Visual Search in Mild Cognitive Impairment: A Longitudinal Study

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Abstract. In the study of Alzheimer’s disease, a multidisciplinary research approach has identified significant abnormality in several areas of visual and visual attention-related brain function in addition to those typically measured as part of clinical diagnosis. This raises the possibility that a similar approach applied to amnestic mild cognitive impairment (aMCI) will increase our understanding of its theoretical and clinical constructs, particularly if functions whose integrity is heterogeneous with respect to etiological outcome can be found. In this study we examined visual search performance (the brain’s ability to search effectively throughout the environment for a particular object) in aMCI compared to healthy aging. Cross-sectionally, visual search performance in aMCI was significantly poorer than healthy aging, with greater intra-group performance heterogeneity in the aMCI compared to the healthy older adult group. This outcome illustrates that although individuals within an aMCI group ostensibly have the same condition they can differ substantially with respect to the integrity of aspects of brain function. Such findings may have implications for the clinical management of the individual patient. The results from the longitudinal aspect of this study also illustrate how heterogeneity in the performance of brain operations other than memory in aMCI may help to inform the likelihood of their developing dementia, as those patients who were diagnosed with dementia within 2.5 years of baseline measurement showed significantly poorer visual search performance compared to those who did not.

Keywords: Alzheimer’s disease, attention, dementia, mild cognitive impairment, reaction time, visual search

INTRODUCTION

Mild cognitive impairment (MCI) is a widespread but controversial term used to describe the presence of acquired cognitive abnormality greater than expected in relation to age and education and in the absence of dementia and detrimental effects upon activities of daily living. However this simple clinical diagnostic label, conferred as a result of a mixture of objective signs and subjective symptoms, belies an etiologically heterogeneous disorder, attributable to the prodromal stages of various degenerative and non-degenerative disorders or the outer limits of performance in healthy aging. Furthermore MCI can be transitory, with normal functional integrity eventually resumed, or stable over time. Although several relatively distinct forms of MCI are reported, the amnestic variant (aMCI) characterized by abnormal memory has received the greatest attention as a result of its association with an increased...
Finding a given object within the visual environment often involves searching through a substantial amount of irrelevant but distracting information. The influence distracting information has upon the search for a particular object can be investigated using a computer-based visual search task [16]. In our previous studies of visual search in AD compared to healthy aging [16, 20] although target reaction time (RT) was quicker for the target in isolation compared to its appearance amongst the distractors for both the healthy older adult and AD groups this difference (the visual search effect) was significantly greater for the AD group. This outcome, suggestive of a greater detrimental impact of distracting items upon information processing in AD compared to healthy aging, confirmed that revealed previously by Foster et al. [21]. Several different areas of hypo-functionality may cumulatively, collectively, or singularly contribute to such poor visual search performance in the presence of distracting information in AD. These include dysfunctional operations associated with serially shifting the focus of attention throughout the scene, processing information once it is attended, information binding, object recognition, stimulus grouping strategy, eye movements, saccade initiation, search strategy planning, adjusting the spatial scale of attention, attentional control, distractor inhibition or suppression mechanisms and over-distractibility to irrelevant information [e.g., 5, 6, 10, 15, 20, 22–28].

Examining visual search performance in aMCI has revealed a significantly greater visual search effect, suggesting inefficiency of processing in the presence of distracting information compared to healthy aging and indicative of the presence of brain dysfunction other than that of memory in aMCI [16]. However, this previous study examined visual search integrity only at the group mean level. The potential impact of intra-group performance heterogeneity and individual performance was not taken into account, which would be important to do if we wish to move towards a more personalized approach to diagnosis and target intervention [29–31].

**Study aims**

In an initial cross-sectional study we test the replicability of our previous findings [16, 20] by comparing mean visual search (RT to target plus distractors – RT to target) performance in a group of patients with aMCI and a control group of healthy older adults. Intra-group heterogeneity of visual search performance within both groups will be examined. The target alone condition also allows us to compare baseline choice RT between and within groups. The aMCI group is followed up for 2.5 years in order to examine whether visual search performance and choice RT at baseline varies with respect to the development of dementia or not.
MATERIALS, METHODS, AND PARTICIPANTS

