatment have failed to find changes in related outcomes regarding behavior, social functioning or quality of life. There is a clear need to develop evidence-based
treatment that targets not only on emotion perception, but also on ToM, empathy and behavior regulation, as the base for improving social functioning, interpersonal relationships and societal participation following TBI.

**Outline of the thesis**

In this thesis, two main themes are addressed: the assessment of social cognition with ecologically valid measures and evaluation of a social cognition treatment in a patient group with moderate to severe TBI. **Chapter 2** reports on the feasibility, validity and sensitivity of the Dutch Awareness of Social Inferences Test (TASIT-short). **Chapter 3** presents the results of a study on fear recognition and risky decision making in patients with moderate to severe TBI and healthy controls. We examined if fear detection has been affected after TBI and if this could be related to risky decision making in a gambling task. **Chapter 4** describes the investigation of the value of measuring social cognition, behavior and executive functioning in predicting vocational and social participation. **Chapter 5** is devoted to a detailed description of a multifaceted treatment of social cognition and emotion regulation (T-ScEmo). **Chapter 6** presents the results of a randomized controlled trial that examined the effects of the T-ScEmo program. In 59 patients with TBI, we evaluated to what extent social cognition, behavior, quality of life, relationship quality and participation in real-life could be improved by a rehabilitation treatment. Finally, in **chapter 7** there is a general discussion of the preceding chapters, in addition to implications for clinical practice, along with directions for future studies.

**References**

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