Self-awareness of cognitive efficiency: differences between healthy elderly and patients with Mild Cognitive Impairment (MCI)

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Abstract

Introduction: Self-estimation of performance implies the ability to understand one's own performance with relatively objective terms. Up to date, few studies have addressed this topic in Mild Cognitive Impairment (MCI) patients. The aim of the present study was to compare objective measures of performance with subjective perception of specific performance on cognitive tests and investigate differences in assessment between MCI patients and healthy elderly. *Methods:* Thirty-five participants diagnosed with MCI (women=16, men=19, mean age=65.09 years ±SD=7.81, mean education=12.83 years ±SD=4.32) and 35similar in terms of age and education control subjects (women=20, men=15, mean age=62.46 years ±SD=9.35, mean education=14.26±SD=2.84) were examined with an extended battery of neuropsychological tests. After every test they were asked to self -evaluate their performance by comparing it to what they considered as average for people of their age and educational level. This self-evaluation was reported on a scale ranging from -100 to +100. *Results:* Significant differences were found in the self-assessment patterns of the two groups in memory measures of verbal and visual delayed recall, visuospatial perception and tests of attention. MCI patients overestimated their performance on every cognitive domain while control participants underestimated their performance on measures of verbal memory. *Conclusions:* The present results indicate that accuracy of self-report is not uniform across groups and functional areas. The discrepancies in the MCI patients indicate unawareness of their memory deficits which is contradictory to subjective memory complaints as being an important component for clinical diagnosis.

***Keywords*:** Self-awareness; Self-assessment;Cognitive assessment;Mild Cognitive Impairment

INTRODUCTION

Defining self-awareness

Self-awareness is a term used in clinical settings to describe the inherent ability that a person has to estimate his state in an accurate and objective manner. Due to the complex and multidimensional nature of the term a widely accepted definition has not yet been developed, resulting in a variety of concepts used differently across the literature.

Etymologically, impaired self-awareness represents a failure to acknowledge or be aware of any physical or mental disorder (Prigatano, 2010). The specific concept has been regarded as a less severe form of anosognosia, which is considered to be "a disorder of human consciousness that negatively impacts the patient's ability to subjectively experience a loss of an impaired neurological or neuropsychological function" (Prigatano, 2009, p. 2). According to this definition, Ries et al. (2007) have also described impaired self-awareness in the context of higher cognitive functions as a decreased ability to accurately evaluate performance on memory or cognitive tasks.

Among the existing definitions, self-awareness has also been described as "insight" (Ready, Ott, & Grace, 2006) and "metacognition" (Cosentino & Stern, 2005) referring to different aspects of the term integrating a variety of cognitive and metacognitive variables, such as autobiographical memory, semantic knowledge and cognitive control (Morris & Mograbi, 2013).

Evaluation methods

In order to evaluate self-awareness, three main methodological approaches are commonly used: (1) ratings of awareness according to the opinion of a specialized clinician, (2) level of agreement between the patient and an informant on questionnaires/scales assessing domains

relevant to self-awareness and (3) level of agreement between subjective rating and actual performance on a specific task. Every methodological approach has been used either separately or in combination with each other, contributing with their distinctive advantages and disadvantages to the investigation of self-awareness (Clare, 2004; Roberts, Clare, & Woods, 2009).

Self-awareness in Alzheimer's Disease

Self-awareness in Alzheimer's disease has long been established as an interesting field of investigation. Among the existing literature concerning self-awareness in the AD population, two main assumptions can be drawn: (a) self-awareness is associated with disease severity, indicating that patients with higher levels of cognitive impairment may exhibit greater signs of unawareness of their deficits (Aalten, Van Valen, Clare, Kenny &Verhey, 2005; Barrett, Eslinger, Ballentine, & Heilman, 2005; Kazui et al. 2006; Smith, Henderson, McCleary, Murdock, & Buckwalter, 2000) and (b) self-awareness is not a unitary phenomenon but rather, it can vary across cognitive and functional domains (Clare, Marková, Verhey, & Kenny, 2005; Cosentino & Stern, 2005; Howorth & Saper, 2003; Marková & Berrios, 2001; O'Connell, Dal Bello-Haas, Crossley, & Morgan, 2014; Okonkwo et al., 2009). For example, Starkstein, Sabe, Chemerinski, Jason, & Leiguarda (1996), identified a different pattern of unawareness in a group of AD patients for cognitive and behavioural symptoms while another study by Barrett et al. (2009) demonstrated unawareness of cognitive abilities in particular cognitive domains, namely memory and visuospatial perception in the specific clinical group.

Self-awareness in Mild Cognitive Impairment

Mild Cognitive Impairment (MCI) is generally considered to be the transitional stage between normal aging and Alzheimer's disease (AD) (McKhann et al., 2011). According to the Petersen criteria (Petersen & Morris, 2005), the presence of memory complaints is essential for

the diagnosis of amnestic MCI, along with memory impairments, preserved general cognitive functions and activities of daily living and the absence of dementia.

Due to the high variability among the clinical symptoms in MCI, recent research has demonstrated the need to establish a multidimensional approach to evaluating the clinical symptoms of MCI. Therefore, the latest diagnostic criteria have also introduced the concept of affective symptoms and of subtle functional decline in more complex activities as essential components for the diagnosis of MCI (Albert et al., 2011; Bondi & Smith, 2013; Lyketsos et al., 2002).

However, the research question regarding the level of awareness in MCI patients as regards their cognitive and functional limitations is an open research issue and the existing studies have not yet reached a consensus (Nobili et al., 2010; Roberts, et al., 2009; Tremont & Alosco, 2011).

According to several investigators, *pro rata* with the emergence of anosognosia in the course of AD pathology, a certain level of impaired self-awareness may be present in the MCI population as well, but with a less prominent and conspicuous clinical phenotype (Orfei et al. 2010; Ries et al., 2007; Vogel et al.,2004).