Stimuli

All trials contained a target element that was either a < or > (i.e., a left or right-pointing arrow) and the participants’ task was to indicate which of these occurred. The non-target, i.e., distracter elements, had the same form as the target but with the apex of the arrow pointing up or down. Both target and non-target elements were black. All stimuli were presented on a Toshiba SatellitePro laptop computer at a viewing distance of 57 cm. We used a ‘clock-face’ configuration [16] positioning the target both when it appeared alone and with 7 distracter items, in a specific counterbalanced place within the clock-face to eliminate any differences in processing between right and left and upper and lower visual fields. Each target or distracter element appeared radially and equidistant from the intersection of the lines forming the fixation cross at a distance of 21 mm, and when all 8 items appeared, were equally spaced. Each line of the ‘>’ shape measured 5 mm in length and 1 mm in width. For each trial the fixation point appeared on screen for 1000 ms prior to the appearance of the target alone or the target plus 7 distracters and remained on screen for the duration of the trial. The stimuli remained on-screen until a response was made, after which the fixation point appeared again. No feedback was given as to the accuracy of each response. The target was presented 8 times at each of the possible locations. On 4 of these 8 times, 7 distracter elements were presented at the other locations whilst on the other 4 no distracter elements were black. All stimuli were presented in the same form as the target but with the apex of the arrow pointing up or down. Both target and non-target elements were black. All stimuli were presented on a Toshiba SatellitePro laptop computer at a viewing distance of 57 cm. We used a ‘clock-face’ configuration [16] positioning the target both when it appeared alone and with 7 distracter items, in a specific counterbalanced place within the clock-face to eliminate any differences in processing between right and left and upper and lower visual fields. Each target or distracter element appeared radially and equidistant from the intersection of the lines forming the fixation cross at a distance of 21 mm, and when all 8 items appeared, were equally spaced. Each line of the ‘>’ shape measured 5 mm in length and 1 mm in width. For each trial the fixation point appeared on screen for 1000 ms prior to the appearance of the target alone or the target plus 7 distracters and remained on screen for the duration of the trial. The stimuli remained on-screen until a response was made, after which the fixation point appeared again. No feedback was given as to the accuracy of each response. The target was presented 8 times at each of the possible locations. On 4 of these 8 times, 7 distracter elements were presented at the other locations whilst on the other 4 no distracters were presented. Thus 64 trials were presented.

Fig. 1. Representation of the visual search stimuli in which the target ‘>’ is surrounded by the 7 distracter items.

Procedure

The participants were instructed to fixate on the center cross at the beginning of each trial and to respond as quickly but as accurately as possible to the orientation (right or left) of the target’s apex by pressing one of two computer keyboard buttons. After instruction, all participants were asked to explain the task to the experimenter in order to demonstrate their understanding of the task requirements and all were required to perform a practice block of approximately 10 trials. The ability of the participant to fixate on the cross at the beginning of each trial continued to be checked throughout the procedure by researcher observation.

Participants

All individuals with aMCI had initially presented to their general practitioner (GP) with a subjective memory problem (corroborated by an informant). Upon subsequent referral to the memory clinics at Cardiff (University Hospital Llandough, Penarth, Cardiff) or Bristol (Blackberry Hill Hospital, Bristol) they were comprehensively assessed, according to normal clinical practice, by detailed clinical history, neuropsychological laboratory tests (routine hematology and biochemistry, thyroid function tests) neuroimaging and neuropsychological examinations. Consensus inclusion criteria for aMCI were a significant subjective decrease in short or long term memory (documented also by a collateral source) and objective decline at a level of >1 standard deviation (SD) (and usually >1.5 SD) from the age and education appropriate mean scores on memory tests (however rigid cutoffs on psychometric scores were not used [32, 33]), preserved daily living (BADLs) and a Clinical Dementia Rating (CDR) score ≤0.5 and age of 60 years and above. The Cardiff neuropsychological battery included Addenbrooke’s Cognitive Examination [34], Mini Mental State Examination (MMSE) [35], Kendrick Object Learning Test (KOLT) [36] and immediate and delayed Story Recall from the Arizona Battery for Communication Disorders of Dementia (ABCD) [37]. For Bristol this included MMSE [35], immediate, delayed and verbal recognition memory (Hopkins Verbal Learning Test-Revised [38], WAIS-III subsists of digit span forwards and backwards, similarities and picture completion [39], face recognition [40], The Boston Naming Test [41], S-word fluency and animal fluency [42], Weigl’s color-form sorting test [43], the CLOX test (Executive function) [44], the Visual Form Discrimination Test (VFDT) [45], the Visual Form Discrimination Test (VFDT) [45], the Visual Form Discrimination Test (VFDT) [45], the Visual Form Discrimination Test (VFDT) [45], the Visual Form Discrimination Test (VFDT)
Consenting patients with a diagnosis of aMCI were then recruited over a period of 18 months on a consecutive incident basis and resulted in the study participation of 34 individuals (20 from Bristol and 14 from Cardiff). None met NINCDS-ADRDA [48] or DSM-IV [49] criteria for possible or probable AD. Although the outcome of independent measures t tests revealed that those recruited from Bristol had a lower average MMSE [55] score than those from Cardiff [t(df 30.1) = 3.6, p = 0.001 (adjusted for unequal group variances)] there were no significant differences in relation to age [t(df 32) = 0.59, p = 0.56] or years of education [t(df 32) = 0.8, p = 0.43].

