The Contribution of Perceived Memory and Information Processing Deficits on Multiple Sclerosis Cognitive Difficulties

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Abstract

MS is one of the major causes of disability in young adults within western countries. More than half of people with MS develop a cognitive impairment, which might be considered as the major quality of life determinant. Although there have been developed several cognitive batteries, cognitive impairment is often overlooked. Information processing speed (IPS) and memory difficulties are the most common cognitive impairments in MS. The Multiple Sclerosis Neuropsychological Questionnaire (MSNQ) is a valid self-report measure of global cognitive difficulties for people with MS. The Attentional Functional Index (AFI) and the Prospective and Retrospective Memory Questionnaire (PRMQ) are self-report measures for perceived cognitive functioning assessing perceived effectiveness in common activities which require attention/IPS and memory. However, it is little known about MS variability between these patterns isolated and co-occurring cognitive deficits. This study aimed to analyse how information processing and prospective and retrospective memory deficits contribute to self-report of cognitive difficulties on the MSNQ and the nature of this relationship. 76 participants with MS completed a series of MS, demographic, and cognition questionnaires along with the MSNQ, the AFI, and the PRMQ on-line. A within-subjects correlation and multiple regression analysis with MSNQ as the dependent variable and AFI and PRMQ as the independent variables were undertaken. The results indicated a significant correlation (p < .01), with a good prediction for the model (p = .05, R² = .73). It was concluded that perceived memory (p < .001), and IPS (p = .05) deficits contribute to self-report of cognitive deficits on the MSNQ separately within the MS population. Findings, limitations, and future implications were discussed.

Keywords: Multiple sclerosis • Cognition • Memory • Information Processing Self-Report • Cognitive Battery

Introduction

Multiple Sclerosis affects the brain and the spinal cord causing a wide range of physical, physiological, psychological, and neuropsychological symptoms. These might cause serious disability as well as severely reduce quality of life. Cognitive dysfunction prevalence in MS, such as memory impairment or information processing speed difficulties, has been recognised as one of the major problems. Therefore, it continues to be investigated from clinical, neuropsychological, and individual perspective. However, research has shown discrepancies on their findings and some areas have not yet been explored.
managing the disease, as well as to reduce the symptoms. These treatments include pharmacological or non-pharmacological interventions and lifestyle changes, along with mental and well-being therapies. Some examples of these MS treatments and interventions are disease-modifying drugs, steroids or corticosteroids, deep brain stimulation, occupational therapy, neurorehabilitation, whole body cryostimulation, physical therapy and exercise, or alternative/complementary therapies and medicine—such as yoga, acupuncture, relaxation or meditation, herbal remedies, massages [17], and diet and dietary supplements—[17–18].

Cognition in MS

In addition to typical physical, neurological and neuropsychiatric symptoms in MS, including a broad range of abnormalities in mood, affect and behaviour such as stress, anxiety, panic attacks, bipolar disorder, substance misuse, and depression, cognitive impairment is also very common but often overlooked. Cognitive changes in MS have a wide range of manifestations that can affect all domains of cognitive function and might develop difficulties with cognition. These difficulties may also interact with and enhance the neuropsychiatric and physical symptoms, for example, by increasing fatigue or affecting mood and overall motivation.

Cognition refers to a broad range of high-level brain processes and functions. These functions may include the ability to learn and remember information, to plan and organise tasks, to solve different problems or challenges, to focus—maintain and shift attention, to understand and use language, to perceive the environment accurately, and to perform calculations. It is known that processing speed has a main influence on other types of cognitive processes. However, cognitive dysfunction occurs when all these abilities are negatively affected or difficult to perform due to changes in processing speed. When a person reports a cognitive problem, he or she describes a change in function from a previous level, what it means, a cognitive decline [19].