Self-evaluation of memory ability in MCI

One of the main clinical concerns regarding the diagnosis of MCI is the validity of Subjective Memory Complaints (SMC) as a useful screening criterion. Most of the studies addressing self-awareness in the MCI population have focused on the self-evaluation of memory performance, both in everyday life and during cognitive testing and have proceeded to direct comparisons between the aforementioned estimations and SMC (Cook & Marsiske, 2006; Galeone, Pappalardo, Chieffi, Iavarone, & Carlomagno, 2011; Hanyu, Sakurai, & Iwamoto,

2007; Perrotin, Belleville, & Isingrini, 2007; Prigatano et al., 2014; Purser, Fillenbaum, & Wallace, 2006; Vogel, Hasselbalch, Gade, Ziebell, & Waldemar, 2005).

For example, Galeone et al. (2011) examined the self-evaluation of memory abilities of patients with MCI in both everyday settings and under objective testing. As the authors report, MCI patients initially overestimated their memory performance in both settings, but they also failed to re-appraise their evaluation in their memory capabilities estimations even after multiple confrontations with the same objective memory testing, in contrast to the control group who adjusted their responses accordingly. Another study by Prigatano et al. (2014) demonstrated the inability of a group of MCI patients to accurately predict their memory performance after distraction, reinforcing the hypothesis of impaired self-awareness in the MCI population.

From the studies examining metamemory processes in the clinical group of MCI, several authors agree on the notion that a certain level of discrepancy arises between informant reports or objective assessment and subjective estimations of memory performance by the patients (Frank, Lenderking, Howard, & Cantillon, 2011; Galeone et al., 2011; Perrotin et al., 2007; Spalletta et al., 2014; Vogel et al., 2005). On the contrary, few studies support the view that MCI patients do not significantly differ from healthy controls in their self-evaluation capacity (Clement, Belleville, & Gauthier, 2008; Crowe et al., 2006; Farias, Mungas, &Jagust, 2005). For example, Farias et al. (2005), reported that, in contrast to AD patients, the examined MCI group did not differ from their informants in the ratings obtained from the Daily Function Questionnaire (a questionnaire assessing activities of daily functioning in comparison to ten years ago with enhanced focus on memory outcomes of everyday life). However, the questionnaire utilized by the specific study allows only for a 3-point categorization of reply (1=same or better, 2=little worse, 3=a lot worse). Taking under account that patients with MCI may exhibit only subtle changes in their functional abilities of everyday life (Albert et al., 2011),

the aforementioned scoring system could be considered as not sensitive enough for detecting signs of self-evaluation difficulties in the specific clinical group.

The role of executive functioning on the self-evaluation process

According to Panuu & Kaszniak (2005), the inaccurate self-evaluation of memory is linked to executive dysfunction by viewing this metacognitive function as one of the cognitive processes that are controlled by the prefrontal cortex (Amariglio et al., 2012; Gallo, Cramer, Wong, & Bennett, 2012; Johnson et al., 2007). Along this line, Morris and Mograbi (2013) introduced the term *executive anosognosia*, which refers to a failure to monitor and acknowledge cognitive errors as they may occur during the execution of a cognitive task. However, despite the main role of the executive system on self-evaluation processes, the assessment of self-awareness regarding executive functioning in particular has not been sufficiently examined (Carmasin, 2015). Up to date, research on the self-evaluation process regarding aspects of the executive functions has focused solely on indirect measures through the following areas: (a) evaluation of activities of daily living (b) evaluation of driving fitness, (c) finance management and (d) error monitoring (Amanzio et al., 2013; Galeone et al., 2011; O'Connor, Edwards, & Bannon, 2013; Okonkwo et al., 2009; Suchy, Kraybill, & Franchow, 2011).

For example, Okonkwo et al (2009), in a study investigating self-awareness in different functional domains, showed that patients with MCI were significantly more inaccurate in their estimates of performance on a task measuring financial capacity compared to a control group, demonstrating some degree of distorted self-awareness among MCI patients. They also identified a trend of overestimation of their driving abilities without this amounting to a statistical significance. According to the aforementioned results, the authors concluded that self-awareness in not a unitary phenomenon but rather it can differentiate across cognitive and functional domains.

Aims

The purpose of this study was to investigate the level of awareness regarding cognitive capacities in healthy elderly and MCI patients by comparing objective results in a broad variety of neuropsychological tasks with the participants' subjective perception regarding their level of performance. In our study, the term self-awareness is used to describe the ability of an individual to evaluate and accurately judge their performance on cognitive tasks by comparing it to the average performance of individuals of a similar age and educational background. Based on the findings of previous research which indicates that patients with MCI exhibit certain difficulties in the self-evaluation of their cognitive skills, we hypothesized that MCI patients would demonstrate impaired self-awareness in several cognitive domains in comparison to their healthy counterparts. In order to explore this hypothesisthoroughly, we used a novel procedure for quantifying the levels of self-awareness that were applied to a broad series of neuropsychological tests that cover multiple cognitive domains, namely memory, executive functioning, attention and visuospatial perception. In addition, in order to gain a deeper and more comprehensive understanding of this phenomenon, we investigated whether participants with MCI would demonstrate a pattern of overestimation or underestimation of their performance in comparison to the objective results.