The healthy older adult group consisted of 34 individuals forming part of the healthy volunteers group at the Bristol Memory Disorders Clinic. Each control participant displayed normal function in relation to their age and educational attainment in relation to the same neuropsychological battery administered to the patients at Bristol (see above) and none met criteria for MCI, dementia or any other cognitive disorder. No patients or healthy older adults had history of signs of stroke or transient ischemic attack, significant head injury, depression, or other psychiatric disorder, or major neurological disease and none were receiving medication (prescribed or non-prescribed) deemed likely to affect cognitive or attention-related function. All had normal or corrected-to-normal vision and were right hand dominant. The study was approved by the North Bristol research ethics committee and participants gave written informed consent to participation.

### Longitudinal parameters

All patients with MCI were followed up as part of the normal clinical process over a 2.5 year period. During this time, outcome i.e., conversion to AD or to another disease (converters), or stable aMCI or improvement (non-converters) was measured as part of normal clinical follow up and diagnostic criteria. Healthy older participants were reassessed at time of follow up after 2.5 years. Diagnosis at baseline and study end-point was determined by consensus decision among members of the typical clinical team that included some of the researchers and was based at both memory clinics. This team reviewed all available clinical, neuroimaging, and neuropsychological information. Those making the clinical determination of whether a person had converted to dementia or not were blind with respect to the research task performance of all participants.

### Data processing

For each participant, target discrimination RT was measured when the target was presented in isolation and when it was surrounded by the 7 distracting items. Responses were omitted if they were incorrect or outliers (i.e., below 150 ms, namely anticipatory responses) or associated with lapses of attention. From the remaining RTs, the median RT for each condition for each individual was determined and from these values the group means were ascertained. For each individual the mean visual search effect (RT to target plus distractors – RT to target) was determined and the group means ascertained.

### RESULTS

#### Cross-sectional study analysis: healthy older adult controls vs. aMCI groups baseline visual search analysis

As shown in Fig. 2, surrounding the target by distractors increased the RT for both groups but the magnitude of this difference, namely the visual search effect, was significantly larger for the aMCI compared to the healthy older adult group [t(df 45.818) = −3.77, p < 0.001 (adjusted for unequal variances); effect size Cohen’s d = 1.1139, r = 0.4865 (using t and df values adjusted for unequal variances)]. Figure 3 shows the individual scores for visual search effect in each group. Receiver operator curve (ROC) analysis

#### Table 1

Baseline demographics for the older healthy adult group and for the patients with aMCI who did and did not convert to dementia

<table>
<thead>
<tr>
<th></th>
<th>Healthy older adults (n = 34)</th>
<th>MCI Non-converters (n = 24)</th>
<th>MCI Converters (n = 10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age: mean (sd)</td>
<td>73.5 (6.6)</td>
<td>71.7 (6.2)</td>
<td>74.1 (7.9)</td>
</tr>
<tr>
<td>Gender: number of males/females</td>
<td>17/17</td>
<td>18/6</td>
<td>5/5</td>
</tr>
<tr>
<td>Years of education: mean (sd)</td>
<td>13.5 (1.0)</td>
<td>12.4 (2.0)</td>
<td>11.1 (2.3)</td>
</tr>
<tr>
<td>MMSE: mean (sd)</td>
<td>25.2 (2.1)</td>
<td>26.0 (2.3)</td>
<td>24.2 (2.3)</td>
</tr>
</tbody>
</table>

Note that although data was normally distributed, the differences in group performance heterogeneously precluded ANOVA statistical analysis. As log-transforming the data failed to reduce this difference to a level suitable for ANOVA, t test analysis, corrected for differences in group variances, was applied instead (note that additional non-parametric analysis confirmed these results).
Mean RT (ms) for target alone and target surrounded by distracters for the older adult and the aMCI baseline groups (bars represent the standard error of the mean).

