

Subjective Cognitive Impairment in 55-65-Year-Old Adults Is Associated with Negative Affective Symptoms, Neuroticism, and Poor Quality of Life

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Abstract. Although subjective cognitive impairment (SCI) is increasingly recognized clinically and in research as a risk factor for mild cognitive impairment and dementia (particularly Alzheimer's disease), it is etiologically heterogeneous and potentially treatable. Compared to mild cognitive impairment and Alzheimer's disease, SCI however remains poorly characterized with debate continuing regarding its clinical relevance. The primary aim of this study was to improve the characterization of SCI within the general public by investigating functions sometimes omitted clinically or in research, namely visual attention-related information processing speed (RT) and its intra-individual variability (IIV_{RT}), general cognition, depression, anxiety, memory, quality of life (QOL), and neuroticism. Compared to individuals without SCI, those with SCI were more likely to reveal higher scores of anxiety, depression, and neuroticism and poorer perceived physical, psychological, and environmental QOL. Within-group analysis identified no significant relationships between any of the above variables for the non-SCI group whereas for the SCI group, poorer Cognitive Change Index scores were significantly correlated with slower RT, raised IIV_{RT} , poorer memory, negative affective symptoms, higher neuroticism scores, and poorer QOL. This indicates that reports of perceived memory changes in SCI can also be associated with other characteristics, namely objectively measured detrimental change in other aspects of brain function and behavior. This outcome emphasizes the importance of a multi-function approach to characterizing and understanding SCI. Thus, although the effect of RT and IIV_{RT} is not strong enough to differentiate SCI from non-SCI at group level, slowing and raised IIV_{RT} do appear to characterize some people with SCI.

Keywords: Anxiety, dementia, depression, memory, neuroticism, quality of life, reaction time, subjective cognitive impairment, visual attention

INTRODUCTION

Subjective cognitive impairment (SCI) is defined clinically as perceived changes in memory and cognition that individuals report in the absence of objective

evidence of abnormality [1]. SCI is increasingly recognized as a risk factor for mild cognitive impairment (MCI) and dementia (particularly Alzheimer's disease [AD]) compared to demographically matched healthy adults free of SCI (hazard ratio 4.5; 95% CI 1.9–10.3) [2, 3]. Nevertheless, as in MCI, SCI appears etiologically heterogeneous. Although for some individuals, SCI may represent the outer limits of the normal aging process, or what is in fact normal aging

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for a particular individual with changes often considered to be ‘senior moments’ [4], a variety of risk and causal factors for SCI continue to be reported. These include age [5], low educational level [6], depression [7, 8], anxiety [9], chronic fatigue [10], whiplash injuries [11], schizophrenia [12], bipolar disorder [13], obsessive compulsive disorder [14], epilepsy [15], multiple sclerosis [16], stroke [17], fibromyalgia [18], sleep apnea [19], medication side effects [2], menopause [20], and thyroid dysfunction [21]. Such evidence indicates that some causes of SCI are potentially treatable and may not be related to neurodegenerative disease [4, 22] and that the factors contributing to SCI may be more varied and complex than previously envisaged. Furthermore, irrespective of etiology, SCI can detrimentally influence quality of life (QOL), self-perceived health [23, 24], perceived workplace performance and restrict social activities and mobility (e.g., driving a car) [25]. Despite such potentially detrimental associations and irrespective of etiology, SCI remains poorly characterized with respect to the integrity of a wide array of brain functions and with debate also continuing regarding its clinical, research, and everyday relevance [26–28]. It is clear therefore that further exploration to identify causality, characteristics, consequences, possible interventions, and required support [25], factors indicative of potentially reversible causes or neurodegenerative etiology, is imperative.