METHOD

Participants

Subjects were seen at the Cognitive Disorders/Dementia Unit at the 2nd Department of Neurology at NKUA "Attikon" University General Hospital in Athens. Thirty-five participants referred to our Unit for evaluation and diagnosed with amnestic MCIwere included in the study (women=16, men=19, age:*M*=65.09, *SD*=7.81, education: *M*=12.83, *SD*=4.32). Diagnosis of

MCI was based on the following: (a) verification of an amnestic MCI symptomatology according to the Petersen criteria (2004) which involve concerns about change in memory capacity verified by an informant, objective memory impairment for the patient's age, preserved functional activities of daily living and absence of dementia, (b) a score in the Clinical Dementia Rating Scale (CDR)=0.5 (Morris, 1993) and (c) the exclusion of secondary causes of cognitive impairment such as tumors, metabolic disorders etc. Participants had no premorbid history of neurological or psychiatric conditions. Thirty-fivecontrol subjects similar in terms oftheir demographic characteristics (age, education, gender and occupational status: independent samples t-test, $p > .05$, n.s.) also participated in this study (women=20, men=15, age: M=62.46, SD=9.35, education: M=14.26, SD=2.84) without any present or past cognitive, neurological or psychiatric conditions.

Procedure

The current study was approved by the ethics committee of "Attikon" University General Hospital. Before the beginning of every evaluation, informed consent was obtained from all subjects and they were informed that their cognitive abilities such as memory, attention and speech would be tested.

In the current study, a battery of 11 neuropsychological tests was administered assessing: (a) *general cognitive ability* (Mini Mental State Examination /**MMSE** [Folstein, Folstein, & McHugh, 1975]), (b) *attention* (Driving Scenes Test – Neuropsychological Assessment Battery / **NAB** [Stern & White, 2003], Useful Field of View / **UFOV** [Ball & Owsley, 1993], Psychomotor Vigilance Test / **PVT**; The specific version of the test is free ware and is retrieved from the Sleep Disorders Centre at Florida, USA and Trail Making Test - Part A / **TMT_A** [Reitan, 1979]), (c) *learning and memory* (Hopkins Verbal Learning Test – Revised / **HVLT_R** [Benedict, Schrelten, Groninger & Brandt, 1998], Brief Visuospatial Memory Test – Revised/ **BVMT_R** [Benedict,

1997]), (d) *visuospatial perception and constructional ability* (Judgment of Line Orientation Test / **JLO** [Benton, 1994], Clock Drawing Test / **CDT** [Strauss, Sherman & Spreen, 2006]) and (e) *executive functions* (Trail Making Test – Part B / **TMT_B** [Reitan, 1979]).

Awareness and evaluation of deficit

After the completion of every test the participants were asked to self-evaluate their performance by comparing it to what they considered as average for people of their age and educational level. This self-evaluation was reported on a scale ranging from -100 to +100 with 10-point intervals, expressed as percentages,as shown in Figure 1.

Figure 1.

If the participant believed that he had performed better than others, he chose a score between +10 and +100 (where +100 stood for "much better"), if he believed he had performed worse than others he chose a score between -10 and -100 (where -100 stood for "much worse") and if he believed that his performance reflected average performance he marked the number 0 (zero).

The 10-point intervals of the scale were used in order to offer the possibility for a detailed quantification of the performance as well as to facilitate the detection of smaller or larger subjectively perceived differences from objective performance.

Specifically, when administrating the scale a set of standardized guidelines were provided to the participants. Initially, the scale was presented in a A4 card (Figure 1) and participants were asked to rate their performance in comparison to other individuals of their own age and educational level according to the following instructions: "in comparison to other people of your own age and educational level did you perform the same, better or worse than the average in the particular test?". If they responded "the same" we instructed them to underline the response under the number zero and we further explained that it represented an average performance. If

they responded “better/worse” we asked them to quantify more their estimated performance by addressing them with the following question: “from a scale of 10 to 100 how much better/worse do you think you performed in comparison to other people of your own age and educational level if we assume that values between 10-20 represent only a slightly better/worse performance, values between 50-60 represent a moderately better performance and values between 90-100 represent a far better/worse performance than the average person?” We insisted that the number 100 did not stood for a perfect/worst possible performance according to the test’s scoring system but it represented a performance that was at a quantitative level strikingly better or worse thanthe performance of the average person.

When necessary, we offered additional specialized examples linked to a particular test. For example in the HVLT test, if we detected a certain difficulty in answering this scale we asked the following question in order to facilitate their response: “do you believe that you remembered the same number of words as other people of your own age and educational level?”. We were constantly monitoring the capacity of the participant to comprehend the self-evaluation procedure and repeated the instructions when this was deemed necessary (e.g. in signs of uncertainty as concern their response). If a participant was unable to comprehend the concept of the scale despite the examples given, they were excluded from the study. Regarding the MCI group that was investigated in the present study, due to the mild nature of the cognitive deficits that were present, we did not experience any major difficulties with the comprehension of the scale and all participants belonging in the initial pool completed the testing process. The same holds true for the participants of the control group, who did not demonstrate any signs of misinterpretation of the scale.

In assessing the capacity of the participants to accurately evaluate their performance, an Awareness Index (AI) was developed as an outcome measure. This AI was calculated by computing the difference for each participant between subjective and objective performance

expressed in percentiles (Figure 2). An example of overestimation and underestimation of performance according to the AI are being also presented in the same figure.

Figure 2

If the AI was a positive value, the participant had made a false estimation by over-evaluating his performance, whereas if the outcome was negative the participant had made a false estimation by under-evaluating his performance. Finally, if the result of the index was close to zero the participant had made an accurate prediction of performance.

By following the aforementioned methodology, we utilized a detailed scale for detecting even mild self-awareness difficulties. Also, through this process, we were able to identify the direction of the difficulties which reflected the tendency of the MCI patients to overestimate their cognitive performance. Notably, these findings are in accordance with relevant research findings focusing on the self-awareness levels of AD patients (for example, Barrett et al., 2005). Finally, we focused on exploring self-awareness under novel situations such as the performance of cognitive tasks and not under familiar everyday situations. According to our view, exploring the specific component of self-awareness can be useful in order to detect very initial and subtle changes in functional and behavioral aspects of patients with MCI that could remain unnoticed through everyday life routines and probably delay diagnosis.

RESULTS

Demographic variables and performance on cognitive testing

The MCI group and the healthy elderly group were similar according to age, sex, educational level and occupational status.