Within people with MS, certain cognitive functions are more likely to be affected than other ones. Generally, these changes in cognitive function are mild and may involve one or two areas. However, in fewer people with MS these changes are more challenging. These functions might be classified as: Information processing memory, attention, and concentration, executive function, visuospatial functions, and motor fluency [20,17]. Cognitive impairment in MS may reduce life satisfaction and health-related quality of life of patients [21]. Also, it may be considered the most important determinant of employment status and associated societal costs of people with the disease. Additionally, other activities and characteristics such as driving safety, household tasks completion, social activity, physical independence, rehabilitation progress, coping, and treatment adherence are usually highly affected [22,2].

Neural Bases of Cognitive Dysfunction in MS.

Magnetic Resonance Imaging (MRI) plays an essential role in MS diagnosis and disease surveillance, therefore, the field of MS is nowadays at the top of novel and innovative MRI technology. This novel technology provides multiple tools for investigating MS-related cognitive deficits [23].

According to early research, cognitive deficits in MS were linked to greater diffusion tensor imaging (DTI) [24] and microstructural brain changes, more specifically loss of myelin and axonal sheath, as well as atrophy [25]. Structural brain damage cortical and subcortical [26–28]. Brain atrophy, lesion load. However, subsequent studies showed the importance of white matter and grey matter lesions, these lesions location [24] microstructural injury [25], structural brain damage cortical and subcortical [26–28]. Brain atrophy, and discrepant patterns of cerebral activation with fMRI[29]. For instance, there have been found neuroanatomical correlates of cognitive deficits in MS (e.g., thalamus) [26, 27]. Although these correlates of cognition could be used as markers for the disease-related cognitive deficits, they are also important for gaining knowledge of precise neural bases in order to identify therapeutic targets for their treatment [20]. However, whether such correlates directly underlie deficits, or are reliable representatives of overall or other cerebral damage—which mediate links to cognition—remains unclear. For example, the thalamus has been shown to be highly susceptible to retrograde degeneration [29], thus, it may have better scan-to-scan reliability than other structures [20]. However, using thalamic volume as a summary measure of disease burden across people with MS with different CNS damage, even if thalamic change does not directly underlie a specific cognitive impairment (e.g., memory or attention).

According to Sumowski [20] advances in ultra-high-field MRI, myelin and molecular imaging—imaging of demyelination and remyelination and non-conventional MRI techniques used to examine microstructural cerebral changes would provide more ways to investigate cognitive deficits due to MS [30–33]. The most promising neuroimaging methods to date includes diffusion tensor imaging (DTI) [24] a type of MRI technique that enables the measurement of water diffusion rates between cells to produce a microstructural map of the brain [34] found this technique to provide supplementary disability progression information over 4 years in MS. However, larger prospective longitudinal studies with multi-modality neuroimaging to accurately document temporal correlations of specific cognitive deficits with changes in specific brain structures and functions are still required. Longitudinal studies may help support cross-sectional links between memory deficits and hippocampal changes [23].

MS Cognitive Assessment

There are several cognitive batteries or tests specifically developed for MS [35]. These include tests of processing speed, memory, and other functions individually administered by trained professionals. For example, information processing speed is typically assessed as the amount of work performed within a time frame or time limit (e.g., number of items completed) whereas episodic memory is assessed as the amount of information learned and recalled (e.g., words, visual stimuli) using several tests [35–37]. These tests developed for MS are reviewed on MS-related cognitive dysfunction, as well as they considered psychometric factors relevant to neuropsychological assessment [38]. Peer-reviewed articles covering a broad spectrum of cultures and scales addressing MS-vulnerable cognitive aspects were selected. Each article was rated by two committee members and candidates based on psychometric qualities, such as reliability, validity and sensitivity, international application, administration, feasibility in the specified context, and acceptability to patients [22]. This exhaustive research resulted in the development of the Minimal Assessment of Cognitive Function in MS (MACFIMS). The MACFIMS is a 90-minute battery composed of seven neuropsychological tests that covers the five most common cognitive impairments in MS. These impairments include processing speed and working memory, learning and memory, executive function, visual-spatial processing, and word retrieval. The battery, the basic version, is most widely used and includes an instrument of measurement of the estimated pre-morbid cognitive ability.

