In the here and now: Short term memory predictions are preserved in Alzheimer's disease

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1   **Abstract**

2   According to neuropsychological models of anosognosia, there is a failure to transfer

3 on-line awareness of dysfunction into a more generalised long term belief about memory

4 function in Alzheimer's disease. This failure results in specific metamemory deficits for

5 global predictions: patients overestimate their performance before the task but are able to

6 monitor their memory performance after having experienced the task. However, after a delay,

7 they are still not able to make accurate predictions. As previous work has mainly focused on

8 long-term memory, the present study investigates this issue in short-term and working

9 memory. Using both global and item-by-item metacognitive judgements in a digit span task,

10 we showed that Alzheimer's disease patients are as accurate as older adults in monitoring

11 their performance despite impaired memory. When they have the opportunity to test

12 themselves, or when they have already performed the task, patients are able to use feedback to

13 adjust their metacognitive judgements. Overall, these results show that even for a relatively

14 complex task, patients with Alzheimer's disease are aware of their difficulties in the here-and-

15 now.

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17 **Keywords**: Metacognition, Short-term memory, Alzheimer's disease, Global predictions

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1   **In the here and now: Short term memory predictions are preserved in Alzheimer's**

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3   Metamemory, defined as the ability to monitor, regulate and predict one's memory

4   performance (Flavell, Miller & Miller, 2002) has often been explored in Alzheimer's disease

5   (e.g. Souchay, 2007; Sunderaraman & Cosentino, 2017). The literature has focused on

6   patients' ability to predict their memory performance on an upcoming test. Such predictions

7   can occur at an item level (i.e., how people expect to perform for each specific item) or a

8   global level (i.e., participants' expectations for their overall test performance). At the item

9   level, metacognitive tasks with episodic and semantic materials have showed a diversity of

10   spared and impaired performance (e.g., Bäckman & Lipinska, 1993; Souchay, Isingrini, &

11   Gil, 2002), supporting the idea that the metamemory impairment in Alzheimer's disease is a

12   consequence of the memory deficit (for a review see Ernst, Moulin, Souchay, Mograbi, &

13   Morris, 2016). Critically, experimental metamemory tasks are known to be related to clinical

14   classifications of awareness (e.g. Consentino, et al., 2016).

15   Fewer studies have explored metamemory in Alzheimer's patients using global

16   judgments but all have shown that patients overestimate their performance initially (Ansell &

17   Bucks, 2006; Barrett, Eslinger, Ballentine, & Heilman, 2005; Moulin, Perfect, & Jones,

18   2000a; 2000b). These studies also compared predictions made before (prospective

19   judgements) and after the task (retrospective judgements), finding that Alzheimer's patients

20   revise their predictions to accurate levels after having experienced the task (Ansell & Bucks,

21   2006; Moulin et al, 2000a; 2000b; Stewart, McGeown, Shanks, & Venneri, 2010). Thus

22   patients are poorly calibrated but they show intact awareness of their memory performance

23   after having experienced the task. Interestingly, after a delay, people with Alzheimer's disease

24   continue to overestimate their function even after having made accurate evaluations during a

25   task (Silva, Pinho, Macedo, Souchay, & Moulin, 2017): there is a failure to transfer the on-

1   line awareness of dysfunction into a more generalised long-term belief about memory

2   function. Several models have been proposed to explain awareness deficits in Alzheimer's

3   disease such as the Levels of Awareness framework (Clare, Marková, Roth, & Morris, 2011)

4   or the Cognitive Awareness Model (CAM, Morris & Mograbi, 2013). Such models converge

5   on a failure to consolidate their knowledge regarding their memory abilities over a long

6   period; *mnemonic anosognosia.*

7   To date, the bias in such research has overwhelmingly been towards examining the

8   ability to monitor long term memory. Clearly, however, the global judgements literature

9   reviewed above points to an ability to make accurate judgements in the short term which are

10   not maintained in the long term. Here we sought to directly assess the ability to monitor short

11   term memory, hitherto unexamined in Alzheimer's disease. Short-term memory underpins

12   many activities of daily living, and evaluation this domain is critical. Our experimental design

13   is based on Flavell's original design (Flavell, Friedrichs & Hoyt, 1970; see also Murphy,

14   Sanders, Gabriesheski, & Schmitt, 1981) and adapted by Bertrand, Moulin, and Souchay

15   (2017) in a recent study. A novelty of our protocol is that it allows the measure of both global

16   predictions and item-by-item judgements. As it has been suggested by previous work in

17   episodic memory, we hypothesised that Alzheimer's disease patients would be impaired on

18   initial global predictions (made before the task). However, according to the idea that on-line

19   metacognitive processes are intact, they should be preserved for item-by-item judgements and

20   global postdiction because these are based on access to short term representations of task

21   performance. Following standard practice in neuropsychological assessment, we examined

22   both forward and backward span, although we made no specific predictions about differences

23   between the two tasks, although the fact that backwards span is more demanding than forward

24   span may be of interest (although this difference between the two tasks is far from clear-cut,

25   e.g. Hester, Kinsella & Ong, 2004).