Occupational status was assessed using the Greek adaptation of Hollingshead Four Factor Index of Socioeconomic Status (Hollingshead, 1975).

Table 1 presents the mean performance and standard deviations of the two groups on the neuropsychological tests that were included in the study.

Control participants performed better from the MCI group on MMSE [$t(68)= 2.95$, $p= .004$]. The control group also outperformed the MCI patients on functions of verbal and visuospatial memory ($p<.05$), attention ($p<.05$), executive functions (TMT_B: $t(68)= -3.46$, $p= .004$) and visuospatial perception (JLO: $t(68)= 2.09$, $p= .040$) [Table 1].

Table 1

In order to investigate whether the two groups showed discrepancies between objective and subjective performance, expressed in percentiles, paired samples t-test was conducted in each group separately for each test. From the results of the analysis, the control group presented some discrepancies between objective and subjective performance, but only in measures of verbal learning and memory. The MCI group presented significant discrepancies in most neuropsychological tests administered, with the exception of tests of immediate free recall of verbal and visuospatial information, a test of attention (UFOV) and reaction time tests. Independent samples t-test was also performed in order to examine differences of the AIbetween the two groups. Table 2 presents the neuropsychological tests that exhibit significant differences between objective and subjective performance for each group separately and the significant differences in the AI between the two groups.

Table 2

The analysis of the differences between the two groups shows that tests of memory, attention and visuospatial perception are those that exhibit the greater differences in the awareness index of the two groups.

A general tendency for overestimation of performance in the MCI group and for underestimation of performance in the control group was observed (Figure 3).

Figure 3

Specifically, MCI patients overestimated their performance on every neuropsychological test administered. On the other hand, control participants presented a more divergent profile by underestimating performance on memory tests, on more complex tasks of attention (Driving Scenes Test, UFOV-part 3) and on reaction time tests (Psychomotor Vigilance) and by overestimating performance on tests of visuospatial perception (JLO) and more simplified tests of attention and executive functions (TMT A&B, CDT).

We also investigated the MCI group for possible associations of the awareness index (AI) with the performance ona number of neuropsychological tests (memory, executive functions and attention)by utilizing a Pearson correlations analysis [Table 3].

Table 3

According to those findings, it appears that, in patients with MCI, higher AI (meaning a greater discrepancy between objective and subjective performance) was correlated with worse performance in all neuropsychological tests examined. Thus, lower awareness of cognition seems to be related to lower scores of neuropsychological measures.

DISCUSSION

The objective of this study was to assess the awareness of cognitive state in healthy elderly and patients with MCI by comparing performance on neuropsychological tests with the subjective perception of the specific performance for each cognitive domain examined. Our

results indicate that both control and MCI participants fail to evaluate their own performance correctly in a number of cognitive domains. However, these groups present a significantly divergent profile.

According to our results, patients with MCI present difficulties assessing their own performance in many cognitive domains. Specifically, when examining discrepancies between objective and subjective performance, we found that MCI patients exhibited significant overestimation errors in tests of episodic verbal and visuospatial memory, visuospatial processing, attention and executive functions. In addition, when the AI of each test was compared with a group of healthy elderly participants, a same profile of overestimation of performance was observed. In contrast, the group of healthy elderly exhibited good awareness in a broad spectrum of cognitive tests with the exception of tests evaluating verbal memory where they under-estimated their abilities.

Previous research on awareness of performance in the MCI population has drawn mixed results. In a review by Roberts et al. (2009), examining 16 studies that investigated the concept of awareness of impairments in patients with MCI, the authors concluded that there seems to be a great level of disagreement among researchers regarding the existence of impaired self-awareness in the MCI population, depending on the aspect of awareness investigated, the methods used and the sampling criteria. According to this review, there is some evidence that a degree of reduced insight in the MCI population exists (Kalbe et al., 2005; Okonkwo et al., 2009; Perrotin et al., 2007). So far, few studies have addressed the problem of awareness in both directions (overestimation or underestimation) (Farias et al., 2005; Kalbe et al., 2005; Okonkwo et al., 2009; Perrotin et al., 2007) with very different methodological designs extracting discordant results.

Along this line, a study by Galeone et al. (2011) demonstrated that patients with MCI, following the same pattern of responses as an AD group, systematically overestimated both their memory capabilities in everyday life and their prediction about their performance on a neuropsychological test assessing memory. The specific pattern remained unmodified even when they were required to revise their self-estimations after multiple memory assessments, where they insisted on overestimating their performance. The study investigated memory monitoring capabilities in the AD and MCI population and demonstrated that both groups failed to revise estimations about their future memory performance.

This pattern of findings may be indicative of a deficit in a specific process which involves the ability to observe and monitor performance on an ongoing task, identify probable indications of failure or success of the task at hand and consequently update previous self-estimations regarding the level of ability on executing the specific task correctly. Such a process utilizes a number of executive functions and therefore could be considered analogous to the one proposed by Morris & Mograbi (2013) who used the term *executive anosognosia* in order to describe a deficiency in successfully monitoring and identifying probable inconsistencies on the self-evaluation of cognitive abilities during the performance of a certain task. This metacognitive process appears to apply across cognitive domains and not only in the case of a specific cognitive function (Morris & Mograbi, 2013). In line with this view, are the findings of the current study that indicate a similar pattern of overestimation in the MCI patients in cognitive tasks of different modalities, namely of memory, executive functioning, attention and visuospatial perception.

Our finding that MCI patients overestimate their performance on cognitive tests is at first glance in contrast with the fact that cognitive complaints are one of the main clinical criteria required for the diagnosis of MCI. However, those complaints are associated with global memory judgments about an individual's memory functioning and are mostly derived from a

subtle estimation of non-optimal performance by the patient in his everyday activities. During neuropsychological testing, patients with MCI may have difficulties in applying these broader schemas in specific procedures and tasks that require ongoing evaluation and monitoring of performance by combining various cues and sources of information. Thus, they result in a different estimation of memory capabilities in comparison to their everyday reports.