However, measures for assessing other factors that may potentially confound interpretation of neuropsychological data, for example, visual, sensory and motor impairment, fatigue, and depression—are offered, as well as strategies for improving future neuropsychological assessment of people with MS. Further paths for improvement were found by [20]. The researchers critically evaluated some of these tests, which are the most widely used. As a result, they identified the Symbol Digit Modalities Test (SDMT), the Brief Visuospatial Memory Test Revised (BVMT-R), and the Selective Reminding Test or California Verbal Learning Test II (CVLT-II) as the most sensitive tests for cognitive monitoring in MS nowadays. However, limitations of these tests were also found. For example, patients referred for specific clinical or research questions beyond monitoring often require more comprehensive evaluations. Also, despite of the briefness of MS batteries based on neuropsychological standards, most of them require even 15 minutes of one-on-one time for every test. However, research versions of MS cognitive batteries are based on MS care standard. The researchers proposed series of possible alternatives such as the usage of computerised. It was concluded that computerised could be the main key of innovation that would improve most important areas of neuropsychological monitoring in MS cognition. These may include better detection of cognitive decline, large datasets from representative samples to advance understanding of prevalence, time course, and risk factors for decline, and greater feasibility of post market studies of disease-modifying therapy effects on cognition [20].

On the other hand, the need for cost-effective screening techniques that identifies neuropsychological impairment in people with MS, as well as the requirement of cognitive testing with subsequent interpretation by a neuropsychologist of existing methods, lead to the development of a brief self-report. This was elaborated by pooling 80 items based on literature review and consultation with healthcare professionals. The set was then reduced to 15 items of MS analysis methods. As a result the MS Neuropsychological Screening Questionnaire (MSNQ) emerged. This is a brief five-minute test that includes patient and informant-report form [38] selected 50 MS patients and their caregivers to complete the MSNQ. Additionally, a comprehensive neuropsychological test battery was also administered. Subsequently, the reliability of the MSNQ and correlations between both patient- and informant-report scores and objective neuropsychological testing were analysed. The result of the analyses indicated that both forms of the test were strongly correlated with a more general cognitive complaints questionnaire. Also, a cut-off-score of 27 on the informant form of the MSNQ separated patients
based on a neuropsychological summary score encompassing measures of processing speed and memory [38]. MS patients are often characterized by studies as as cognitively impaired based on average scores on multiple tests that measure several or specific cognitive functions. However, this could lead to heterogeneity of impaired groups of patients with different isolated or co-occurring cognitive deficits. This may challenge the interpretation of results and confront comparisons across studies, especially those aiming to identify neural correlates of cognitive impairment. Moreover, cognitive impairment might differ across specific cognitive domains. Therefore, it is suggested that future research should better characterise groups as impaired in isolated or across specific tests that measure several or combined as well as to use utilize purer measures for each cognitive domain [20].

Self-Report Cognition and Quality of Life in MS

A self-report study is a type of method in which participants or respondents are able to answer questionnaires, surveys or polls without interference. Researchers obtain participants’ views or opinions about their own attitudes, feelings or beliefs through this method [39]. Numerous studies have indicated that people with brain damage are prone to underestimate neuropsychological (NP) impairment when self-report ratings are compared to informant ratings. Research suggest that these discrepancies have not been well examined in MS [40-42]. Moreover, evidence also showed a greater underestimation of or less self-awareness of cognitive dysfunction and unemployment within people with MS [43].