Fig. 2. Mean RT (ms) for target alone and target surrounded by distracters for the older adult and the aMCI baseline groups (bars represent the standard error of the mean).

Mean visual search effect (reaction time [ms])

Fig. 3. Dot plot of the baseline visual search effect (RT for target surrounded by distracters – RT for target alone). Each data point represents the search data for one individual: group 1 = healthy older adult controls; group 2 = patients with aMCI.

Also confirmed this group differentiation at baseline [area = 0.754: standard error 0.059: asymptotic significance < 0.001: asymptotic 95% confidence interval lower bound = 0.639, upper bound = 0.869]. The difference in baseline visual search between the older adult and the aMCI groups are not the result of mean differences in age \( t(66) = -0.29, p = 0.77 \), or outliers \( t(66) = -0.459, p = 0.65 \), nor the influence of group gender mix as there was no significant difference in visual search performance between male and female participants in either the healthy older adult \( t(32) = 0.931, p = 0.36 \) or MCI group \( t(32) = 1.1, p = 0.27 \) respectively. The mean education level for the aMCI group was, however, lower than that of the healthy older adult group by approximately 1.8 years \( t(59.3) = 2.82, p = 0.007, \) unequal variances; mean difference 1.8 with a 95% confidence interval [0.526 to 3.1].

Longitudinal study analysis of visual search: converters vs. non-converters

After a 2.5 year period none of the healthy older control group had changed with respect to cognitive integrity or general health. Of the 34 original members of the MCI group, 2 (6%) developed vascular dementia (VaD) (one 6 months and one 15 months after testing), 1 (3%) developed fronto-temporal dementia (FTD) at 18 months, and 7 (21%) developed AD at an average time of 15.3 (sd 6.8) months from baseline assessment (according to current criteria for AD [48], FTD [50], and VaD [51]). Thus 10 (29%) developed dementia and 24 (71%) of patients did not convert, among whom 1 patient returned to normal function at 6 months and 23 remained with a diagnosis of MCI (MCI → MCI). The visual search performance at baseline for these individuals (converters and non-converters) can be viewed in the dot plot (Fig. 4).

Although surrounding the target with distractors increased RT for both the non-converted and converted groups, independent \( t \) test analysis revealed that the magnitude of this visual search effect (RT target and distracters – RT target alone) at baseline was significantly greater for the converters [all etiologies combined] compared to non-converters \( t(10.3) = 3.83, p = 0.003 \) (adjusted for unequal variances): Effect size Cohen’s \( d = 2.38, r = 0.766 \) (based
on unequal variance \( t \) and df values). ROC analysis confirms this differentiation between converters and non-converters with an area under the curve of 0.892, standard error 0.066, asymptotic significance <0.001, asymptotic 95% confidence interval 0.762 to 1.022.

The mean number of errors across both target conditions (alone or distracters present) was small for both the converters and non-converters, with independent \( t \) test analysis revealing no significant group difference in the mean number of errors \( t(10) = -0.88, p = 0.4 \), adjusted for unequal variance. The mean number of outliers was also small for both the converters and non-converters with independent \( t \) test analysis revealing no significant group differences \( t(32) = 0.69, p = 0.5 \). Furthermore, converters and non-converters did not differ with respect to age \( t(32) = 1.27, p = 0.2 \), mean years of education \( t(32) = 1.59, p = 0.12 \) or mean MMSE \( t(32) = 1.96, p = 0.06 \). Although the male to female ratio differed between the groups visual search in both the healthy older adult line \( t(32) = 0.93, p = 0.36 \) and the aMCI group at baseline \( t(32) = 1.1, p = 0.27 \) did not vary with respect to gender.

Reaction time analysis

Independent \( t \)-test analysis revealed that RT to the target in isolation was slowed in aMCI compared to healthy aging at baseline \( t(48.24) = -2.295, p = 0.027 \); mean difference \( M = -158.697 \) with a 95% confidence interval of \(-259.3 \) to \(-19.094 \). Effect size Cohen’s \( d = 0.66, r = 0.3 \) (all adjusted for unequal variances) it was not significantly different for the converters and non-converters in the longitudinal aspect of the study \( t(11.48) = 1.926, p = 0.079 \).

