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PERSPECTIVES IN REHABILITATION

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Why cognition matters: perspectives in post-stroke motor rehabilitation research

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ABSTRACT

Purpose: Post-stroke cognitive impairment (PSCI) is common (reported prevalence 20–80%) and can limit engagement with motor rehabilitation, yet it is often overlooked in research. This perspective aims to highlight a gap in post-stroke motor rehabilitation research: whilst cognition critically impacts post-stroke motor rehabilitation, the current evidence base does not represent individuals with PSCI.

Materials: We draw on peer-reviewed literature, stroke rehabilitation guidelines and ethical guidance on including adults with impaired capacity to consent.

Methods: Using a narrative synthesis of selected literature and rehabilitation guidelines, we critically appraise how cognition is addressed in guideline-informing trials, highlight common cognition-related exclusion practices, and draw on illustrative examples of inclusive approaches. Consent processes are considered as a modifiable barrier to inclusion.

Results: Guideline-informing trials often exclude or underreport cognitive impairment, limiting generalisability to routine stroke populations. Barriers extend beyond capacity: studies should incorporate cognitive strategies and adopt inclusive recruitment pathways. Importantly, cognitive impairment should be distinguished from decision-making capacity, with consultee involvement where needed.

Conclusions: Motor rehabilitation risks inequity and poor real-world translation unless trials routinely include and characterise PSCI. NIHR-INCLUDE emphasises inclusion of under-served groups, supporting the need for trials and service models that adapt interventions for cognitive impairment rather than excluding affected individuals.

➢ IMPLICATIONS FOR REHABILITATION

- Cognition should be considered in motor rehabilitation because it supports motor relearning and influences engagement and response.
- Research should include stroke survivors with cognitive impairment using inclusive consent that distinguishes impairment from capacity, with consultee routes where needed.
- Clinicians should interpret motor rehabilitation guidelines cautiously when trials exclude or underreport cognition and adapt delivery to support participation.

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Cognitive barriers to post-stroke motor rehabilitation

Rehabilitation is a complex, individualised intervention that considers biological, psychological and social factors to optimise functioning and reduce disability [1].

Receiving timely and effective rehabilitation is a key priority for the many millions of people who have a stroke each year; to enable them to regain movement, become as independent as possible in daily life and to participate in life roles such as education, work, recreation and caring for others.

Post-stroke cognitive impairment (PSCI) is common; prevalence estimates vary based on the timing of assessment, population included and tools used [2], with studies reporting population-based prevalence widely varying between 20 and 80% [3]. Post-stroke neuropsychological impairment is heterogeneous and may involve multiple cognitive domains. These include attention and processing speed, executive

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functions, learning and memory, language, and perceptual-motor (praxis/action) functions. In clinical terms these may present as distinct syndromes such as aphasia (language disorder), visuospatial neglect, or apraxia (praxis/action disorder). These can co-occur but are not interchangeable with domain-general cognitive impairment [4]. For example, when measured with the stroke-specific Oxford Cognitive Screen within the first three weeks, 73.7% of participants (total $N = 429$) showed multi-domain cognitive impairment. This included different domain-specific impairment prevalences ranging from e.g. 26.7% in praxis to 46.8% in attention [5].

PSCI negatively affects quality of life, is associated with symptoms of depression related to limitations in activities of daily life and participation [6–8]. Lower scores on the Oxford Cognitive Screen predict worse long-term cognitive and physical outcomes. This effect is independent of stroke severity as measured by the National Institutes of Health Stroke Scale (NIHSS)[9]. Although cognitive status reliably predicts motor outcomes and engagement in rehabilitation [10,11], motor and cognitive impairments are typically assessed and treated separately after stroke. Recent neuroanatomical findings suggest a clear association between motor and cognitive deficits, reflected in large-scale network interactions. In subacute stroke, both cognition-related and motor-related resting-state networks are associated with upper-limb motor recovery. Notably, cognition-related networks become especially predictive when motor-network integrity is reduced [12]. This integrated view is consistent with motor learning theory. Early phases of skill reacquisition depend heavily on attention, memory, and particularly executive function domains commonly affected after stroke [13]. Executive function may be especially relevant because early motor learning recruits frontal control regions (including dorsolateral prefrontal systems) [14], that support goal maintenance and flexible switching, providing top-down support when movements are not yet automatic [15]. This is particularly evident when we consider that many of the currently recommended and utilised therapies are based on models of motor (re)learning [16,17]. As an example, dual-task studies have shown that adding a cognitive load disrupts motor performance [18]. Stroke survivors also demonstrate greater prefrontal engagement during dual-task compared to single-task performance, [19,20] further supporting the relationship between motor and cognitive resources post-stroke.