Perceived cognitive impairment (PCI) might be considered as the major health-related quality of life (QoL) and work outcomes determinant [43-45]. According to [40], self-reported cognitive measures may be an indicator for objective cognitive impairment in MS population. [46] examined the specific contribution of cognitive impairment to daily living problems in multiple sclerosis using either cognitively intact or cognitively impaired MS patients trough neuropsychological testing. Results showed that cognitively impaired MS patients were more likely unemployed and less likely engaged in fewer social and avocational activities. They also reported more sexual dysfunction, experienced greater difficulty in performing routine household tasks, and exhibited more psychiatric symptoms than cognitively intact patients. However, researchers find difficult to assess the PCI accurately due to the variability in how it is defined, either by longitudinal clinical assessment or by individual self-report of perceived symptoms [47-48]. Moreover, it is complex to prevent or treat cognitive deficits in MS effectively through pharmacological interventions [49]. Therefore, lifestyle modification such as physical activity, better diet, and avoiding unhealthy behaviours (such as smoking or alcohol consumption) might be a supplementary and protective strategy given their strong association against age-related cognitive decline in the general population [49]. A cross-sectional analysis study found several factors positively associated with PCI using specific definitions in people with MS. These factors increased in magnitude directly and proportionally as their specific definition, including associations for smoking and body mass index. In contrast, physical activity, dietary quality and use of vitamin supplements were inversely associated with PCI [43]. In addition, these factors along with body mass index (BMI) and meditation have also been associated with MS onset [50-51], as well as with general health.

Information Processing and Memory in MS.

According to many studies, people with MS often report difficulties in executive function, verbal fluency, and visuospatial analysis, although additional difficulties in multitasking and word-finding are also very characteristic [52-53]. Cognitive decline often emerges at an early stage of the disease [54]. Whereas impairment is more prevalent [21-20] and may differ qualitatively and even qualitatively among patient groups or the disease against MS. However, the most common deficits in MS correspond to slowed Cognitive Processing Speed or Information Processing Speed (IPS) and memory. However, it is not known whether deficits in one cognitive function regardless of premorbid ability or disease-related mediators, might be premature and potentially misleading [20]. Moreover, although MS leads to deficits in several cognitive domains in the group level [36,53] it is little known about the disease’s variability of cognitive deficits in a patient-level expression, for example, patterns of isolated deficits in comparison to co-occurring deficits. In addition, it is not known whether deficits in one cognitive function or domain contribute to dysfunction in other domains, for example, whether IPS contributes to memory. All these factors may lead to groundless expectations or assumptions, such as the idea that treatment of one function may improve correlate functions [20].

Research Question, Objective, and Hypothesis

The MSNQ is a validated self-report measure of global cognitive difficulties for people with MS. The two most prevalent cognitive impairments in MS occur in information processing speed and memory, and any other cognitive function or domain contribute to dysfunction in other domains, for example, whether IPS contributes to memory. These factors may lead to groundless expectations or assumptions, such as the idea that treatment of one function may improve correlate functions [20]. On the other hand, studies have also had empirically demonstrated that Long-term memory (LTM) is one of the principal multiple cognitive functions affected by MS. The LTM deficits have often been associated with retrieval failure [58]. However, increased self-reported memory impairments were significantly correlated with higher levels of normative dissociation experiences as well as with several psychiatric symptoms such as depression, anxiety, and neuroticism rather than neuropsychological variables in people with MS [59]. Some researchers often use alternative classifications to refer to LTM based on the temporal direction of the memories. Retrospective Memory (RM) refers to the process of recalling past memories or episodes (e.g., people, words, events). It includes semantic, episodic and autobiographical memory, and declarative memory [60-61], whereas Prospective memory (PM) is employed when the content is to be intentionally remembered in the future (“remembering to remember”). PM is often triggered by a cue and it may be either event-based when the action is reminded by a specific event—, or time-based—when the action or event is planned on a specific time [62-63].

