ion and Reality of Cognitive n: Information Processing Speed, ed Memory Function, and Perceived ifficulty in Older Adults

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y examines the relationships between two measures of information processing speed associated with Trail Making Test and a computer-based visual search test), the perceived difficulty of the tasks, and unction (measured by the Memory Functioning Questionnaire) in older adults (aged 50+ y) with normal ition (Montreal Cognitive Assessment score of 26+), and mood. The participants were recruited from r than through clinical services, and none had ever sought or received help from a health professional aint or mental health problem. For both the trail making and the visual search tests, mean information s not correlated significantly with perceived memory function. Some individuals did, however, reveal nformation processing speeds (outliers) that may have clinical significance and indicate those who may rther assessment and follow up. For the trail making, but not the visual search task, higher levels of ysfunction were associated with a greater perception of task difficulty. The relationship between actual ng speed and perceived task difficulty also varied with respect to the task used. These findings highlight ting into account the type of task and metacognition factors when examining the integrity of information older adults, particularly as this measure is now specifically cited as a key cognitive subdomain within work for neurocognitive disorders.

formation processing speed, metacognition, reaction time, subjective cognitive impairment

self-perceived cognitive decline, nory, commonly occur in older is increasingly apparent that both can be characterized by an earlier rmed subjective cognitive impair- ine (SCD), without any objective from neuropsychological assess- wever, subjective cognitive com- ys represent a prodromal stage of me causes (e.g., anxiety, depres- sorder) potentially responsive to 27, 28]. Irrespective of causality, emory function can impact neg- day life and mental health, with loping dementia and withdrawal h and social behavior [20, 29].

rized by objectively defined nor- ogical test performance. It is of at objective change is absent in memory because the tests used lo not measure the specific aspect n individual perceives as having tal change in brain functions other occur in what we term SCI, but t for the general public to describe ay manifest only as vague percep- deed, emerging evidence indicates rain operations may be disrupted n SCI [30]. Therefore, it is pos- tion in integrity of fundamental ay impair memory function to a perceived by the individual, but urrent neuropsychological testing

e of inter-relationships between

In this study, therefore, we examine perceived memory function in relation to information processing speed in community-living older adults who have not approached health care services with concerns about their memory or cognitive function [23, 27] and with normal levels of general cognitive function and no significant anxiety or depression. In addition, as metacognition can be a factor in the self-perception of the integrity of memory and cognition [31], we also ask whether there is any relationship between reported memory performance and the perception of task difficulty (i.e., is high level of perceived memory dysfunction associated with greater perception of task difficulty?) and whether perceived task difficulty is related to actual (objectively measured) speed of information processing.

There is evidence (e.g., [5]) to suggest that the speed of information processing, and thus study outcome, can differ significantly with respect to the test used, because of the different brain networks and processes recruited by specific task demands. We therefore report studies using two different measures, the pen-and-paper-based trail making test (TMT) and a computer-administered visual search task.

The TMT is commonly used in clinical settings and in aging, MCI, and dementia research to examine information processing speed and executive function [32]. Trails A is a one-trial task typically described as probing functions such as speed of processing in relation to attention, visual scanning and search, number recognition, numeric sequencing and motor speed; giving a baseline measure of perceptual processing and motor speed. Trails B is again a one-trial task typically described as probing the efficiency

Table 1
res and Trails A and Trails B information processing speeds for older adults. Standard deviation in parenthesis. Note that range refers to observed range within the data

Age (y)	Education (y)	MFQ-total score	Trails A (s)	Perceived difficulty scale for Trails A	Trails B (s)	Perceived difficulty scale for Trails B
(5.5) e 50–79	16 (4.8)	295 (49.1)	29.05 (9.3)	2 (1.2) Range 1–6	43.43 (9.4)	3 (1.6) Range 1–6

speed for both Trails A and Trails B is represented by the box plot in Fig. 1. Note the presence of outliers in the k.

L MAKING TEST:

approved by the ethics committee rsity, Department of Psychology. ave written informed consent to

elling older adults ($n = 100$) were dverts placed in local newspapers roughout the Swansea area and by clusion criteria included poor self- alth, any past history of significant ical, or mental health problems, al slowing (e.g., related to Parkin- hritis), or previous visit to a health with memory complaints, anxiety, m those recruited, 19 individuals these, 8 had Montreal Cognitive A) scores of 24 or 25, 3 had MoCA 8 had current or past history of problems, anxiety, or depression. in the study ($n^1 = 81$; age 50+ y; Testing took place within the Psychology Department at the University of Swansea.