MCI symptomatology, especially of the amnestic subtype, which is the most common form of MCI, has been mostly attributed to an underlying AD pathology (Dubois et al., 2014). For example, a study by Lehner et al., (2015) evaluating multiple clinical groups (MCI, AD and patients with Parkinson's disease) regarding their memory self-estimations on everyday activities in comparison to objective memory tests, demonstrated that the MCI group examined followed a similar pattern of responses as the AD group and failed to evaluate their performance on the memory testcorrectly. Another observation however was that, the subgroup of amnestic MCI made significant overestimation errors on their performance in accordance to the AD group while on the contrary, the subgroup of non-amnestic MCI presented a tendency to underestimate their performance. Such findings enhance the hypothesis that impaired self-awareness in MCI may indeed share common ground with the pathological mechanisms observed in AD and result in similar clinical observations of impaired self-awareness, anosognosia and denial of deficits in the particular group (Clare et al., 2013; Nobili et al., 2010).

On the other hand, studies investigating self-assessment of performance in the AD population have shown that lack of self-awareness tends to increase as the disease progresses (Aalten et al., 2005). Other studies also note that unawareness of deficits can also serve as a harbinger for later development of dementia (Hannesdottir & Morris, 2007; Ries, et al., 2007; Tabert et al., 2002). A recent study investigating underlying neuropathological mechanisms of impaired awareness in MCI groups in relation to probable conversion to AD, reported that the level of self-awareness for memory abilities at baseline was lower at the group that later

converted to the disease. What is more, a different pattern of grey matter volume loss was identified in this particular group through follow-up evaluations for 5 years in comparison to the group that remained stable during this period (Spalletta, et al., 2014). Similar findings were also found in a study by Nobili et al. (2010), where an increased pattern of hypometabolism was observed on an MCI group that was rated as unaware of their cognitive deficits. According to the authors, those findings are indicative of an underlying AD pathology and MCI patients with impaired self-awareness may be at increased risk for developing dementia. It should be noted, however, that in the MCI group their inability to accurately self-evaluate themselves is not as prominent or consistent as in the AD population (Okonkwo et al., 2009; Vogel et al., 2005).

In our study, a correlation between the AI in the MCI group and neuropsychological tests assessing memory, executive functions and attention was also found, indicating that as the discrepancy between objective and subjective assessment increases, performance on the particular neuropsychological tests is significantly worse.

In respect to previous research, our finding that greater discrepancies in the AI were correlated with lower performance on neuropsychological tasks that are sensitive to the detection of cognitive impairments associated with an underlying AD pathology, may suggest that persons with greater difficulties in assessing their own performance may be at greater risk for developing dementia.

In conclusion, our study suggests that patients with MCI exhibit low awareness of cognition deficits, compared to healthy elderly controls. This finding may indicate that low awareness, which is usually found in patients with dementia (Perrotin et al., 2015; Zamboni et al., 2013) is not exclusive to more severe levels of cognitive impairment but may also exist in pre-dementia stages when mild cognitive deficits arise. In our study, we used a systematic methodology in order to compare objective and subjective performance in patients with MCI and healthy elderly

individuals. We found that MCI patients showed impaired levels of awareness by overestimating their performance and that the level of reduced awareness is related to the level of the cognitive deficit.

The current study had as goal to further our insight by studying the capacity of MCI patients to self-evaluate their performance on various, relatively novel, cognitive tasks that assess a variety of cognitive domains. However, self-awareness is a multidimensional construct and a limitation of this study could be considered the absence of measures of self-awareness focusing on common everyday activities that would provide the capacity to explore self-awareness from a broader perspective. In addition, future research regarding self-awareness in the MCI population could focus on clarifying the probable distinct effect of the various types of MCI on the self-evaluation process and whether individuals with amnestic MCI demonstrate more prominent signs of impaired self-awareness in contrast to MCI patients without specific indications of AD neuropathology. Also, by taking the behavioral and affective symptoms which commonly appear in patients with MCIinto account, future studies could expand our knowledge by studying self-awareness through this viewpoint as well (Prigatano et al., 2014). Finally, another issue that needs to be mentioned is that in order to control the general intellectual capacity of the groups we compared patients with MCI and healthy controls that had similar educational and occupational orientation. In this direction, the inclusion of a comprehensive measure of premorbid intelligence would have been beneficial for strengthening the outcomes of the present research.

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REFERENCES

Aalten, P., Van Valen, E., Clare, L., Kenny, G., &Verhey, F. (2005). Awareness in dementia: a review of clinical correlates. *Aging &Mental Health, 9*(5), 414-422. doi**:**10.1080/13607860500143075

Albert, M. S., DeKosky, S. T., Dickson, D., Dubois, B., Feldman, H. H., Fox, N. C., ... Snyder, P. J. (2011). The diagnosis of mild cognitive impairment due to Alzheimer's disease: Recommendations from the National Institute on Aging-Alzheimer's Association workgroups on diagnostic guidelines for Alzheimer's disease. *Alzheimer's & Dementia, 7*(3), 270-279. doi:10.1016/j.jalz.2011.03.008

Amanzio, M., Vase, L., Leotta, D., Miceli, R., Palermo, S., &Geminiani, G. (2013). Impaired awareness of deficits in Alzheimer's disease: the role of everyday executive dysfunction. *Journal of the International Neuropsychological Society, 19*(01), 63-72. doi: http://dx.doi.org/10.1017/S1355617712000896

Amariglio, R. E., Becker, J. A., Carmasin, J., Wadsworth, L. P., Lorius, N., Sullivan, C., ... Johnson, K. A. (2012). Subjective cognitive complaints and amyloid burden in cognitively normal older individuals. *Neuropsychologia, 50*(12), 2880-2886. doi: 10.1016/j.neuropsychologia.2012.08.011

Ball, K., & Owsley, C. (1993). The useful field of view test: a new technique for evaluating age-related declines in visual function. *Journal of the American Optometric Association, 64*(1), 71-79.