There is considerable evidence that cognitive impairment in MS extend to activities requiring PM [64-65] and that MS is associated with impaired retrospective memory [66]. For example, [67] investigated the ability to remember and perform delayed intentions in a sample of individuals with Multiple Sclerosis (MS) in comparison to a neurologically intact control group through a task division model. Performance on the PM component and the RM component were examined. The results showed significantly poorer performance of the MS group in both components. However, findings suggested that failure in PM might be primarily attributable to RM deficits, showing that both PM and RM rely on each other [63].

However, although IPS and memory are correlated in MS these cognitive functions are also highly correlated in healthy population, probably due to general ability [68]. Therefore, conclusions about direct relationships between decline in processing speed, memory, and any other cognitive function regardless of premorbid ability or disease-related mediators, might be premature and potentially misleading [20]. Moreover, although MS leads to deficits in several cognitive domains in the group level [36,53] it is little known about the disease’s variability of cognitive deficits in a patient-level expression, for example, patterns of isolated deficits in comparison to co-occurring deficits. In addition, it is not known whether deficits in one cognitive function or domain contribute to dysfunction in other domains, for example, whether IPS contributes to memory. All these factors may lead to groundless expectations or assumptions, such as the idea that treatment of one function may improve correlate functions [20].

Method

Participants

Participants were N=76 adult male and female individuals with MS from the United Kingdom. All participants were recruited on-line through different...
MS organisations. All participants were English speakers. Additionally, demographic data was collected for statistical purposes.

**Material**

The material employed was a demographic questionnaire informing of participants' ethnicity, nationality, age, gender, academic level, and occupation; an Informed Consent Form providing details of the study and specifying its aims and purposes, and a specially constructed set of questions about cognition services.

Participants completed The Multiple Sclerosis Neuropsychological Screening Questionnaire (MSNQ), a valid 15-item self-report measure developed to screen patients for cognitive deficits and neuropsychological impairment in daily activities on MS population [38].

In order to measure participants' self-report memory we employed The Prospective and Retrospective Memory Questionnaire (PRMQ) [61] a valid 16-item self-report questionnaire assessing prospective and retrospective memory impairment. On a 5-point scale (Very Often, Quite Often, Sometimes, Rarely, Never) participants are asked to indicate their perceived memory errors frequency [70].

The Attentional Functional Index was employed in order to analyse information processing. It is a 13-item self-report measure with 3 subscales designed to assess cognitive function and perceived effectiveness or performance on tasks requiring attention and working memory, particularly, the ability to formulate plans, carry out tasks, and function effectively in daily life. Its construct gained validation using exploratory principal component factor analysis with varimax rotation on a breast cancer study and has demonstrated usefulness for assessment of perceived cognitive functioning [2].

All the material questionnaires and data were administered and collected via on-line through Qualtrics. Additionally, SPSS Statistics was employed for data analysis.

**Procedure**

All questionnaires were on-line administered through Qualtrics. Participants were provided with a direct link to the study and followed on screen procedures. Data was treated anonymously, as well as confidentially stored, and analysed using SPSS Statistics in computers with access restricted to researchers.

**Design**

A correlational or regression design (within subjects) were memory, with two levels—prospective and retrospective—and attention were the independent variables (IV) and the MSNQ (neuropsychological screening) the dependent variable (DV)

**Statistical Analysis Plan (SAP)**

- **Outcome Measures (Dependent Variable)**
  Self-reported cognitive impairment on the MSNQ [38].

- **Independent Variables**
  Perceived information processing speed deficits; Attentional Functional Index [69].
  Perceived memory deficits; Prospective and Retrospective Memory Questionnaire [61]

- **Confounders**
  Demographic: Sex, Age, Socio-economic status, education. Physical and cognitive factors: type of MS, general fitness, and self-cognition awareness.

**Statistical Analyses**

1. **Data primary observations**: Descriptive statistics, tests of normality, homogeneity, multicolinearity, outliers (check and exclusion).