DISCUSSION

Baseline cross-sectional visual search performance

The initial cross-sectional data revealed that mean visual search performance was significantly poorer for the aMCI compared to healthy older adult group; an outcome with a large effect size (Cohen’s \( d = 1.1 \)) and in accord with that from our previous study [16]. The concept of abnormality in brain function other than that of memory in aMCI is thus upheld. Although participants numbers in the present study (34 aMCI and 34 healthy older adults) exceeded those we studied previously [16] (13 aMCI and 20 healthy older adults), both resulted in a statistically significant group-level differentiation. Arguably, such findings are indicative of an effect robust enough to emerge from the study of what may be regarded as small participant groups [52]. Indeed the effect size of the present study is comparable to that seen in studies using greater numbers of participants [e.g., 31]. This is an important factor with respect to the challenges of recruiting patients with this specific form of MCI within the context of typical clinical practice [53].

Furthermore, the robust outcome was not the result of significant group differences in age or gender, or number of errors and outliers. However, the mean educational level was lower for the aMCI group and whether educational level influences visual search remains to be determined in future studies.

Evidence so far appears indicative of a greater detrimental impact on distracting items upon information processing in aMCI compared to healthy aging per se. Although how our experimentally elicited effect relates to real life experience remains to be investigated, experimentally induced visual search is generally regarded as having ecological validity with poor performance detrimental to many aspects of information processing and behavior [e.g., 54, 55]. Individuals with aMCI may therefore have deficits undetected by conventional neuropsychological and clinical evaluation, with a subsequent underestimation of the true impact of the condition. However, ROC analysis revealed that the healthy older adult and the aMCI group could not be completely separated with respect to visual search performance; the explanation for which is clearly evident from the dot plot (Fig. 4), namely the considerably greater intra group heterogeneity in the aMCI compared to the healthy older adult group. While some patients with aMCI displayed performance similar to that of the healthy older adults, the performance of others was substantially poorer. Rather than reporting that visual search is abnormal in aMCI [16], it may therefore be more accurate to report that a proportion of people with aMCI can be characterized by distinctly abnormal visual search (with the significant group differences between aMCI and healthy aging accounted for predominantly by the proportion of the group who show this grossly impaired performance).

Baseline cross-sectional RT performance

Although the focus of our study relates to visual search performance, debate continues regarding the potential clinical utility of RT measures in the study of MCI and dementia, particularly AD [e.g., 9, 13,
A component of our paradigm is the forced choice discrimination RT response to whether the target, appearing in the absence of distracters, is pointing to the right or left. We therefore examined this RT data at baseline alongside that for visual search in order to contribute to ongoing investigations. The results revealed that mean target RT was significantly longer for the aMCI compared to the healthy older adult group. Note however that intra-group variation in this RT measure was evident, particularly within the aMCI group. Our finding that visual search and RT abnormality is not common to all patients with aMCI highlights the importance of determining brain function at the level of the individual. In principle, identifying individual variation in many areas of brain function other than those used as part of normal diagnosis may promote the development of outcome markers which test areas of function other than those related to cognition and quality of life which may be insensitive to some of the effects of an intervention.

**Longitudinal outcome**

The longitudinal aspect of this study was performed in order to examine the etiological variation within a typical group of aMCI patients recruited from a memory clinic 2.5 years after initial testing and to examine the heterogeneity of visual search performance identified at baseline with respect to the development of dementia within this epoch. Conversion to dementia was the primary outcome measure as histological confirmation of specific etiologies of dementia was not available.

Over the 2.5 year period the greatest proportion of patients with aMCI (71%) did not convert to dementia (of these, one returned to normal and all others remained stable), a finding in agreement with the outcome of many other studies and one which contributes to the debate surrounding the implications of confirming the diagnosis of aMCI on an individual [53]. Nevertheless some did develop dementia thus emphasizing also the importance of continued follow-up of individuals with such a diagnosis. Of the 10 people (29%) who converted to dementia most (n = 7) were diagnosed with probable AD, 1 developed FTD and 2 developed VaD; an outcome in accord with the findings of other longitudinal studies of aMCI and one which indicates that aMCI may not be always a specific early stage of AD. Although it is now apparent that with more detailed initial testing impairment in other domains of cognition can be found in what is ostensibly labeled aMCI [58] all MCI subtypes are at risk of converting to AD [59] and our conversion rates were consistent with those in the literature (see also [3, 53]). Our outcome rates are also in accord with those from larger and smaller cohort longitudinal studies (e.g. [53, 60, 61]) thus indicating that our results are not due to a lack of power within the study.