Subjective memory assessment

Subjective memory function was measured using the Memory Functioning Questionnaire (MFQ) [37]. This 64-item questionnaire assesses the perception of everyday memory functioning with seven sections on general rating of memory, retrospective functioning (compares current memory with past ability), frequency of forgetting, frequency of forgetting while reading, remembering past events, seriousness of forgetting (how memory impairment impacts daily life), and mnemonics usage. Each item is scored on a 1 to 7 Likert scale (1 = severe memory problems; 7 = no problems). Scores range between 64 and 448 with high scores reflecting less severe memory complaints.

Table 1 shows the demographics and TMT data.

Trail Making Test

Practice trails were provided for both Trails A and B. For Trails A, the participants were instructed

Table 2
aphics, information processing speed and errors. Standard deviation in parenthesis. Note that range refers to observed range within the data

e	Education (y)	MFQ Total score	Information processing speed		Mean group errors		Perceived performance Likert scale
			Target alone	Target plus distracters	Target alone	Target plus distracters	
5–79)	15 (3.7)	290 (46.5)	743.02 (164.91)	1685.55 (314.23)	0.37	0.33	3 (1.4) Range 1–6

speed for both the Target alone and Target plus distracter conditions is represented by the box plot in Fig. 3. Note in the performance of this task.

processing speed and function

elational analysis showed no asso- MFQ total score and information or either Trails A or B (all p val- seven subscales of the MFQ, none ion with either Trails A or Trails B) except for a significant negative s A with the Mnemonics subscale 07, which survives Bonferroni cor-

processing speed and culty

erceived task difficulty score was ge from 1 to 6 for Trails A and ge of 1 to 6 for Trails B. This ly correlated with performance on) but was significantly positively rformance on Trails B (r = 0.293,

STUDY 2: VISUAL SEARCH TASK: METHODS

Participants

In the second study, another (separate) group of older adults ($n = 62$) were recruited. The protocol (i.e., inclusion and exclusion factors) was exactly the same as in study 1, as was the recruitment procedure. From those recruited, 6 individuals were excluded due to MOCA scores of 25 or less, with 2 further individuals excluded as a result of current poor medical health. Demographic details for the participants ($n^2 = 54$; age 50+ y; 24 male, 30 female) of this second study are shown in Table 2. All participants completed all 64 items on the MFQ.

Visual Search Task: Experimental task and procedure

For the computer-based visual search task, the time taken to respond to a target (target discrimination) when it appeared in isolation upon the screen and

ate any differences in processing
left and upper and lower visual
4 trials were presented; the target
t each of the possible 'clock-face'
of the trials distracters were pre-
locations and for the other half no
esented. For each trial the central
eared on screen for 1000 ms prior
of the target (with or without dis-
ned on screen for the duration of
uli remained on screen until the
ded, after which the fixation point
articipants were instructed to fix-
ross at the beginning of each trial
quickly but as accurately as possi-
target was pointing to the right or
e of two computer keyboard keys.
ll participants were asked to reiter-
to ensure understanding and then
ce block of no more than 10 trials.
articipants to fixate on the cross at
ach trial continued to be checked
cedure by researcher observation.
edback was provided.
rors were calculated. Responses
they were incorrect or obviously
e/lapse of concentration or below
n 'natural' reaction time therefore
re-empting of the stimulus). No
to respond to a trial. For each
dian time (information processing
spond for the target alone and the
er trials was determined and group
d (see Table 2).

difficulty

the visual search tasks were very small (mean group errors 0.37 for target alone and 0.33 for target plus distracters) and the number of errors was not significantly correlated with MFQ scores (p values > 0.05).

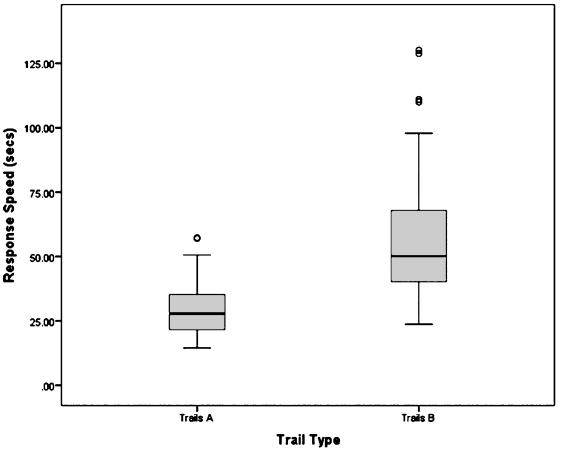

Fig. 1. Box plot of mean information processing speed (s) for Trails A and B performance in older adults.

