Metacognitive function poststroke: a review of definition and assessment

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ABSTRACT
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. A computer database search was conducted using MEDLINE, CINAHL, PsychINFO, Cochrane Reviews, Scopus and Web of Science. A total of 1412 publications were retrieved from the initial database search. Following the removal of unrelated articles, 34 articles remained eligible. 5 studies examined metacognition in relation to cognitive and/or emotional functioning, 4 examined the concept in relation to memory, while others investigated its relationship to driving, employment or restrictions in daily living. 12 studies examined metacognitive function exclusively in stroke. Only 1 study examined metacognition in the acute phase of stroke. 7 studies adhered to the standard definition of metacognition in line with the neuropsychological literature. The main assessment tools utilised 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). Assessment of metacognition has tended to focus on traumatic and other acquired brain injury in comparison to stroke. 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. In some cases, subtle cognitive deficits remain undetected and these lesser cognitive impairments can result in substantial functional problems that can affect rehabilitation and secondary stroke prevention. The importance of cognitive assessment to help plan rehabilitation interventions has been well established. These cognitive assessments have primarily focused on global and executive function. However, in the recent literature, there is now greater interest in exploring metacognition in tandem with recovery. Metacognition generally refers to any knowledge an individual has about their own cognitive abilities and the regulation of these activities through cognitive monitoring. 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 recognise their deficits, causing them to engage in activities that exceed their capabilities, set unrealistic performance goals and fail to use adaptive compensatory strategies. 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. 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). 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. However, although 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.

Since metacognition is an extensive term encompassing awareness and regulation of cognitive capacity, 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 (eg, self-awareness, self-monitoring, self-regulation, subjective cognitive complaints), or terms that focus on a domain of metacognition (eg, metamemory), 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. Few studies have explored the relationship between metacognition and stroke location, type and severity, or its clinical application in stroke care and rehabilitation. Stroke
survivors may be particularly susceptible to metacognitive deficits, as neuropsychological disorders such as magnitude estimation deficit,\textsuperscript{17} anosognosia or anosodiaphoria, spatial neglect, and problems with emotional semantics and abstraction in stroke, are common.\textsuperscript{15} These deficits are associated with poor stroke outcome, and even mild unawareness of impairments could lead to poor rehabilitation and recovery.\textsuperscript{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.\textsuperscript{19}

A major component of metacognition, self-awareness, is what has received the most attention in the neuropsychological literature.\textsuperscript{20} There have been some reviews\textsuperscript{16}–\textsuperscript{22} and theoretical frameworks\textsuperscript{23}–\textsuperscript{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 better rehabilitation outcomes.\textsuperscript{22} Only one review\textsuperscript{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.\textsuperscript{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 utilisation 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 standardised measures of metacognitive function in studies of patients with stroke. A computer search was performed on databases: MEDLINE (1976–2014), PsycINFO (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 standardised questionnaires measuring metacognition or a component of metacognition in cross-sectional, longitudinal, interventional or single case studies.
B. The sample population compromised or included patients with stroke or stroke was a patient group within a study.
C. They published peer-reviewed research in the English language, for 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.\textsuperscript{26}

Analysis of psychometric criteria
Reliability and validity of the commonest assessment tools used were examined in this review. Internal consistency was examined using Cronbach’s α, with a value above 0.7 considered acceptable.\textsuperscript{27} Test–retest and inter-rater reliability were also assessed with a correlation of ≥0.7 considered significant.\textsuperscript{27} Construct validity, the degree to which an instrument measures the theoretical framework it is intended to measure, was reported.\textsuperscript{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 1412 studies identified, 34 studies met the inclusion criteria. Of these studies, five examined metacognition in relation to cognitive and/or emotional functioning,\textsuperscript{20}–\textsuperscript{22} four examined the concept of metamemory,\textsuperscript{33}–\textsuperscript{36} three investigated the relationship between driving and metacognition,\textsuperscript{37}–\textsuperscript{39} three examined metacognition in relation to motor or functional restrictions including activities of daily living,\textsuperscript{40}–\textsuperscript{42} three investigated the use of an assessment tool\textsuperscript{43}–\textsuperscript{45} and two studies examined the effect of metacognition on employment status.\textsuperscript{46} Online supplementary tables S1 (cross-sectional) and S2 (longitudinal, interventional and single case) present a summary of the studies reviewed.

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 |
Conceptual basis and definition of metacognition

Only seven studies adhered to the original definition ‘metacognition’ in line with the 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 (eg, discrepancy between a person’s self-assessment and an external criterion of the person’s ability). Seven studies did not define the term. Sixteen studies made reference to a theoretical framework or model to describe a component of metacognition. 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 recognise that a particular function or skill is impaired compared with 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 recognise 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.