Information processing speed and intra-individual variability

At present, by definition, SCI is characterized in both clinical and research forums by the *absence* of significant deficits in objectively measured aspects of cognitive function such as memory, visuo-constructional skills, and executive function, namely those brain functions assessed by tools such as the Montreal Cognitive Assessment (MoCA) [29]. This focus on the functional integrity of a relatively narrow range of brain function in SCI means that its potential detrimental effect upon ‘real life’, other brain functions, and medical and psychological health may be underestimated or undetected by clinicians, researchers, and the general public [30]. Previous research has shown that MCI, vascular cognitive impairment, and AD (all of which may reveal SCI as a prodromal stage) can be characterized by significant abnormality in some aspects of attentional function and attention-related reaction time (RT) and its intra-individual variability (IIV_{RT}) [30–42]. RT and IIV_{RT}

are associated with brain white matter integrity [36], poorer daily activity levels and quality of life [43–49]. Therefore, one of the aims of this study is to examine such function in SCI. Evidence of changes in such function in SCI can be expected to improve our understanding of factors contributing to the signs and symptoms of SCI.

A challenge when investigating SCI and the comparison of study outcome is the associated lack of consensus related to its concept and terminology [21]. However, subjective cognitive decline (SCD), related more specifically to the neurodegenerative decline associated with AD, is increasingly described clinically and in research [21]. SCI was examined in the present study in order to investigate the wider concept of perceived changes in a wide range of etiologies not specifically related to neurodegeneration, such as anxiety and mood and thus intervention for potentially reversible causes.

Furthermore, despite the fact that previous studies have tended to recruit people living with SCI with a formal diagnosis from memory services (i.e., received a clinical diagnosis of SCI), not everyone perceiving detrimental changes in cognitive function seeks medical attention and thus formal assessment [50, 51]. Such individuals may represent a sizeable proportion of community dwelling older adults [25, 50]. In order to redress this imbalance, SCI was investigated in those who had not been in contact with memory services. This study also extends previous work examining RT and IIV_{RT} in relation to perceived memory changes in older adults [49, 52, 53].

SCI and anxiety, depression, quality of life, neuroticism, and memory

Although debate continues with respect to cause and effect, increasing evidence is indicative of links between SCI and anxiety, depression, the reporting of health problems, lower self-efficacy, less perceived control of potential difficulties in life, and higher scores on neuroticism, poorer QOL [9, 23, 24, 54–57, 64, 65], and links between anxiety, attention, and RT [25, 55, 58–63]. These factors will therefore be further investigated in this study. Furthermore, as a relationship between objectively identifiable cognitive impairment (i.e., MCI and/or AD) and the personality trait neuroticism has frequently been identified in previous research (e.g., [66–69]), with some evidence that it acts as a mediating factor between memory complaints and physical and psychological health problems [54], neuroticism will

also be included in the investigation of SCI in the present study.

Study aims

The aim of the current study was to further characterize SCI (in the general public) with respect to information processing speed (RT) and its IIV_{RT}, and with respect to visual and verbal memory function, general objectively measured cognitive functioning, anxiety, depression, QOL, and neuroticism. We hypothesized the following: RT will be slower and IIV_{RT} greater in individuals with compared to without SCI and that scores of general cognitive function, QOL, memory (visual and verbal) will be poorer, and scores of neuroticism, depression, and anxiety worse, in SCI.

METHODS

Participants

An opportunity sample methodology was used. Males (N=24) and females (N=75) aged 55–65 years were recruited from the general public living in South Wales, UK (Number of participants [N]=99; mean [M] age=60.43 years, standard deviation [SD]=2.96). Inclusion criteria: general public aged 55–65, and from a self-reported perspective, in good general medical and mental health. Exclusion criteria: a clinical diagnosis of MCI or dementia (self-reported medical diagnosis), self-report of decline in cognitive ability which can be explained by a psychiatric or neurological disease, previous head injury, medical disorder, medication (prescribed and non-prescribed), or substance use. A further exclusion factor was a visit to their general practitioner (GP) or memory services about memory concerns. Participants were recruited via advertisement on social media, group email (i.e., 50+ Network), posters, etc. Older adults aged 55–65 years were recruited in order to represent the typical age-range through which SCI presents. This study was approved by Swansea University ethics review boards and written informed consent was obtained from all participants.

