Metacognitive function poststroke: a review of definition and assessment.

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Metacognitive Function Post-Stroke: A Review of Definition and Assessment

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ABSTRACT

Background and objective: Metacognition is the conscious knowledge individuals have about their own cognitive capacities and the regulation of these activities through self-monitoring. The aim of this review was to identify the definitions and assessment tools used to examine metacognition in relation to stroke studies.

Methods*:* A computer database search was conducted using MedLine, CINAHL, PsycINFO, Cochrane Reviews, Scopus and Web of Knowledge.

Results*:* A total of 1,412 publications were retrieved from the initial database search. Following the removal of unrelated articles, 34 articles remained eligible. Five studies examined metacognition in relation to cognitive and/or emotional functioning, four examined the concept in relation to memory, while others investigated its relationship to driving, employment or restrictions in daily living. Twelve studies examined metacognitive function exclusively in stroke. Only one study examined metacognition in the acute phase of stroke. Seven studies adhered to the standard definition of metacognition in line with the neuropsychological literature. The main assessment tools utilized included the Self-Regulation and Skills Interview (SRSI), the Self-Awareness of Deficits Interview (SADI), the Awareness Questionnaire (AQ) and the Patient Competency Rating Scale (PCRS).

Conclusions*:* Assessment of metacognition has tended to focus on traumatic and other acquired brain injury in comparison to stroke exclusively. The majority of the studies that examined metacognition in stroke did not assess patients in the acute phase. The heterogeneity of assessment tools was in keeping with the variation in the definition of metacognition. The emergence of a standard metacognitive assessment tool may have important implications for future rehabilitative programmes.

INTRODUCTION

Impairments in cognitive function are a major cause of disability after stroke. Up to 50% of stroke survivors will experience some degree of cognitive deficit in the early or chronic phase of the insult.[1] In some cases, subtle cognitive deficits remain undetected and these lesser cognitive impairments can result in substantial functional problems that can affect both rehabilitation and secondary stroke prevention.[2] The importance of cognitive assessment to help plan rehabilitation interventions has been well established.[3, 4] These cognitive assessments have primarily focused on global and executive function. However, in the more recent literature, there is now greater interest in exploring metacognition in tandem with recovery.[5-7] Metacognition generally refers to any knowledge an individual has about their own cognitive abilities and the regulation of these activities through cognitive monitoring.[8] The cause for this changing trend is the argument that global or broad objective measurements of cognition do not adequately assess a patient's ability or capacity in executing self-regulatory cognitive, physical or social activities. Impairments in higher order cognitive functions will hinder an individual's ability to recognize their deficits causing them to engage in activities that exceed their capabilities, set unrealistic performance goals and fail to utilize adaptive compensatory strategies.[9, 10] Therefore, those with cognitive deficits can only reach their potential for independent functioning if metacognitive abilities are primarily addressed.

The term metacognition was first coined by John Flavell in 1979.[11] According to Flavell, metacognition consists of metacognitive knowledge which includes knowledge about cognitive abilities and strategies, and metacognitive regulation, which includes cognitive monitoring and cognitive control (planning, error correction, and resource allocation).[12] There is a strong overlap between executive function and the self-regulatory component of metacognition as executive function is defined as the group of cognitive processes responsible for monitoring and controlling cognitive, emotional, and behavioural functions during novel tasks.[12, 13] However, although both metacognition and executive function involve top-down self-regulatory processes that guide, direct and manage cognitive functions, metacognition also involves knowledge and subjective assessment of one's own cognitive capacities and abilities.[12]

Since metacognition is an extensive term encompassing both awareness and regulation of cognitive capacity,[14] interpretations of the term have extended beyond its original definition and now encompass many functions that relate back in some form to a component of cognitive function. As a result, several comparable terms (e.g self-awareness, self-monitoring, self-regulation, subjective

cognitive complaints) or terms that focus on a domain of metacognition (e.g meta-memory) have emerged. This has led to a wide array of assessment tools developed in an attempt to measure metacognitive function or one of its components.