2. **Correlation (within-subjects)**: Statistical relationship between IV (MSNQ scores) and DVs—MS population self-reported information processing speed deficits scores and self-reported prospective and retrospective memory scores. It will be determined if the correlations are statistically significant.

3. **Multiple Linear Regression**: Participants' self-reported scores reversed if required and coded appropriately of information processing speed will be analysed in order to determine whether these and other variables predict the MSNQ score.

These analyses were designed to address the research question or hypothesis; whether perceived attention or IPS and memory deficits are associated with the MSNQ. These analyses also explained the nature and the power of these relationships. In addition, confounders were explored through a visual evaluation (graphs, plots…) of interaction between the outcome questionnaires scores and demographical data, divided into subgroups or subcategories (i.e. sex, age, type of MS…). Data was confidentially stored for future replication in order to obtain more representative results, and for subsequent observations.

**Results**

Responses from a total number of 186 adult male and female participants with MS were collected in the study. However, only N=76 cases of all completed respondents were included in the analyses. Thus, missing values were excluded using Listwise deletion. Despite the fact that no outlier was detected (Figure 1), the descriptive statistics indicated slightly asymmetrical data distribution (Figure 2) with a negative skewness (Skp) value between -0.5 and 0.5 considered generally acceptable for all predictors; and an approximately normal or symmetrical distribution for the dependent variable [Table1]. Nevertheless, given the low Skp. coefficient values, which suggests an approximately symmetrical distribution, no transformation was considered to be required.

The relationship between the MSNQ scores (M= 47.38, SD= 13.02)—the DV—and both the PRMQ (M= 54.17, SD= 16.51) and the AFI (M= 925.71, SD= 333.87) scores—the IVs or predictors—was explored in order to
determine whether either information processing speed and prospective and retrospective memory deficits contribute to self-report of cognitive difficulties in MS population [Figure 1].

Correlational analyses were executed to test the statistical relationship between the three variables. The results of the analysis were statistically significant indicating a strong positive correlation between MSNQ scores and PRMQ scores; r (76) = .85, p<.01. Similarly, MSNQ scores and AFI scores showed a strong significant relationship; r (76) = .63, p<.01. On the other hand, Pearson’s correlation also suggested a strong significant relationship between the predictors; r (76) = .63, p<.01. This suggests that self-reported prospective and retrospective memory and information processing speed are significantly associated with self-reported cognitive deficits on the MSNQ. However, interim analysis were required to examine a possible interaction (multicollinearity) between all correlated predictors.

Additionally, a within-subjects multiple linear regression was performed in order to examine the nature of this relationship. A significant regression equation was found; F (2, 73) = 99.21, p<.05 with an R² of .73, indicating a good model. This suggests that both the PRMQ (B=.59, p<.001) and the AFI (B=.41, p=0.5) are good predictors of MSNQ scores in MS population, being the PRMQ highly significant. Collinearity diagnostic suggested that there was no multicollinearity between the variables with VIF<10, this indicates that no correction was required. Therefore, it is concluded that each independent predictor makes separate contribution in the statistical relationship with a 73% of variance of the MSNQ explained by both the PRMQ and the AFI. However, the 27% of variability remaining was unexplained, which could be due to the influence other factors or confounding variables; such as age, gender, or further cognitive features.

**Discussion**

It is uncertain how different prevalent cognitive domain deficits affect global cognitive dysfunction in MS. Moreover, the nature of this relationship remains unexplored. As predicted, this study showed a strong positive relationship between the PRMQ, the AFI and the MSNQ. These findings support the usefulness and effectiveness of the PRMQ and the AFI to measure and assess self-report cognitive function in MS. However, the statistical analyses showed that both variables made an individual contribution to the predicted outcome, being perceived memory impairment the MSNQ main predictor with greater variability explained. This indicates a higher correlation, hence, a stronger relationship between the PRMQ and the MSNQ. Hence, despite the hypothesis that the AFI would be closely associated to the MSNQ compared to the PRMQ according to previous research, the raised null hypothesis was rejected based on these findings. In addition, these results suggest drawing attention to memory deficit, in contrast to previous research, which hints IPS as the main cognitive deficit domain in MS. This also suggests further examination.