Battery of measures

Mean education level, ethnicity, employment status/level, and family history are presented in (Table 1). The test battery comprised: Cognitive Change Index (Self report) (CCI-S) and the Cognitive

Change Index (Informant report) (CCI-I) to measure SCI symptoms [71]; The World Health Organization Quality of Life (WHOQOL-BREF) (shortened version of the WHOQOL-100) [72]; Hospital Anxiety and Depression Scale (HADS) [73]; The Big Five Inventory (BFI) to measure neuroticism [74]; Montreal Cognitive Assessment (MoCA) [29]; The Rey Osterrieth Complex Figure (ROCF) to measure visual memory [75]; The Hopkins Verbal Learning Test (HVLT) to measure verbal memory [76]; The National Adult Reading Test (NART) to measure predicted IQ [77]; Trails A (TMT A) and Trails B (TMT B) [52]; and the adapted Multi-Item Localization task (MILO) [53].

Figure 1 is a schematic example of a trial from the tablet-based implementation of MILO which was employed in the current study [78]. The participants needed to touch each virtual pool ball from one to eight in ascending order as quickly, but as accurately as possible. The advantages of computer-based test presentation in comparison to paper-and-pencil tests include the recording of reaction times for each item, rather than basic completion overall such as that in the TMT (e.g., see [79]), and the capacity to investigate spatial patterns of search organization (e.g., see [80]). Additionally, the MILO task makes it possible to easily manipulate the sequence type (e.g., digits, letters, or both) and sequence behavior (e.g., items vanishing or remaining, sequence position remaining fixed or shuffling between responses), in order to investigate the temporal context of visual search [53]. Therefore, a task such as this could potentially be employed in a clinical situation, providing information about RT speed and variability and attention processing, and additional features of higher level, cognitive processing. For this study, a fixed sequence of the digits one to eight was used, and the display was configured so that items vanished when touched. The additional sequences (i.e., shuffling) were not used because only a simple measure of information processing time (RT) and IIV_{RT} that did not take too long to complete was required, thus mimicking the limited time a clinician would have to use such a test in real life.

The sample was split based on their CCI-S scores (CCI-S) (i.e., the SCI group and the non-SCI group) in order to determine any between-group differences (i.e., between SCI and non-SCI) or within-group relationships. The CCI measure has one set of cut-off values to use as a method of grouping, which are the ones used within the well-established Alzheimer's Disease Neuroimaging Initiative (ADNI) study [81].

Table 1
Participant characteristics in both the SCI and the non-SCI group

	SCI	Non-SCI	Pearson Chi Square Test results of the corresponding categories within the SCI and non-SCI group	Mann-Whitney Test results of the corresponding categories within the SCI and non-SCI group
Total N	47	52	–	–
Age mean (SD) [y]	60.34 (2.71)	60.52 (3.20)	–	NS
Gender N (%)	35 (74.5) Female; 12 (25.5) Male	40 (76.9) Female; 12 (23.1) Male	NS	–
Years in FT Education mean (SD)	14.26 (2.96)	15.15 (2.97)	–	NS
Ethnicity group N (%)	Welsh – 31 (66) English – 8 (17) British/other – 8 (17)	Welsh – 35 (67.3) English – 6 (11.5) British/other – 11 (21.2)	NS	–
Employment status N (%)	Retired or unemployed – 23 (49) Employed or self-employed (full time) – 15 (32) Employed or self-employed (part time) – 9 (19.1)	Retired or unemployed – 22 (42.3) Employed or self-employed (full time) – 18 (34.63) Employed or self-employed (part time) – 12 (23.08)	NS	–
Employment level N (%)	Supervisor – 12 (25.5) Manager – 19 (40.4) None – 16 (34.0)	Supervisor – 11 (21.2) Manager – 27 (51.9) None – 14 (26.9)	NS	–
Family history of cognitive impairment N (%)	Yes (maternal) – 18 (38.3) Yes (paternal) – 1 (2.1) None – 28 (59.6)	Yes (maternal) – 20 (38.5) Yes (paternal) – 6 (11.5) None – 26 (50.0)	NS	–
CCI-S mean (SD)	27.62 (7.45)	15.04 (2.17)	–	U = 1.50 (Z = –8.57), $p < 0.001$ Cohen's effect size: –0.86 Large
CCI-I mean (SD)	22.26 (9.49)	15.29 (4.08)	–	U = 586.00 (Z = –4.49), $p < 0.001$ Cohen's effect size: –0.45 Medium
NART errors mean (SD)	11.55 (7.82)	9.31 (6.84)	–	NS

*NS, not significant.