Barrett, A. M., Eslinger, P. J., Ballentine, N. H., &Heilman, K. M. (2005). Unawareness of cognitive deficit (cognitive anosognosia) in probable AD and control subjects. *Neurology, 64*(4), 693-699. http://dx.doi.org/10.1212/01.WNL.0000151959.64379.1B

Benedict, R. H. (1997). *Brief visuospatial memory test--revised: professional manual.* Odessa, FL: Psychological Assessment Resources.

Benedict, R. H. B., Schretlen, D., Groninger, L., & Brandt, J. (1998). Hopkins Verbal Learning Test – Revised: Normative Data and Analysis of Inter-Form and Test-Retest Reliability. *The Clinical Neuropsychologist, 12*(1): 43-55. doi:10.1076/clin.12.1.43.1726

Benton, A.L. (1994). *Contributions to Neuropsychological Assessment*, (2nd ed.) Orlando: Psychological Assessment Resources.

Bondi, M. W., & Smith, G. E. (2014). Mild cognitive impairment: A concept and diagnostic entity in need of input from neuropsychology. *Journal of the International Neuropsychological Society*, *20*(02), 129-134. doi: http://dx.doi.org/10.1017/S1355617714000010

Carmasin, J. S. (2015). *Awareness of executive functioning as a diagnostic tool for mild cognitive impairment and Alzheimer's disease* (Unpublished doctoral dissertation thesis). Department of Psychological and Brain Sciences, University of Louisville, Louisville, Kentucky

Clare, L. (2004). Awareness in early-stage Alzheimer's disease: a review of methods and evidence. *British Journal of Clinical Psychology, 43*(2), 177-196. doi: 10.1348/014466504323088042

Clare, L., Marková, I., Verhey, F., & Kenny, G. (2005). Awareness in dementia: A review of assessment methods and measures. *Aging & Mental Health, 9*(5), 394-413. doi: 10.1080/13607860500142903

Clare, L., Whitaker, C. J., Roberts, J. L., Nelis, S. M., Martyr, A., Marková, I. S., ... Morris, R. G. (2013). Memory awareness profiles differentiate mild cognitive impairment from early-stage

dementia: evidence from assessments of performance monitoring and evaluative judgement. *Dementia and Geriatric Cognitive Disorders, 35*(5-6), 266-279. doi: 10.1159/000346735

Clement, F., Belleville, S., & Gauthier, S. (2008). Cognitive complaint in mild cognitive impairment and Alzheimer's disease. *Journal of the International Neuropsychological Society, 14*(02), 222-232. doi: http://dx.doi.org/10.1017/S1355617708080260

Cook, S., &Marsiske, M. (2006). Subjective memory beliefs and cognitive performance in normal and mildly impaired older adults. *Aging and Mental Health, 10*(4), 413-423. doi: 10.1080/13607860600638487

Cosentino, S., & Stern, Y. (2005). Metacognitive theory and assessment in dementia: do we recognize our areas of weakness? *Journal of the International Neuropsychological Society, 11*(07), 910-919. doi: http://dx.doi.org/10.1017/S1355617705050964

Crowe, M., Andel, R., Wadley, V., Cook, S., Unverzagt, F., Marsiske, M., & Ball, K. (2006). Subjective cognitive function and decline among older adults with psychometrically defined amnestic MCI. *International Journal of Geriatric Psychiatry, 21*(12), 1187-1192. doi: 10.1002/gps.1639

Dubois, B., Feldman, H. H., Jacova, C., Hampel, H., Molinuevo, J. L., Blennow, K., ...Cappa, S. (2014). Advancing research diagnostic criteria for Alzheimer's disease: the IWG-2 criteria. *The Lancet Neurology, 13*(6), 614-629. doi:10.1016/S1474-4422(14)70090-0

Farias, S. T., Mungas, D., &Jagust, W. (2005). Degree of discrepancy between self and other-reported everyday functioning by cognitive status: dementia, mild cognitive impairment, and healthy elders. *International Journal of Geriatric Psychiatry, 20*(9), 827-834. doi:10.1002/gps.1367

Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). “Mini-mental state”: a practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research*, *12*(3), 189-198. doi:10.1016/0022-3956(75)90026-6

Frank, L., Lenderking, W. R., Howard, K., &Cantillon, M. (2011). Patient self-report for evaluating mild cognitive impairment and prodromal Alzheimer's disease. *Alzheimer's Research & Therapy*, *3*(6), 1-12.

Gallo, D. A., Cramer, S. J., Wong, J. T., & Bennett, D. A. (2012). Alzheimer's disease can spare local metacognition despite global anosognosia: Revisiting the confidence–accuracy relationship in episodic memory. *Neuropsychologia*, *50*(9), 2356-2364. doi: 10.1016/j.neuropsychologia.2012.06.005

Galeone, F., Pappalardo, S., Chieffi, S., Iavarone, A., &Carlomagno, S. (2011). Anosognosia for memory deficit in amnestic mild cognitive impairment and Alzheimer's disease. *International Journal of Geriatric Psychiatry*, *26*(7), 695-701. doi: 10.1002/gps.2583

Hannesdottir, K., & Morris, R. G. (2007). Primary and secondary anosognosia for memory impairment in patients with Alzheimer's disease. *Cortex*, *43*(7), 1020-1030. doi:10.1016/S0010-9452(08)70698-1

Hanyu, H., Sakurai, H., & Iwamoto, T. (2007). Are subjective memory complaints mandatory for the diagnosis of mild cognitive impairment? *Internal Medicine*, *46*(11), 791-792. doi: http://doi.org/10.2169/internalmedicine.46.6241

Hollingshead, A. A. (1975). *Four-factor index of social status*. Unpublished manuscript.