Metacognitive deficits may cause stroke survivors to overestimate their level of function and underestimate stroke impact.[15] Few studies have explored the relationship between metacognition and stroke location, type and severity or its clinical application in stroke care and rehabilitation.[15, 16] Stroke survivors may be particularly susceptible to metacognitive deficits as neurospsychological disorders such as magnitude estimation deficit,[17] anosognosia or anosodiaphoria, spatial neglect, and problems with emotional semantics and abstraction in stroke are common.[15] These deficits are associated with poor stroke outcome, and even mild unawareness of impairments could lead to poor rehabilitation and recovery.[18] Assessments evaluating cognitive impairment as an objective primary measure might fail to detect and incorporate the impact of these deficits on the rehabilitative process. Initial studies suggest that treatments focused on improving metacognitive processes in acquired brain injury could lead to better functional outcomes.[19]

A major component of metacognition, self-awareness, is what has received the most attention in the neuropsychological literature.[20] There have been some reviews [16, 21, 22] and theoretical frameworks [23, 24] on self-awareness and its clinical application in brain injury rehabilitation but there is a scarcity in the literature examining the concept in relation to stroke. In a review examining the association between awareness deficits and rehabilitation outcome after acquired brain injury, the reviewers reported an association between greater awareness of deficits and more favorable rehabilitation outcomes.[22] Only one review [16] examined the clinical application of self-awareness in stroke rehabilitation exclusively. This review indicated that there is no consensus as to which tool is the most useful for assessing self-awareness, resulting in researchers adopting different treatment approaches to address self-awareness. Another review examined subjective cognitive complaints and again concluded a lack of consensus on definition and measurement.[25] However, these reviews do not encompass the full composition of metacognition, as they only address self-awareness and overlook the second major constituent which is the utilization of self-regulatory and compensatory strategies including cognitive monitoring and cognitive control. Therefore, the aim of this review is to examine the concept of metacognition and to identify the definitions and assessment tools used to quantify the concept in relation to stroke care, assessment and management.

METHODS

Search Strategy

A review was conducted of standardized measures of metacognitive function in studies of patients with stroke. A computer search was performed on databases: MEDLINE (1976-2014), PsychINFO (1972-2014), CINAHL (1978-2014), Cochrane library databases (2007-2014), Scopus (1959-2014) and Web of Science (1974-2014). The following keywords were used: "metacognition" AND "stroke" AND "measurement" (see table 1 for associated words with keywords used in the database search).

Inclusion Criteria

Articles were included in the review if they fulfilled the following criteria:

a. They used standardized questionnaires measuring metacognition or a component of metacognition in cross-sectional, longitudinal, interventional or single case studies.
b. The sample population comprised or included patients with stroke or stroke was a patient group within a study.
c. They published peer-reviewed research in the English language from which the full text was available.

Studies that met the inclusion criteria were then evaluated against indicators of methodological quality with a focus on study design and statistical methods employed.[26]

Table 1: Initial key search terms and associated words

Main Search Terms	Relevant associated words
Metacognition	Self-awareness AND/OR Unawareness AND/OR Self-regulation AND/OR Self-monitoring AND/OR Self-evaluation AND/OR Self-knowledge AND/OR Self-predictions AND/OR Subjective cognitive complaints AND/OR Agnosognosia AND/OR Meta-memory AND/OR Agnosia AND/OR self-identity AND/OR Frontal Network Syndrome
Stroke	Cerebrovascular Accident AND/OR CVA AND/OR Transient Ischemic attack AND/OR TIA AND/OR Acquired brain injury
Measurement	Measure AND/OR Assessment AND/OR evaluation AND/OR Tool AND/OR Questionnaire AND/OR Survey

Analysis of Psychometric Criteria

Reliability and validity of the commonest assessment tools utilized were examined in this review. Internal consistency was examined using Cronbach's alpha, with a value above 0.7 considered

acceptable.[27] Test-retest and inter-rater reliability were also assessed with a correlation of ≥0.7 considered significant.[27] Construct validity, the degree to which an instrument measures the theoretical framework it is intended to measure, was reported.[28] Convergent and discriminant validity, subtypes of construct validity, were also reported. Where studies did not report on validity, correlations between variables were examined.