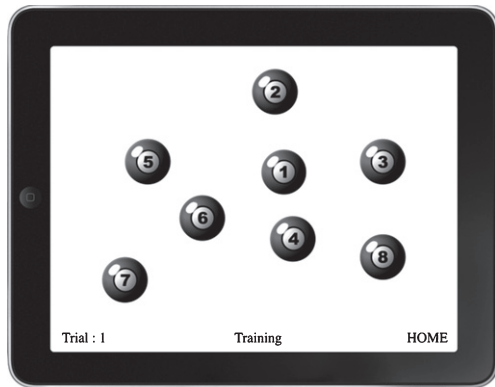


Fig. 1. The Multi-Item Localization task (MILO).

They are the only validated cut-off values, but analysis in this study using the full-scale scores yielded the same pattern of results. These cut-offs are based on the first 12 CCI items (out of 20) which relate to perceived memory concerns. Therefore, individuals are believed to be experiencing memory concerns if they score 20 or above on the first 12 items of the CCI-S.

Statistical analysis

MILO generates data-rich results due to its multiple-trial format, thus individual RT values can be provided for each item. MILO can for instance provide data relating to the time taken to touch the first virtual pool ball (RT1), also the cumulative time it takes to touch the second pool ball (RT2) and so on, until all eight virtual pool balls have been touched (overall time is RT8). Within the current study, the measure of how quickly an individual touches all eight balls and completes the trial (RT8) was employed within the statistical analysis. As mentioned earlier, in this study, there were 30 trials in the MILO test. Therefore, the median value of RT8 was calculated for the statistical analysis of between-group differences and within-group correlations. The IIV_{RT} in relation to these 30 trials was also calculated and statistically analyzed as interquartile range (IQR).

Overall, based on Kolmogorov-Smirnov analysis the data (i.e., on the CCI, TMT A, TMT B, MILO, MoCA, HVL, ROCF, WHOQOL-BREF, HADS, and the BFI) were not normally distributed despite score transformations, therefore non-parametric analysis was applied. This lack of normality can be typical of such studies and therefore

the use of non-parametric tests is common (e.g., see [31, 32]). To determine group differences (between the SCI and non-SCI group), the Mann-Whitney test was employed for continuous data and the Chi Square test was employed for categorical data. Furthermore, correlations (within-group relationships) between all test battery scores were analyzed using non-parametric Spearman's correlation coefficient. Due to the multiple comparisons being investigated in some of the correlational analyses, the Bonferroni correction method was used in order to control for the possibility of type-one errors.

RESULTS

Hypothesized *a priori* predictions were made and therefore one-tailed analyses were run and reported below. For completeness the analysis at a two-tailed level was also carried out, but there were only scant and minor differences between these two sets of analyses.

As can be seen in (Table 1), no significant participant characteristic group differences (i.e., age and years in education) were identified apart from for the CCI scores (which was the means by which the groups were divided [CCI-S]) [71].

Figure 2 (non-SCI group) shows the distribution of scores on the CCI-S measure from 10 (lowest possible score) to 19 (highest possible score before the SCI group cut-off score of 20). Figure 3 (SCI group) shows the distribution of scores on the CCI-S measure from 20 (lowest possible score cut-off value) to 60 (highest possible score on the CCI-S measure).

Subjective cognitive impairment, information processing speed, and variability

Processing speed (RT) and IIV_{RT} in SCI and non-SCI

We predicted that compared to people with no cognitive complaints, individuals with SCI (as defined by CCI scores) will have slower information processing speed (RT) with respect to TMT A, TMT B, and MILO, and greater IIV_{RT} with respect to the MILO test, than individuals without SCI. Statistical analysis however failed to reveal any significant differences between groups on information processing speed with respect to TMT A, TMT B, MILO RT scores, or MILO IIV_{RT} scores (all *p*-values >0.05) (see Supplementary Table 1 for detail).