Howorth, P., &Saper, J. (2003). The dimensions of insight in people with dementia. *Aging & Mental Health*, *7*(2), 113-122. doi: 10.1080/1360786031000072286

Johnson, S. C., Ries, M. L., Hess, T. M., Carlsson, C. M., Gleason, C. E., Alexander, A. L., ... Sager, M. A. (2007). Effect of Alzheimer disease risk on brain function during self-appraisal in healthy middle-aged adults. *Archives of General Psychiatry*, *64*(10), 1163-1171. doi:10.1001/archpsyc.64.10.1163

Kalbe, E., Salmon, E., Perani, D., Holthoff, V., Sorbi, S., Elsner, A., ... Luedecke, S. (2005). Anosognosia in very mild Alzheimer's disease but not in mild cognitive impairment. *Dementia and Geriatric Cognitive Disorders*, *19*(5-6), 349-356. doi: 10.1159/000084704

Kazui, H., Hirono, N., Hashimoto, M., Nakano, Y., Matsumoto, K., Takatsuki, Y., ... Takeda, M. (2006). Symptoms underlying unawareness of memory impairment in patients with mild Alzheimer's disease. *Journal of Geriatric Psychiatry and Neurology*, *19*(1), 3-12. doi: 10.1177/0891988705277543

Lehrner, J., Kogler, S., Lamm, C., Moser, D., Klug, S., Pusswald, G., ...Auff, E. (2015). Awareness of memory deficits in subjective cognitive decline, mild cognitive impairment, Alzheimer's disease and Parkinson's disease. *International Psychogeriatrics*, *27*(03), 357-366. doi: http://dx.doi.org/10.1017/S1041610214002245

Lyketsos, C. G., Lopez, O., Jones, B., Fitzpatrick, A. L., Breitner, J., &DeKosky, S. (2002). Prevalence of neuropsychiatric symptoms in dementia and mild cognitive impairment: results from the cardiovascular health study. *The Journal of the American Medical Association*, *288*(12), 1475-1483. doi: 10.1001/jama.288.12.1475

Markova, I. S., & Berrios, G. E. (2002). The 'object'of insight assessment: relationship to insight 'structure'. *Psychopathology*, *34*(5), 245-252. doi: 10.1159/000049317

McKhann, G. M., Knopman, D. S., Chertkow, H., Hyman, B. T., Jack, C. R., Kawas, C. H., ... Mohs, R. C. (2011). The diagnosis of dementia due to Alzheimer's disease: Recommendations from the National Institute on Aging-Alzheimer's Association workgroups on diagnostic guidelines

for Alzheimer's disease. *Alzheimer's & Dementia, 7*(3), 263-269. doi:10.1016/j.jalz.2011.03.005

Morris, J. C. (1993). The Clinical Dementia Rating (CDR): Current version and scoring rules. *Neurology,43*: 2412-2414. Retrieved from http://psycnet.apa.org/psycinfo/1994-19989-001

Morris, R. G., &Mograbi, D. C. (2013). Anosognosia, autobiographical memory and self knowledge in Alzheimer's disease. *Cortex, 49*(6), 1553-1565. doi: http://dx.doi.org/10.1016/j.cortex.2012.09.006

Nobili, F., Mazzei, D., Dessi, B., Morbelli, S., Brugnolo, A., Barbieri, P., ... Pagani, M. (2010). Unawareness of memory deficit in amnestic MCI: FDG-PET findings. *Journal of Alzheimer's Disease, 22*(3), 993-1003. doi: 10.3233/JAD-2010-100423

O'Connell, M. E., Dal Bello-Haas, V., Crossley, M., & Morgan, D. (2014). Clinical correlates of awareness for balance, function, and memory: Evidence for the modality specificity of awareness. *Journal of Aging Research, 2014*. http://dx.doi.org/10.1155/2014/674716

O'Connor, M. L., Edwards, J. D., &Bannon, Y. (2013). Self-rated driving habits among older adults with clinically-defined mild cognitive impairment, clinically-defined dementia, and normal cognition. *Accident Analysis & Prevention, 61*, 197-202. doi: 10.1016/j.aap.2013.05.010

Okonkwo, O. C., Griffith, H. R., Vance, D. E., Marson, D. C., Ball, K. K., & Wadley, V. G. (2009). Awareness of functional difficulties in mild cognitive impairment: a multidomain assessment approach. *Journal of the American Geriatrics Society, 57*(6), 978-984. doi: 10.1111/j.1532-5415.2009.02261.x

Orfei, M. D., Blundo, C., Celia, E., Casini, A. R., Caltagirone, C., Spalletta, G., &Varsi, A. E. (2010). Anosognosia in mild cognitive impairment and mild Alzheimer's disease: frequency and

neuropsychological correlates. *The American Journal of Geriatric Psychiatry*, *18*(12), 1133-1140. doi: 10.1097/JGP.0b013e3181dd1c50

Pannu, J. K., &Kaszniak, A. W. (2005). Metamemory experiments in neurological populations: A review. *Neuropsychology Review*, *15*(3), 105-130.doi: 10.1007/s11065-005-7091-6

Prigatano, G. P. (2009). Anosognosia: clinical and ethical considerations. *Current Opinion in Neurology*, *22*(6), 606-611. doi: 10.1097/WCO.0b013e328332a1e7

Prigatano, G. P. (2010). *The study of anosognosia*. Oxford University Press.