RESULTS

Overview

A flow diagram of study selection is shown in Figure 1. Of the 1,412 studies identified, 34 studies met the inclusion criteria. Of these studies, five examined metacognition in relation to cognitive and/or emotional functioning,[20, 29-32] four examined the concept of metamemory,[33-36] three investigated the relationship between driving and metacognition,[37-39] three examined metacognition in relation to motor or functional restrictions including activities of daily living,[40-42] three investigated the use of an assessment tool,[2, 43, 44] and two studies examined the effect of metacognition on employment status.[6, 45] Supplementary tables S1 (cross-sectional) and S2 (longitudinal, interventional and single case) present a summary of the studies reviewed.

Study design and Sample Characteristics

Twenty-two studies were cross-sectional in design,[2, 6, 20, 30-44, 46-49] two were longitudinal,[29, 45] nine were interventional[5, 50-57] and one was a descriptive single case study.[58] The sample size and type varied between the studies. Twelve studies examined metacognitive function exclusively in stroke patients.[2, 29, 31, 34-36, 39, 40, 44, 53, 56, 58] The remaining 22 studies consisted of other patient groups alongside stroke (e.g. traumatic brain injury, tumor or hypoxic event). Sample sizes varied across the cross-sectional studies ranging from 25 – 437 participants, however in studies that examined a mixed sample of aetiologies the stroke subgroups were of a small size. The mean age (average of reported means) was 48.2 (SD 13.2). The timing of assessment also varied ranging from one week post-insult to 10.1 years. Only one study examined metacognitive function in the acute phase of stroke.[56]

Conceptual Basis and Definition of Metacognition

Only seven studies [37, 43, 45, 53-56] adhered to the original definition “metacognition” in line with generic and historical literature of the term. The majority of the studies defined only a single dimension of the concept. Self-awareness was the predominant term used and component examined in the studies. Two studies used an operational definition of metacognition (e.g. discrepancy between a

person's self-assessment and an external criterion of the person's ability).[38, 48] Seven studies did not define the term.[2, 30-32, 42, 44, 47] Sixteen studies made reference to a theoretical framework or model to describe a component of metacognition.[5, 6, 20, 29, 33, 34, 37, 40, 46-48, 50, 51, 53, 54, 58] The main theoretical framework discussed was Crosson et al.'s three level model of self-awareness. The model has three hierarchical levels of awareness. The first level, intellectual awareness, refers to an individual's ability to recognize that a particular function or skill is impaired compared to premorbid levels and to acknowledge the implications that these deficits may have on activities of daily living. The second level, emergent awareness, refers to an individual's ability to recognize a problem as it occurs during an activity. The third level, anticipatory awareness, refers to an individual's ability to anticipate a particular problem that could arise during a particular task.[20, 23]

Assessment of Metacognition

Eighteen different assessment measures were identified in the studies reviewed. The most common assessment tools utilized were the Self-awareness of Deficits Interview (SADI),[59] the Self-regulation Skills Interview (SRSI),[43] the Patient Competency Rating Scale (PCRS)[60] and the Awareness Questionnaire (AQ).[61] The PCRS and the AQ use a discrepancy based method, comparing the patient's self-rating of function with that of informant or allied health professional's rating. The SADI is a structured interviewer-scored approach that measures intellectual awareness after acquired brain injury.[47] The SRSI is a semi-structured interview that assesses self-regulation skills by focusing on a main area of difficulty experienced by the patient in an activity of daily living.[47] In most studies assessing metacognition with the SADI and SRSI, these measures were both included. The psychometric characteristics of five most common metacognitive measures assessing stroke is outlined in supplementary table S3. Internal consistency and test-retest reliability were reported for four of the measures and inter-rater reliability were reported for the SADI and SRSI. Where reported, Cronbach's alpha ranged from 0.73 to 0.95. There were high correlations in test-retest reliability and inter-rater reliability in all the measures. Construct validity was only reported for the SRSI.[43] The remaining studies reported convergent or discriminant validity or correlated the assessment tool scales with other specified variables (see supplementary table S3).