Ultimately, cognitive impairment is likely to affect the efficacy of all types of therapy, including physiotherapy. Stroke survivors with cognitive impairments report that cognition is often overlooked during rehabilitation. Qualitative studies describe rehabilitation as having "been more physical," which can lead to feelings of anger, anxiety, and uncertainty [21]. This highlights the need to address cognition during therapy. It also supports adapting cognitive rehabilitation techniques so that they can be integrated into motor-based interventions [22]. This is particularly important to maximise the benefit of the time-limited rehabilitation typically provided after stroke.Embedding cognitive strategies into routine therapy is vital to enhance patient engagement, support functional recovery, and promote transferable skills. In this perspective, we argue that cognition is a critical yet under-recognised determinant of post-stroke motor rehabilitation, and that current trial designs and guideline-informed evidence systematically under-represent individuals with PSCI.

Gaps in the guidelines: who gets left out and why does it matter?

Clinical practice guidelines clearly outline recommended interventions for stroke care and rehabilitation. Guidelines are evidence-based. However, they also reflect the strengths and limitations of the underlying research studies and reviews. For rehabilitation practitioners and researchers, it is important to determine whether stroke survivors with cognitive impairments benefit from currently recommended physical interventions. For example, repetitive task practice is recommended as the predominant treatment approach to motor recovery after stroke in the most recent United Kingdom National clinical guidelines for stroke [23], the American Heart Association/American Stroke Association guidelines [24] and Australian and New Zealand Living Clinical Guidelines for Stroke Management [25]. The evidence underpinning this recommendation includes the Cochrane review by French et al. [26]. This robustly conducted review included 33 trials (3 of which contained unpublished data) of training based on repetitive practice of tasks. However, 19 of the 30 included trials explicitly excluded participants with cognitive impairments from participation. Only 5 studies reported cognitive scores (Mini-mental state examination, MMSE) [27] and the average scores suggested that the vast majority of participants had

little or no cognitive deficits. This exclusion is also apparent in studies included in the 2015 Cochrane review by Corbetta et al. [28] of constraint-induced movement therapy (CIMT) to improve upper limb activity after stroke. This seminal review is cited in 10 international clinical guidelines, including Australian and New Zealand Living Clinical Guidelines for Stroke Management [25] and Canada Stroke Best Practice Recommendations [29], and recommends the use of CIMT. It included 42 randomised controlled trials (RCTs) involving 1453 participants, but notably, stroke survivors with cognitive impairment were excluded from the included trials. These observations are supported bya meta-analysis in 2016 [30] which showed that only 31% out of 215 stroke rehabilitation RCTs reported cognitive status. Of those that did report cognition, nearly half used this information to exclude those participants with cognitive deficits.

Collectively, these examples highlight that trials of motor rehabilitation after stroke often recruit a select group of participants who have no cognitive impairments as measured by a set cut-off score on a screening tool [31]. However, it is important to recognise that these criteria are used for valid reasons. They allow researchers to achieve homogenous samples with greater control and fewer confounding variables. This homogeneity is particularly important to achieve a mechanistic understanding of highly specific interventions, to minimise sample sizes and ultimately reduce costs. Indeed, several systematic reviews of interventions to improve motor recovery after stroke highlight small sample sizes in the included articles [32] with funding being proposed as a major barrier to conducting larger RCTs.