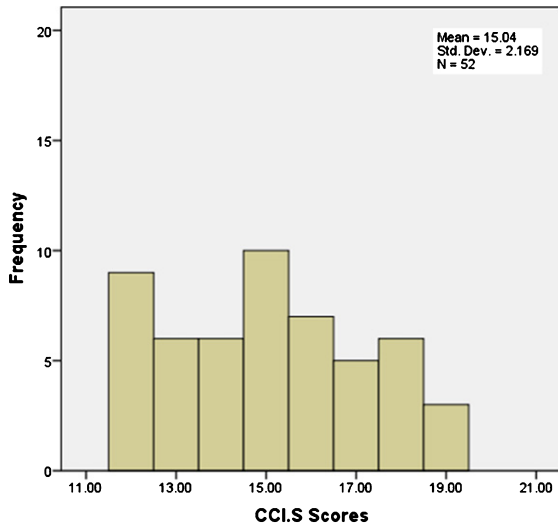


Fig. 2. Distribution of CCI-S scores within the non-SCI group.

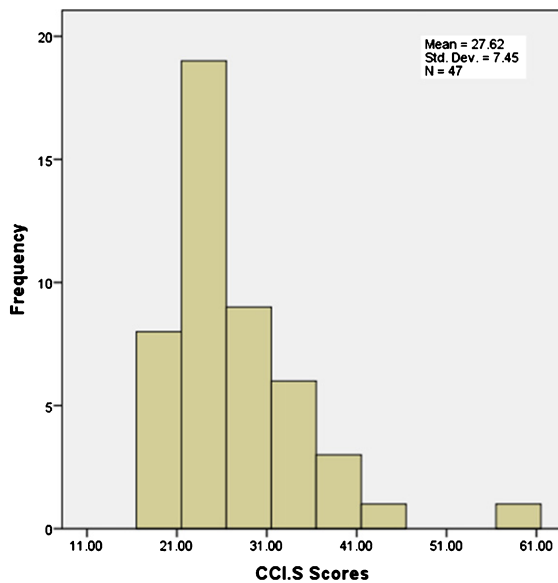


Fig. 3. Distribution of CCI-S scores within the SCI group.

Within-group relationships

There were no significant within-group correlations between CCI-S scores, RT, and IIV_{RT} in the non-SCI group (all *p* values >0.05) (see Supplementary Table 2 for details). Within the SCI group, however, the time taken to perform TMT B was significantly positively correlated to CCI-S score, i.e., the higher the CCI-S score (indicating worse perceived cognitive functioning), the slower the RT ($r_s = 0.35$, *p* (1-tailed) <0.01) (Fig. 4). Furthermore, within the SCI group, a significant positive correlation between

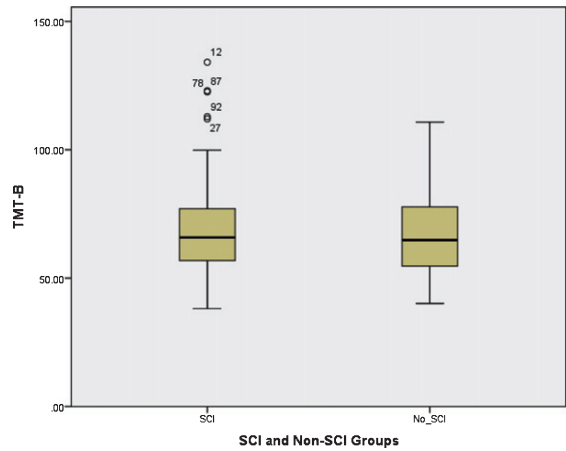


Fig. 4. Distribution of TMT B scores in the SCI and non-SCI group.

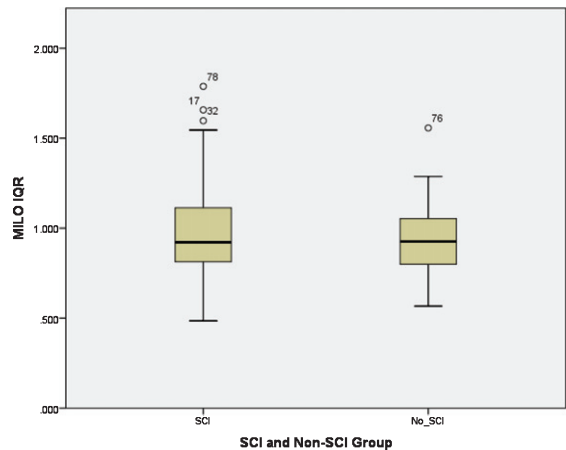


Fig. 5. Distribution of MILO IIV_{RT} scores in the SCI and non-SCI group.