DISCUSSION

The aim of this paper was to review the definition and the standardized assessment tools used to quantify metacognition in relation to a stroke population. Even though a modest number of studies

examined a component of metacognition, a limited number adhered to the original definition of the term and studied the concept fully including all its components (self-awareness, self-regulation and self-monitoring). The first arm of the metacognitive concept, self-awareness, was given the most attention, whereas the self-regulatory and self-monitoring arms were mostly overlooked. Even though there has been some recent attention given to metacognition in stroke, there remains a scarcity of quantitative research on the subject as stroke rehabilitation continues to focus mainly on physical disability and cognitive impairment. Few studies examined stroke populations exclusively and there was a broad variation of domains assessed in relation to metacognitive deficits (e.g. memory, cognitive impairments, driving and employment). In addition, only one study evaluated the changes in self-awareness post-stroke over time limiting conclusive evidence of temporal changes in this domain.[29] All of these elements, alongside the large variability in sample sizes and timing of assessments, makes comparison between the studies complex and reduces the possibility of reporting a definitive outcome that can be spanned across the majority of studies and generalized to the concept as a whole.

That being said, the studies that examined how metacognition impacts rehabilitation and post-stroke outcome reported that higher levels of metacognitive skills correlated with greater adjustment and better task performance.[20, 37, 45, 46, 52] Interventional studies showed that participants had significantly improved levels of self-regulation skills and psychosocial functioning at post-intervention assessment.[50, 51, 55] This indicates that metacognition is a critical variable that links cognitive impairments and functional outcome.

Conceptual Basis and Definition

This review outlined some of the key conceptual difficulties that exist in the literature in relation to metacognitive function after stroke. These difficulties stem from a lack of consistent definitions and a deficiency in the use of an appropriate metacognitive theoretical framework as a basis for clinical research. The use of terms ‘‘self-awareness’’ and ‘‘metacognition’’ interchangeably adds an additional lack of clarity of the broader sense of the concept. The most common framework discussed was Crosson et al.’s Pyramid Model of Self-Awareness.[23] Though the model addresses self-awareness and self-monitoring, the use of self-regulatory strategies (eg. goal setting, planning) to overcome the particular impairment, is not addressed. Toglia and Kirk expanded the Pyramid Model and used a dynamic rather than hierarchical relationship between the types of self-awareness and grouped emergent and anticipatory awareness together as “online awareness”.[24] In addition, this newer model incorporates

other important aspects such as situational context, the demands of a particular task and the individuals' beliefs. The model addresses the self-regulatory concept of metacognition by acknowledging that online experiences of task performances provide feedback to enhance intellectual awareness and was referenced in three studies in this review.[20, 46, 53] None of the studies referred to the Nelson and Narens' model of metacognition [8] which splits cognitive processes into two interrelated levels, the "meta-level" and the "object-level" in which the flow of information between these two interrelated levels is dominated by cognitive monitoring and cognitive control.[8, 12]

Assessment of Metacognition

A large number of assessment tools examining different dimensions of metacognition exist in the literature. This was reflected in our review as 18 different tools were utilized in the studies reviewed. The wide array of assessment tools was in keeping with the scope of different dimensions that can be examined in relation to metacognitive impairments. The heterogeneity of the measures creates challenges as it is difficult to compare tools examining a specific function with others that attempt to assess function more globally. Regardless of the specificity or generality of the measures, most measures, with the exception of the SRSI, only examined self-awareness and not self-regulation.

The majority of assessment tools [5, 6, 29, 37, 38, 41, 42, 46, 48, 49, 52, 58] applied discrepancy scores, a comparison between the patient's self-rating and that of a proxy rater (eg. caregiver, significant other or health professional), based on the operational definition of self-awareness deficits. These assessments include the PCRS and AQ but also include tools that assess specific functions. A possible drawback of this method could be rater bias or the inaccuracy of the family member or clinician to estimate the individual's true abilities.[6, 48, 62] This may be due to various reasons, for example the clinician's unfamiliarity with the individual prior to the injury or the caregiver's own level of anxiety and depression influencing their assessment of the patient.[6, 62] Other studies used semi-structured interviews or compared the patient's self-ratings with specific functional tasks such as driving. This approach would minimize the subjectivity in caregiver or clinician scores but could also limit the number of functions of metacognition that could be assessed.[6] Some studies emphasized the importance of using a combination of approaches to tackle metacognitive function.[6, 48, 54]. Although there are strengths and limitations to all types of assessment, the need to consolidate existing measures by combining subjective and global objective assessment is evident.