**Longitudinal visual search performance**

aMCI patients who were diagnosed with dementia within 2.5 years showed significantly poorer mean visual search performance compared to those who did not (i.e., remained stable with aMCI or returned to normal): a result accompanied by a large effect size (Cohen’s $d = 2.38$) thus indicative of a meaningful and robust effect. There was some evidence that the intra-group heterogeneity at baseline in aMCI was strongly related to the development of dementia, as ROC analysis (area under the curve = 0.89) revealed that patients with particularly poor visual search performance were the most likely to develop dementia over this time period. We do not claim that visual search performance is a marker for the early presence of dementia. However, as suggested by one of the reviewers of this paper, it is possible that impairments in visual search performance indicate that a subset of individuals with aMCI not only have pathology involving memory systems of the brain, but also disruption of systems mediating visual attention and that individuals suffering from pathological disruption of multiple brain networks are likely to be at greater risk for developing clinical dementia within the following few years. The outcome of the present study should also be interpreted in relation to the fact that at the initiation of this study there was no consensus regarding the different ways to define subgroups of MCI and since then, multi-domain aMCI has been identified. Our initial criteria required a predominant deficit in memory only with performance on tests other than memory within normal limits. However, it is possible that our participants may have had subtle undetected underperformance in other domains and indeed that this factor may contribute to an increased likelihood of developing dementia. Furthermore, it is possible that as visual search appears to be the result of several component processes, its integrity may be related to the degree of cognitive impairment (i.e., one would expect poorer visual search performance in multi-domain aMCI compared to aMCI). This differentiation was not the result of significant differences in age, education, errors or outliers and although the ratio of males to females differed between the groups we showed that, in both healthy aging and aMCI search...
did not vary with gender [62]. However, there was a trend for there being a difference in MMSE scores with a p value of 0.06. Considering that the sample only had 10 converters, lack of significance may well reflect inadequate power and thus warrants further investigation. It is possible that visual search performance is related to the integrity of various aspects of cognitive function and that other neuropsychological tests used in the diagnosis of aMCI could also have differentiated converters and non-converters. However, the present study was not designed, and thus not powered to investigate these factors. Such analysis was also precluded by the variation in some aspects of the neuropsychological test batteries between the memory clinics. However, in an additional longitudinal study (Tales et al. in preparation) a very similar group of patients with aMCI and one of healthy older controls were tested on several aspects of spatial attention related function, namely attentional disengagement, inhibition of return, and non-spatial factors such as phasic alerting, none of which were found to differentiate between converters and non-converters. This outcome may indicate that there is some specificity of the visual search technique in differentiating these two groups rather.

The visual search technique may be of use in informing the development of future longitudinal studies examining the relationship between aMCI and the development of dementia. However, another potentially clinically relevant finding from the present study is that although we cannot be sure of the underlying mechanism (see Introduction), it appears that a robust characteristic of converters at group level is a pronounced difficulty in managing distracting information (see also [16]), which, appears to be the case in AD, has the potential to disrupt other aspects of information processing and thus behavior. Indeed, as suggested by one of our reviewers, such distraction effects may impact upon the outcome of any form of testing and may even transfer to the actual presence of the researcher in the room, a factor which may need to be taken into consideration when interpreting the outcome of clinical and research tests.

Longitudinal RT performance: converters vs. non-converters

There was no statistically significant difference between the converters and the non-converters in baseline target RT. Conversion to dementia, under these experimental conditions, does not appear to be characterized by slowing per se although this is not to say that slowing in the component processes of visual search doesn’t contribute to the overall performance of visual search. Furthermore, one might argue that at a significance level (p value) of 0.079 a trend exists and thus perhaps one should report that differences in visual search RTs are more sensitive than choice RTs in distinguishing converters from non-converters.

Closing remarks

In general, MCI is described as a heterogeneous disorder, with aMCI conceptualized as a relatively homogenous sub-group defined by deficits in memory. However, the cross-sectional results presented here illustrate that although the individuals within an aMCI group ostensibly have the same diagnosis they can clearly differ substantially with respect to the integrity of other aspects of brain function, namely visual search. Such findings may have implications for the clinical management of the individual patient. The results from the longitudinal aspect of this study also illustrate how heterogeneity in the performance of brain operations in patients with aMCI may help to inform the likelihood of their developing dementia.

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