Assessment of metacognition

Eighteen different assessment measures were identified in the studies reviewed. The most common assessment tools used were the Self-Awareness of Deficits Interview (SADI), the Self-Regulation and Skills Interview (SRSI), the Patient Competency Rating Scale (PCRS) and the Awareness Questionnaire (AQ). The PCRS and the AQ use a discrepancy-based method, comparing the patient’s self-rating of function with that of an informant or allied health professional’s rating. The SADI is a structured interviewer-scored approach that measures intellectual awareness after acquired brain injury. The SRSI is a semistructured interview that assesses self-regulation skills by focusing on a main area of difficulty experienced by the patient in an activity of daily living. In most studies assessing metacognition with the SADI and SRSI, these measures were both included. The psychometric characteristics of the five most common metacognitive measures assessing stroke are outlined in online supplementary table S3. Internal consistency and test–retest reliability were reported for four of the measures and inter-rater reliability was reported for the SADI and SRSI. Where reported, Cronbach’s α 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. The remaining studies reported convergent or discriminant validity or correlated the assessment tool scales with other specified variables (see online supplementary table S3).

DISCUSSION

The aim of this paper was to review the definition and the standardised 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 (eg, memory, cognitive impairments, driving and employment). In addition, only one study evaluated the changes in self-awareness poststroke over time limiting conclusive evidence of temporal changes in this domain. All of these elements, alongside the large variability in sample sizes and timing of assessments, make
comparison between the studies complex, and reduce the possibility of reporting a definitive outcome that can be spanned across the majority of studies and generalised to the concept as a whole.

That being said, the studies that examined how metacognition impacts rehabilitation and poststroke outcome reported that higher levels of metacognitive skills correlated with greater adjustment and better task performance.\textsuperscript{30, 37, 45, 46} Intervventional studies showed that participants had significantly improved levels of self-regulation skills and psychosocial functioning at postintervention assessment.\textsuperscript{10, 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 the 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\textsuperscript{82} Pyramid Model of Self-Awareness. Although 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\textsuperscript{24} 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’. 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.\textsuperscript{20, 46, 53} None of the studies referred to the Nelson and Narens\textsuperscript{8} model of metacognition, which splits cognitive processes into two inter-related levels, the ‘meta-level’ and the ‘object-level’, in which the flow of information between these two inter-related levels is dominated by cognitive monitoring and cognitive control.\textsuperscript{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 utilised 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\textsuperscript{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.\textsuperscript{5, 48, 62} This may be due to various reasons, for example, the clinician’s lack of familiarity with the individual prior to the injury, or the caregiver’s own level of anxiety and depression influencing their assessment of the patient.\textsuperscript{6, 62} Other studies used semistructured interviews or compared the patient’s self-ratings with specific functional tasks such as driving. This approach would minimise the subjectivity in caregiver or clinician scores but could also limit the number of functions of metacognition that could be assessed.\textsuperscript{6} Some studies emphasised the importance of using a combination of approaches to tackle metacognitive function.\textsuperscript{5, 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.\textsuperscript{56} Although there may be barriers to 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.\textsuperscript{51, 63}

Although 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 Pyramid 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).\textsuperscript{87} 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 utilised in traumatic brain injury.

**Further directions and conclusions**

The concern with assessing metacognition is that it is a complex as well as broad concept.\textsuperscript{63, 65} This is primarily due to the ‘domain generality’ of metacognitive processes\textsuperscript{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.\textsuperscript{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 the conceptual and the clinical perspectives.\textsuperscript{68} This is because self-regulation appears to be beneficial in improving task performance in motor as well as cognitive abilities when compared with conventional functional rehabilitation in patients with stroke.\textsuperscript{68, 69} A useful model to consider may be the Baltes model of selective optimisation with compensation (SOC) for successful ageing.\textsuperscript{70} As previous studies have indicated that the SOC model may potentially be used to address loss of regulatory function in stroke rehabilitation.\textsuperscript{70, 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.\textsuperscript{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 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 use of a standard theoretical framework for metacognition. Although there have been a number of recent reviews conducted on executive function and awareness deficits, limited clarification and differentiation of these cognitive functions from a conceptual and methodological perspective still remain. 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. Therefore, in accordance with this premise, metacognitive function should be one of 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 programs, as metacognition is a key area that needs to be addressed at the onset of any rehabilitation intervention.

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