CCI-S scores and MILO IIV_{RT} ($r_s = 0.34$, *p* (1-tailed) <0.01) was revealed (i.e., worse perceived cognitive functioning was related to greater RT variability) (Fig. 5). This remained significant after Bonferroni correction (*p* = 0.010). Figures 4 and 5 also reveal that a proportion of individuals showed disproportional slowing (RT) and greater variability (IIV_{RT}) only in the SCI group. This is shown by the outliers in RT and IIV_{RT}, which appear in the SCI group only.

Subjective cognitive impairment, general cognitive functioning, depression, anxiety, QOL, memory, and neuroticism

Between-group differences

There were no significant differences in performance on general cognitive functioning, visual

and verbal memory, or the social relationship QOL sub-scale (all p values >0.05) between the SCI and non-SCI groups (see Supplementary Table 3 for details). However, there were significant differences between these two groups regarding physical ($U=709.00$ ($Z=-3.63$), $p<0.01$), psychological ($U=728.50$ ($Z=-3.51$), $p<0.01$), and environmental ($U=764.50$ ($Z=-3.26$), $p<0.01$) QOL (all moderate effect size). There were also significant differences on anxiety ($U=670.50$ ($Z=-3.881$), $p<0.01$; Cohen's effect size: -0.39 moderate), depression ($U=806.00$ ($Z=-2.947$), $p<0.01$; Cohen's effect size: -0.30 moderate), and neuroticism ($U=822.00$ ($Z=-2.809$), $p<0.01$). Overall, the SCI group demonstrated poorer perceived physical, psychological, and environmental QOL; poorer scores on anxiety and depression; and higher levels of neuroticism respectively compared to the non-SCI group.

Within-group relationships

There were no within-group correlations in the non-SCI group between CCI-S scores and any of the variables (i.e., general cognitive functioning, memory, QOL, anxiety, depression, and neuroticism). However, in the SCI group, there were within-group correlations between CCI-S scores and performance on visual ($r_s=-0.38$, p (1-tailed) <0.01) and verbal ($r_s=-0.34$, p (1-tailed) <0.05) memory, physical ($r_s=-0.30$, p (1-tailed) <0.05), psychological ($r_s=-0.37$, p (1-tailed) <0.01), and environmental ($r_s=-0.24$, p (1-tailed) <0.05) QOL, anxiety ($r_s=0.39$, p (1-tailed) <0.01), depression ($r_s=0.45$, p (1-tailed) <0.01), and neuroticism ($r_s=0.26$, p (1-tailed) <0.05). Thus, within the SCI group, poorer CCI-S scores were correlated with poorer visual and verbal memory; poorer physical, psychological, and environmental QOL; worse anxiety and depression; and higher scores on neuroticism. However, after Bonferroni correction on the QOL sub-scales, the only significant within-group correlation to remain was in relation to psychological QOL.

Further analyses: Subjective cognitive impairment, slower information processing speed (RT: TMT B), greater IIV_{RT}, worse levels of anxiety and depression in the SCI group

The only measure of information processing speed (RT) that was significantly correlated with CCI-S scores in the SCI group was TMT B. Also, in relation to variability, IIV_{RT} was significantly correlated with CCI-S scores in the SCI group. Therefore, fur-

ther analyses were run to investigate whether TMT B and IIV_{RT} performance was significantly related to anxiety and depression.

Statistical analysis revealed that IIV_{RT} was not significantly related to anxiety ($r_s=0.20$, $p>0.05$) or depression ($r_s=0.04$, $p>0.05$) scores. In relation to RT, a significant positive correlation was identified between higher scores on anxiety and poorer TMT B score (higher score, i.e., slower information processing speed) ($r_s=0.34$, p (1-tailed) <0.01) in those with SCI. This suggests that worse anxiety symptoms are associated with slower information processing with respect to TMT B test performance and worse scores on the CCI-S measure (i.e., slowing associated with greater perceived feelings of poor cognitive functioning). After Bonferroni correction (α level $0.05/2=0.025$), this remained significant ($p=0.010$). In addition, statistical analysis revealed that there was no significant correlation between TMT B and depression ($r_s=0.15$, p (1-tailed) >0.05).