Most of the studies examined individuals with chronic stroke and injury and only one study examined metacognitive impairment in the acute phase of recovery.[56] Though there may be barriers with evaluating patients in this critical phase, providing metacognitive assessment, detecting impairments and providing strategy training may be optimal in the acute phase given the evidence that supports early rehabilitation intervention.[56, 63]

Though the internal consistency, test-retest and inter-rater reliabilities for the reported measures were all of acceptable values, construct validity was only reported for one measure, keeping it in line with the Pyramidal Model of Self-awareness. Few comments were made regarding the measurements' clinical utility (ease of use, time required for assessment, training required by test administrator, ease of interpretation of results)[64] and this is an imperative element to consider in the clinical setting. Concerns also exist regarding validity of these assessment tools in the specific context of stroke as they were mainly utilized in traumatic brain injury.

Further Directions and Conclusions

The concern with assessing metacognition is that is it both a complex and broad concept.[65, 66] This is primarily due to the "domain generality" of metacognitive processes [65] and its pervasiveness in all tasks ranging from the cognitive, involving learning or memory, to driving, motor functional limitations, employment status or any activity of daily living requiring higher order thought. It is also important to consider coping patterns, premorbid personality traits and baseline level of function as they largely interplay with metacognitive function and influence rehabilitation outcome.[48, 67]

Despite the difficulty of measuring self-regulatory function, it is an important component in the scope of metacognition and requires more focus from both the conceptual and clinical perspectives. [68] This is because self-regulation appears to be beneficial in improving task performance in both motor and cognitive abilities when compared to conventional functional rehabilitation in stroke patients.[68, 69] A useful model to consider that addresses self-regulatory function may be the Baltes model of selective optimization with compensation (SOC) for successful ageing,[70] as previous studies have indicated that the SOC model may potentially be used to address loss of regulatory function in stroke rehabilitation.[7, 71]

Another development in recent years in addition to goal management intervention for stroke rehabilitation, has been the introduction of self-management programmes used to support self-care in the long-term after stroke.[72] Self-management programmes aim to facilitate patients in taking control

of their own rehabilitation and daily function. However, in the absence of self-regulation and metacognition functions, it remains to be questioned whether patients should be entered into a goal-planning or self-management rehabilitative interventions without adequate assessment of metacognition and associated functions to determine patients' readiness for rehabilitation in the first instance as their decision-making competence and self-awareness judgments may be heavily compromised.

CONCLUSION

There has been no consensus on the definition or of the use of a standard theoretical framework for metacognition. Although, there have been a number of recent reviews conducted on executive function and awareness deficits, there still remains to be limited clarification and differentiation of these cognitive functions from a conceptual and methodological perspective. Assessment of metacognition has tended to focus more on specific components of the concept such as self-awareness masking the self-regulatory component. Studies have focused on traumatic and other acquired brain injury in comparison to stroke studies exclusively. Despite evidence in support of early rehabilitation intervention, the majority of the studies that have examined metacognition in stroke did not assess patients in the acute phase. Decreased self-awareness and the inability to monitor and regulate cognitive processes impede functional recovery and therefore, in accordance with this premise, they should be the primary assessments undertaken in cognitive rehabilitation in stroke. The assessment tools included in this review each have their strengths and limitations. However, no tool emerged that was able to consolidate subjective and global objective assessment and thereby measure the full breadth of metacognitive function. The emergence of a clinically useful standard metacognitive assessment tool for stroke may have important implications for future rehabilitative programmes as metacognition is a key area that needs to be addressed at the onset of any rehabilitation intervention.

Competing interests: None

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