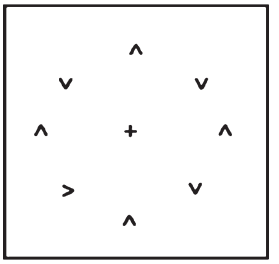

Fig. 2. Search stimulus.

rmation processing speed
difficulty

perceived task difficulty score for
sk was 3 (1.4) with a range from 1
ficantly negatively correlated with
dition (r = –0.294, $p = 0.031$), with
rmation processing speed associ-
ceived task difficulty, but not for
racters conditions ($p > 0.05$). The
as not significantly correlated with
culty (p values > 0.05).

function and perceived task

e was not significantly correlated
sk difficulty for either the target
plus distracters condition (p val-
oc tests revealed that all the above
ary with respect to whether the
le or female.

and information processing

c analysis revealed that although
was not significantly related to
performance it was significantly
ed with perceived test difficulty
) and it was significantly nega-
ith information processing speed
acter (r = –0.398, $p = 0.003$) condi-

Information processing speed and subjective memory

Greater levels of overall subjective memory complaint (MFQ total score) were not significantly associated with slower information processing speed as measured by the TMT or Visual Search Task. For Trails A there was a significant negative correlation between information processing speed and the mnemonics subset of the MFQ and although this survived Bonferroni correction, the significance level of this effect was low ($p = 0.042$). For Trails B and both conditions of the visual search test, information processing speed was not significantly correlated with any of the MFQ subsets.

Given the close relationship between information processing speed and white and grey matter structure [6–12], the general absence of an association with perceived memory dysfunction in otherwise cognitively healthy, euthymic older adults suggests perceived memory dysfunction is less likely to be related to structural abnormality or possible neurodegenerative change. Similarly, given the association between Alzheimer's disease, vascular dementia and MCI and slowed information processing speed the lack of a relationship between perceived memory function and information processing speed may be indicative of a non-neurodegenerative basis for perceived impairment in individuals with 'normal' levels of general cognition (e.g., MoCA score within the normal range).

Note, however, that these ideas are speculative in nature given the absence of neuroimaging, a full range of objective and subjective measures of memory, cognitive and information processing speed performance, and longitudinal analysis examining the risk

the outliers evident in our results,
nay be representative of detrimen-
rlying structure and function and
ibility of underlying neurodegen-
llow-up and medical intervention
ts could be prioritized, whereas
more from focus on psychologi-
ng expectations regarding normal
ive performance, and providing
tegies to reduce the required effort

difficulty and subjective

ve memory complaint was associ-
tion of greater task difficulty for
Trails B of the TMT, especially
lt Trails B test, with higher levels
nory complaint related to greater
ficulty. With respect to the TMT
als who reported higher levels of
dysfunction (total MFQ score) are
ported the greater levels of task
ctual (objectively measured) infor-
speed not being associated with
function. To speculate, the rela-
perceived memory and perceived
individuals with MOCA scores
range in the absence of objective
ion processing speed suggests that
dysfunction may be related more
factors than underlying structural

he visual search task, greater sub-

perceived memory impairment (in the absence of objective change in memory function) is related to structural change or metacognition (which is more likely to be responsive to intervention and treatment than structural change), or indeed whether a much more complex relationship exists between metacognition, structural change and actual and perceived functional integrity.

Information processing speed and perceived task difficulty

For Trails A, perceived task difficulty was not significantly correlated with objectively measured information processing speed. In contrast, perceived task difficulty was positively correlated with information processing speed for Trails B, i.e., slower information processing speed was associated with greater perceived task difficulty. For the target plus distracters condition of the visual search task, perceived task difficulty was not significantly correlated with objectively measured information processing speed. For the target alone condition however, perceived task difficulty was significantly negatively correlated with information processing speed, i.e., slower information speed was associated with a lower level of perceived task difficulty. This pattern of results indicates that, irrespective of perceived memory function, the judgement of task difficulty is related to the nature of the task and is not always related to actual performance.

Educational level

For both Trails A and B, educational level was

tion upon perceived task perfor-
task performance *per se* and a
n factors into account in research
nterpretation of study outcome.

s in each study cohort were rela-
n age 65 y). However, this is the
bjective memory changes are typ-
d when pathological changes of
disease start to become more com-
, including neuroimaging, needs
ctural and functional relationships
on processing speed, actual and
function and metacognition fac-
oups and in those seeking clinical
respect to mood and personality.
s also required to investigate why
do not approach health care ser-
erceived memory function. Some
e anxious about a formal diagno-
y may be developing dementia and
ossible reversible causes of impair-
nterventions to improve quality of

cipants on only one occasion and
o account the possibility that per-
ay fluctuate, as it can be due to
ons such as fatigue, or everyday
ts. Perceived memory was mea-
e MFQ. Related to this issue is the
ot able to determine the accuracy
his measure. Furthermore, we did
ry of tests objectively measuring
ition, while information process-

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