However, where the aim is not to understand the efficacy or mechanisms of complex interventions, but instead to gauge the effectiveness of interventions in a real-world setting, a more inclusive approach to recruitment is vital to ensure research participants reflect the wider clinical population.

Indeed, a review by Paci et al. [33] commented on the lack of generalisability in RCTs of post-stroke physiotherapy, noting that post-stroke cognitive impairment was the second highest exclusion criteria (69%) following comorbidity (83%). Intentional or unintentional exclusion of stroke survivors with cognitive problems from research studies creates a mismatch between the individuals that present clinically and those that are included in research.

This mismatch has several consequences; firstly, excluding individuals with cognitive impairments from studies of motor rehabilitation interventions limits their access to potentially beneficial interventions in research. Secondly, such exclusion risks generating research findings that do not translate effectively into clinical practice, particularly given the high prevalence of cognitive impairment post-stroke. This undermines the power and confidence of research to inform care and risks interventions being used in people who are not represented in the research population. Finally, if clinicians perceive that study populations do not reflect the patients they treat, they may disregard both research findings and the guidelines based on them [34,35].

Our position aligns with NIHR's NIHR-INCLUDE guidance [36], which frames inclusion as a core element of good research design and expects applicants to justify how and why under-served groups (including people living with cognitive impairment) have been considered, rather than treating inclusion as an optional add-on. In parallel, funder priorities increasingly emphasise the psychological and cognitive longer-term consequences of stroke, reflecting both unmet needs and areas that remain underexplored (as highlighted through JLA priority-setting work) [37].

Capacity and consent

One potential reason for the systematic exclusion of stroke survivors with cognitive deficits from motor rehabilitation research is a perception or fear that they may lack the mental capacity to provide informed consent to take part in a research study. However, it is important to note that there is a clear distinction between cognitive impairment and decision-making capacity. The presence of PSCI does not automatically mean that a stroke survivor lacks mental capacity (Intercollegiate Stroke Working Party, 2016) [23]. Where cognitive impairment is present, and there are doubts about capacity, a mental capacity assessment should be completed to determine whether, on balance, a stroke survivor is able to sufficiently understand, retain and weigh up the information to take part and communicate a decision (Mental Capacity Act, 2005) [38]. Inclusive research follows mental capacity and human rights guidance on maximising decision capacity, including supported and joint decision making, and where participants are

deemed, on the balance of probability, not to have sufficient mental capacity, procedures such as consultee consent can be highly effective [39].

Rehabilitation researchers often avoid including participants who lack the capacity to provide informed consent, citing the Medical Research Council guidance on ethics [40] which states that research should not include people without capacity if the research can be conducted with people who do have capacity to consent. However, crucially, this principle only applies to studies where the lack of capacity is incidental to the research question and where the research findings would be equally applicable to the general population with capacity (e.g. some surgical interventions). In contrast, within stroke rehabilitation research, cognitive impairments are highly prevalent and often directly relevant to the intervention being applied (e.g. interventions requiring cognitive engagement). In such cases, the inclusion of individuals with cognitive impairment, even if it impacts their capacity to consent, is essential to ensure the study sample is representative and the findings are generalisable to the population for whom the intervention is intended. This is consistent with the spirit of the Mental Capacity Act 2005 [38] which allows for research linked to an impairing condition to be conducted with those affected, particularly when it cannot be effectively done with those who have capacity.

Future directions for rehabilitation research

Many stroke survivors with cognitive impairment cannot effectively engage in rehabilitation and have reduced benefit from usual care creating inequity and underlining the need for adaptive models [11]. To make motor recovery research and resulting clinical guidelines more representative and applicable, motor recovery trials must explicitly consider individuals with cognitive impairment after stroke. This can be approached in two ways. Firstly, if motor recovery interventions are unsuitable for stroke survivors with cognitive impairments, new motor rehabilitation interventions should be specifically designed and tested for those with domain-specific or global cognitive impairments. Secondly and more preferably, studies should make every effort to ensure that individuals with cognitive deficits are actively included if they can undertake the intervention.