DISCUSSION

The aim of this study was to examine visual attention-related processing speed (RT), the intra-individual variability of reaction time (IIV_{RT}), general cognitive functioning, memory, depression, anxiety, quality of life, and neuroticism in SCI in order to improve knowledge of its characteristics and thus of its potential signs and symptoms.

Contrary to our prediction that individuals with SCI would show greater slowing in information processing speed (RT) and greater IIV_{RT} variability compared to those without SCI, there was no significant difference in mean RT or IIV_{RT} between these groups, with respect to the TMT A and B or the MILO test. SCI *per se* does not therefore appear characterized by slowing and raised IIV_{RT}. However, within-group investigation revealed that in the SCI group only was a proportion of individuals showing disproportional slowing (RT) and greater variability (IIV_{RT}). This is clearly demonstrated by the outliers in RT and IIV_{RT}, which are present only within the SCI group. For some individuals therefore, SCI is associated with slowed and/or more variable information processing speed and some individuals with SCI may therefore experience greater deficits in behaviors and activities of daily living associated with such measures (e.g., driving [25]). Furthermore, again for the SCI group only, CCI-S scores were significantly correlated with TMT B performance, not with TMT

A, and MILO RT. Such a pattern of results indicates that although slowing (with respect to certain tasks and therefore brain processes recruited) may be related to psychological differences (e.g., anxiety), it may also represent a predictor of further decline as slowed RT and increased IIV_{RT} can be characteristics of MCI and AD [31–40]. However, the cross-sectional design of the current study precludes such analysis.

As predicted, levels of anxiety, depression, and neuroticism were significantly greater in the SCI compared to the non-SCI group, and QOL (all forms) was significantly poorer in the SCI group. Again, in the SCI but not the non-SCI group, CCI-S scores were significantly correlated with visual and verbal memory, anxiety, depression, physical, environmental, and psychological QOL.

This suggests that some individuals with SCI can be disproportionately slowed and variable in their responses indicating that individuals with SCI should be investigated beyond the findings of general objective outcome in currently used psychological tests. These results further highlight the need for a stratified and person-centered approach to SCI, rather than simply comparing effects at group level particularly with respect to its possibly detrimental influence upon an individuals' daily life and its potential to represent early neurodegenerative disease.

Level of SCI, MoCA score

To reiterate, the population sample in the present study was not a clinical one but represented instead those living within the community who experience poorer perceived cognition but do not approach memory services or general practitioners about it. As can be seen in (Fig. 3), the distribution of CCI-S scores in the SCI group is positively skewed, i.e., scores are loaded close to the group cut-off point (i.e., towards the non-SCI group distribution scores). This skewed distribution may represent the fact that individuals in the study tended to experience relatively low levels of cognitive decline compared to those who approach memory services or their GP and this fact could provide an explanation for the lack of significant group differences (SCI and non-SCI) in relation to TMT A, TMT B, MILO RT, and MILO IIV_{RT} scores.

Importantly, the main group-differences and within-group correlations previously summarized were evident despite normal MoCA scores indicating that SCI should not be dismissed as unimportant by testing and diagnosis based solely on general cog-

nitive screening tools. This is further supported by the results of Reisberg et al. [2] which revealed that 54% of individuals with SCI declined to MCI or AD but that the average Mini-Mental State Examination [82] baseline scores for those who declined was 29 out of a maximum 30. In a clinical setting therefore, individuals with SCI, who would typically score normally on such measures, would most likely have been precluded from further investigation and follow up (see Jenkins et al. [28]).

Memory

As predicted, in the non-SCI group there were no significant correlations between CCI-S, HVL (verbal), and ROCF (visual) scores. In the SCI group, however, both the HVL and ROCF scores were significantly negatively correlated with CCI-S scores. The correlation between ROCF and CCI-S scores was stronger and had a greater effect size than that between HVL and CCI-S scores. These results suggest that within the SCI group greater degrees of subjective impairment are associated with poorer visual/non-verbal memory and verbal recognition. This finding provides support for past research (i.e., see [83–85]) indicating that impairments in episodic memory are characteristic of SCI, although there are also inconsistencies in such research findings [86].