Prigatano, G. P., Montreuil, M., Chapple, K., Tonini, A., Toron, J., Paquet, C., ...Truelle, J. L. (2014). Screening for cognitive and affective dysfunction in patients suspected of mild cognitive impairment. *International Journal of Geriatric Psychiatry*, *29*(9), 936-942. doi: 10.1002/gps.4082

Perrotin, A., Belleville, S., &Isingrini, M. (2007). Metamemory monitoring in mild cognitive impairment: Evidence of a less accurate episodic feeling-of-knowing. *Neuropsychologia*, *45*(12), 2811-2826.doi:10.1016/j.neuropsychologia.2007.05.003

Perrotin, A., Desgranges, B., Landeau, B., Mézenge, F., La Joie, R., Egret, S., ... Chételat, G. (2015). Anosognosia in Alzheimer disease: Disconnection between memory and self-related brain networks. *Annals of Neurology, 78*(3), 477-486.doi: 10.1002/ana.24462

Petersen, R. C. (2004). Mild cognitive impairment as a diagnostic entity. *Journal of Internal Medicine, 256(3),* 183-194.doi: 10.1111/j.1365-2796.2004.01388.x

Petersen, R. C., & Morris, J. C. (2005). Mild cognitive impairment as a clinical entity and treatment target. *Archives of Neurology*, *62*(7), 1160-1163. doi:10.1001/archneur.62.7.1160.

Purser, J. L., Fillenbaum, G. G., & Wallace, R. B. (2006). Memory Complaint Is Not Necessary for Diagnosis of Mild Cognitive Impairment and Does Not Predict 10-Year Trajectories of

Functional Disability, Word Recall, or Short Portable Mental Status Questionnaire Limitations. *Journal of the American Geriatrics Society, 54*(2), 335-338. doi: 10.1111/j.1532-5415.2005.00589.x

Ready, R. E., Ott, B. R., & Grace, J. (2006). Insight and cognitive impairment effects on quality-of-life reports from mild cognitive impairment and Alzheimer's disease patients. *American Journal of Alzheimer's Disease and Other Dementias, 21*(4), 242-248. doi: 10.1177/1533317506290589

Reitan R.M. (1979). *Trail Making Test: TMT*. Arizona: Reitan Neuropsychology Library.

Ries, M. L., Jabbar, B. M., Schmitz, T. W., Trivedi, M. A., Gleason, C. E., Carlsson, C. M., ... Johnson, S. C. (2007). Anosognosia in mild cognitive impairment: relationship to activation of cortical midline structures involved in self-appraisal. *Journal of the International Neuropsychological Society*, *13*(3), 450-461. doi: http://dx.doi.org/10.1017/S1355617707070488

Roberts, J. L., Clare, L., & Woods, R. T. (2009). Subjective memory complaints and awareness of memory functioning in mild cognitive impairment: a systematic review. *Dementia and Geriatric Cognitive Disorders*, *28*(2), 95-109. doi: 10.1159/000234911

Smith, C. A., Henderson, V. W., McCleary, C. A., Murdock, G. A., &Buckwalter, J. G. (2000). Anosognosia and Alzheimer's disease: the role of depressive symptoms in mediating impaired insight. *Journal of Clinical and Experimental Neuropsychology*, *22*(4), 437-444. doi: 10.1076/1380-3395(200008)22:4;1-0;FT437

Spalletta, G., Piras, F., Piras, F., Sancesario, G., Iorio, M., Fratangeli, C., ...Orfei, M. D. (2014). Neuroanatomical correlates of awareness of illness in patients with amnestic mild cognitive impairment who will or will not convert to Alzheimer's disease. *Cortex*, *61*, 183-195.doi:10.1016/j.cortex.2014.10.010

Starkstein, S. E., Sabe, L., Chemerinski, E., Jason, L., &Leiguarda, R. (1996). Two domains of anosognosia in Alzheimer's disease. *Journal of Neurology, Neurosurgery & Psychiatry*, *61*(5), 485-490. doi:10.1136/jnnp.61.5.485

Stern, R. A., & White, T. (2003). *NAB, Neuropsychological Assessment Battery: Attention Module Stimulus Book. Form 2*. Psychological Assessment Resources.

Strauss, E., Sherman, E. M., & Spreen, O. (2006). *A compendium of neuropsychological tests: Administration, norms, and commentary*. Oxford University Press, USA.

Suchy, Y., Kraybill, M. L., &Franchow, E. (2011). Instrumental activities of daily living among community-dwelling older adults: Discrepancies between self-report and performance are mediated by cognitive reserve. *Journal of Clinical and Experimental Neuropsychology*, *33*(1), 92-100. doi: 10.1080/13803395.2010.493148

Tabert, M. H., Albert, S. M., Borukhova-Milov, L., Camacho, Y., Pelton, G., Liu, X., ...Devanand, D. P. (2002). Functional deficits in patients with mild cognitive impairment Prediction of AD. *Neurology, 58*(5), 758-764. doi: http://dx.doi.org/10.1212/WNL.58.5.758

Tremont, G., & Alosco, M. L. (2011). Relationship between cognition and awareness of deficit in mild cognitive impairment. *International Journal of Geriatric Psychiatry*, *26*(3), 299-306.doi:10.1002/gps.2529

Vogel, A., Stokholm, J., Gade, A., Andersen, B. B., Hejl, A. M., &Waldemar, G. (2004). Awareness of deficits in mild cognitive impairment and Alzheimer’s disease: do MCI patients have impaired insight? *Dementia and Geriatric Cognitive Disorders*, *17*(3), 181-187. doi: 10.1159/000076354

Vogel, A., Hasselbalch, S. G., Gade, A., Ziebell, M., &Waldemar, G. (2005). Cognitive and functional neuroimaging correlate for anosognosia in mild cognitive impairment and

Alzheimer's disease. *International Journal of Geriatric Psychiatry*, *20*(3), 238-246. doi: 10.1002/gps.1272

Zamboni, G., Drazich, E., McCulloch, E., Filippini, N., Mackay, C. E., Jenkinson, M., ...Wilcock, G. K. (2013). Neuroanatomy of impaired self-awareness in Alzheimer's disease and mild cognitive impairment. *Cortex*, *49*(3), 668-678. doi:10.1016/j.cortex.2012.04.011