Successful examples of this come from a body of work that use metacognitive strategies for those with PSCI. One illustration is Skidmore et al. [41] pilot randomised trial comparing direct skill training with guided training for people with PSCI. A closely aligned occupational therapy approach is the Cognitive Orientation to daily Occupational Performance (CO-OP) [42], which integrates principles from motor learning and cognitive strategy use. Instead of relying primarily on direct instruction, CO-OP uses "guided discovery" to help individuals evaluate their own performance and develop transferable, metacognitive strategies. Studies of CO-OP, e.g. McEwen et al. [43] specifically included stroke survivors with PSCI. A subsequent knowledge translation study [44] demonstrated how this cognitively oriented, strategy-based approach can be implemented in routine clinical practice through interprofessional training, enabling clinicians across disciplines to shift from traditional impairment-focused models towards goal-directed, functional interventions. A secondary analysis of this work found increased odds of achieving a minimally clinically important difference on the Functional Independence Measure (FIM) motor subscale, particularly for those with mild-to-moderate cognitive impairment [45].Together, these inclusive studies highlight the value and need for interprofessional team training to support the implementation and scaling of cognitively informed approaches, and reinforce the practical and clinical rationale for tailoring therapy for those people with cognitive impairment.

To strengthen generalisability and equity, future post-stroke motor rehabilitation trials should adopt an inclusion-first approach in which all stroke survivors are eligible by default, with exclusions justified only where the intervention is demonstrably infeasible or unsafe. While these principles provide a general framework for inclusive research, their implementation will require context-specific adaptation across jurisdictions, reflecting differences in healthcare systems, regulatory frameworks, and available resources. This requires inclusive recruitment and consent procedures (e.g. verbal or witnessed consent, and personal or nominated consultee pathways where appropriate), supported by structured tools such as the Consent Support Tool to maximise accessible information-sharing for people with aphasia [46,47]. Beyond recruitment, inclusion should be designed into trial *structure, measurement, and analysis*. Specifically, researchers should: (i) pre-specify stratification and subgroup analyses based on clinically meaningful cognitive

profiles and severity (analogous to common stratification by motor impairment severity in recovery trials) [48,49], (ii) intentionally measure and report how cognitive challenges shape engagement, dose received, and adherence using embedded process evaluations and fidelity metrics, and (iii) select outcomes that capture a broader range of motor and cognitive consequences relevant to participation and real-world function (rather than relying solely on narrow impairment measures). Inclusive designs that combine broad eligibility with planned stratification enable subgroup analyses while preserving representativeness, improving interpretability, and clarifying "what works for who" in routine clinical populations.

Conclusion

Cognitive impairment affects most people after stroke, reduces engagement with rehabilitation and negatively impacts recovery. Consequently, the presence and effects of cognitive impairment should not be overlooked in motor rehabilitation research, despite cognition not being the primary target of motor recovery interventions. The exclusion of stroke survivors with cognitive impairments from motor rehabilitation limits the applicability to the wider clinical population. This approach risks underserving many thousands of people after stroke who have common, but complex needs. We suggest that this is particularly important for those with cognitive impairments, who are not a minority, but in fact constitute the majority of stroke survivors in the early weeks and months after stroke.

We call for both an inclusive approach to motor rehabilitation research, as well as targeted and adapted interventions to determine effective clinical interventions to improve motor recovery for stroke survivors with cognitive impairments, ensuring wider applicability and ultimately better outcomes for all.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Author contributions

CRediT: **Faye Tabone**: Conceptualization, Data curation, Investigation, Project administration, Writing – original draft, Writing – review & editing; **Rachel C. Stockley**: Conceptualization, Investigation, Supervision, Writing – review & editing; **Nele Demeyere**: Conceptualization, Investigation, Supervision, Writing – review & editing.

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