Previous evidence suggested that IPS underlies all cognitive deficits in MS, therefore, despite the fact all variables showed a positive relationship amongst, it was expected that perceived IPS was strongly associated with MS global cognitive deficit on the MSNQ. Nonetheless, the results indicated that self-report of cognitive difficulties in prospective and retrospective memory, as well as information processing speed or attention, made independent contributions to self-report of perceived global cognitive difficulties on the MSNQ. This suggests that different cognitive deficit functions may operate independently rather than interacting, which provides a deeper insight in their mechanisms, but also questions previous research and gives rise to new or less commonly examined approaches. For example, whether intervention target should change perspective and treat each cognitive function individually.

On the other hand, similarly to previous research, these findings reaffirmed the MSNQ accuracy and usefulness for evaluating different domains of cognitive function impairment in MS population, being the MSNQ a feasible and suitable measurement of global MS cognition, as well as for perceived MS cognition. Furthermore, the strong significance among variables supports that both IPS and memory underlie two of the main cognitive impairments in MS based on the MSNQ.

These findings are not exempt of limitations. Many researchers agreed that more cognitive impaired participants tend to underestimate their cognitive deficits. However, the consensus in the literature that cognitive deficits are overestimated or underestimated by individuals remain contradictory and discrepant. Although self-report measures and, more concretely, online or computerised self-report measures, have many advantages (e.g., confidentiality, ability to recruit large samples and different groups), these also have validity and reliability weaknesses. This is due to their lack of control over confounders, such as respondents’ fitness and physical ability to complete surveys and questionnaires – which might be, in turn, related to the type of MS [Table 2], which may result in, for example, a second party completing them on behalf, exaggeration or under-report of severity of symptoms, and participants’ mental or psychological state. For example, it is known that depression may influence or affect cognitive ability. If a person with MS suffers from depression, this might mediate, be the directly related to, or responsible for cognitive function decline perception rather than disease itself. Thus, the self-report constructs or measures employed in the study could not evaluate the respondents’ answers accuracy or reliability due to a lack of control over these factors. This might have lead to a biased description of their cognitive ability perception. In other words, the sample might not be an exactly or accurately illustrative of the real MS population. Moreover, the influence of further factors like individual and demographic characteristics...
such as age, education, gender, marital status or occupation [Table 2] may also play an essential role on self-report, enabling further research on the current implications of these elements.

Furthermore, generally, people with higher socio-economic status and education might have more technological accessibility as well more facility to navigate the internet, thus, to complete questionnaires. Social gender roles may also be regarded as a factor of consideration. At a household level, for example, this might condition individual availability to take part in these studies.

On the other hand, a small sample size, resulting from the exclusion of missing cases, i.e. uncompleted questionnaires (missing values or blank responses) might have also had a relevant impact. Missing values might be explained by the duration of the study; although brief questionnaires were employed, the survey comprised multiple batteries which may elongate the completion time of this, affecting respondents’ task performance. Previous factors like, for example, physical ability, might have equally and simultaneously influenced such performance.

Finally, it is also worth to mention that, with the exception of the MSNQ, the constructs employed for this study have not been currently tested and validated for the specific assessment of MS cognitive difficulties, which may also weaken the reliability of the findings. Notwithstanding, this opens a window for further investigation. The set of these additional variables and how they affect self-report of cognition in MS population requires further examination, thus, future replication and larger sample sizes. Future research could target the identification of effective tools or the improving existing examination, thus, future replication and larger sample sizes. Future research how they affect self-report of cognition in MS population requires further validation for the specific assessment of MS cognitive difficulties, which the constructs employed for this study have not been currently tested and validated and

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References