Neuroticism

Neuroticism was significantly greater in the SCI compared to the non-SCI group. Furthermore, within the SCI, but not the non-SCI group, neuroticism was significantly correlated with CCI-S score. These results are in alignment with those of Ausen et al. [66] in that a high level of neuroticism may represent a risk factor for experiencing cognitive impairment and for further decline [54, 66, 69].

Affective symptoms

As expected, anxiety and depression (specifically sub-clinical depression, thus low mood) scores were significantly poorer for the SCI compared to the non-SCI groups. Within the SCI group only, CCI-S score (i.e., poorer SCI scores) was significantly correlated with both higher levels of anxiety and depression (sub-clinical) [8], although directional causality [25, 62, 88–92] could not be ascertained in the current study.

Affective symptoms, RT and IIV_{RT}

Further analyses were run on the significant relationship found between anxiety and TMT B performance. A significant positive correlation was found between TMT B performance and anxiety, thus slower RT was associated with greater levels of anxiety indicating that processing speed on the TMT B could be associated with anxiety for those in the SCI group. No significant correlation was found between TMT B performance and sub-clinical depression scores. Despite the commonly identified co-morbid relationship between anxiety and depression [60], these results indicate that anxiety may have more impact on RT compared to depression. The identified increase in negative affective symptoms and related slowing in the SCI group supports the recommendation by Jessen et al. [21] to not dismiss such sub-threshold symptoms, to ensure they are considered when assessing for cognitive decline (specifically SCD).

Quality of life

After Bonferroni correction, only psychological QOL was significantly correlated with CCI-S scores within the SCI group, thus indicating that SCI may be particularly associated with psychological factors, again of course causality cannot be determined here [23, 24]. Also, our finding of significantly higher levels of anxiety in the SCI group is in agreement with Strine and colleagues [93] who found that individuals with higher levels of self-reported anxiety were more likely to have poorer levels of health-related QOL [93]. Therefore, there may be an association between poor SCI, poor anxiety, and poor QOL.

Despite the inability to determine causality and loss of post correction significance, what the current study does highlight is that a characteristic of SCI is a diminished sense of psychological QOL. To conclude, a number of variables measured appeared to characterize SCI in comparison to those without SCI. At group level, individuals with SCI were more likely to have higher scores on anxiety, depression (specifically low mood), and neuroticism, together with worse perceived physical, psychological, and environmental QOL. Correlational analysis identified no significant relationships between any of the variables within the non-SCI group. However, in the SCI group, there were a number of meaningful correlations identified with CCI-S data, thus, RT (TMT B) and IIV_{RT} (MILO), verbal memory, non-verbal/visual memory,

anxiety, depression (specifically low mood), neuroticism, and QOL.

Study limitations and future research

It is questionable whether a larger sample would have produced similar or different results. The sample size was determined based on past research studies of attention related RT tests, in MCI and AD, with typical numbers approximately between 20 and 30 participants. Since the relationship between SCI and RT (in the general public) has not been investigated using such studies and because the effects in SCI may be smaller than in MCI and AD, the number of participants in the present study was increased in each group to 50.

The fundamental aim of this study was to highlight potential SCI characteristics in a normal population and irrespective of etiology, and its cross-sectional design thus rendered it impossible to determine causal relationships and any relationship between the findings and the development of MCI or dementia, or the successful treatment of SCI. These are areas for further and longitudinal investigation; factors beyond the scope of the present study [23, 94].

This study has provided a valuable contribution to research regarding the characterization of SCI in the general population. It is clear that despite the sample having a low level of cognitive impairment, they were still reporting poorer scores in relation to anxiety, depression, and QOL. Regardless of whether the SCI symptoms are a cause or consequence of such distress, their cognitive concerns should not be dismissed as benign. Thus, appropriate SCI management might enable potentially reversible symptoms to be treated (e.g., psychological difficulties), therefore not only possibly alleviating SCI symptoms but also decreasing the risk of further cognitive decline [60].

DISCLOSURE STATEMENT

Authors' disclosures available online (<https://www.j-alz.com/manuscript-disclosures/18-0810r3>).

SUPPLEMENTARY MATERIAL

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