1   **Method**

2   **Participants**

3   Twenty-three older adults (M_{age} = 73.09, SD_{age} = 6.04; 17 females) and eighteen

4   Alzheimer's patients (M_{age} = 76.44, SD_{age} = 5.89; 6 females) participated in the study. The

5   healthy older adults were recruited from in the local community. Participants were defined as

6   cognitively healthy if they had a mini-mental state exam (MMSE; Folstein, Folstein, &

7   McHugh, 1975) score of 28-30.

8   All patients were recruited from the Memory Clinic at the Dijon university hospital.

9   Diagnosis was determined by a group of neurologists at the memory clinic. Patients had a

10   MMSE score ranging from 14 to 28 (M = 21.67, SD = 4.38). Participants were excluded if

11   they had a history of clinical stroke, traumatic brain injury, alcohol or drug abuse or

12   medical/psychiatric condition. The study was approved by the Institutional Review Board of

13   the Dijon Hospital.

14   **Materials and procedure**

15   For the two tasks (i.e., forward digit span and backward digit span), there were three

16   phases (for a summary of the entire procedure see Figure 1). The first phase was a global

17   prospective judgement task, where participants had to report how many digits they thought

18   they would be able to remember (from 0 to 9). The second phase was an online task where

19   participants gave item-by-item metacognitive judgements for the short-term memory task

20   (either forward digit span or backward digit span). Here, there were two types of judgements:

21   the prospective judgements (made before a trial) and the retrospective judgements (made after

22   the trial). Item-by-item judgements were made after being presented a set of digits of a

23   certain length: they were based on the participant's recent experience of the to-be-

24   remembered digits. Participants were presented with first one series of digits and then asked

25   whether they would be able to recall the number by giving a Yes/No answer. The number of

1 digits increased sequentially (to a maximum of 9), until the participants said 'No'. For

2 example, if after the presentation of 4 items a participant decided to say 'No', the item-by-

3 item judgement stopped, with the participants therefore predicting having a span of 3. Note

4 that in this paradigm, performance and predictions are not taken for the same trial. Rather,

5 there is blocked presentation, such that a first set of digit spans are used to make the item-by-

6 item prospective judgements, then there is the block of digit spans where recall is measured in

7 the standard fashion, and finally a third block where the retrospective item-by-item

8 predictions are made (see Figure 1). For the span tasks where recall was measured, the digit

9 forward and backward span tasks from the Wechsler Adult Intelligence Scale-IV (WAIS-IV,

10 Wechsler, 2011) were used. For the item-by-item judgements, lists of numbers matched in

11 length with the span task were created and these differed for the two judgements. Lists were

12 counterbalanced across judgements and participants. The third phase was a global

13 retrospective judgement task. As in the first phase, participants had to say how many digits

14 they thought they would be able to remember.
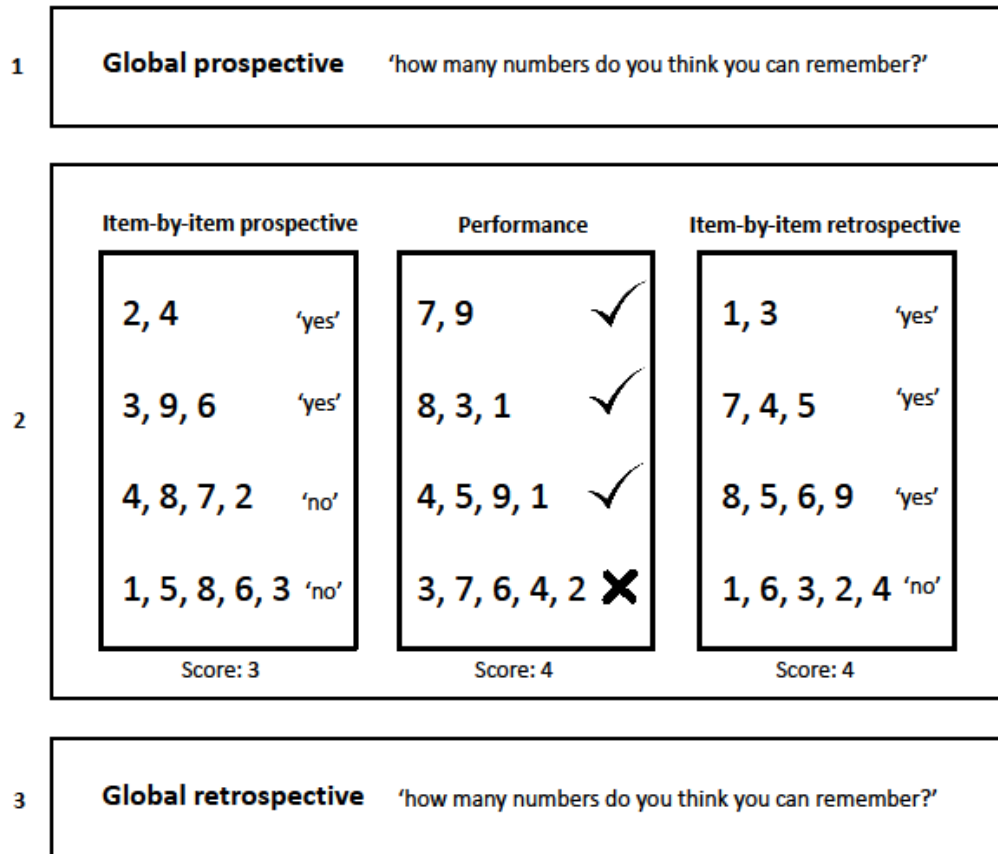
1
2 **Figure 1**. Summary of the procedure. The first phase is a global prospective judgement. The
3 second includes prospective judgements, the actual task (either forward span or backward
4 span) and retrospective judgements. The third phase is a global retrospective judgement.
5

6 **Data analyses**

7 Analyses were conducted in R and included linear regressions (yielding t statistics

8 which can be interpreted exactly as factorial ANOVAs) and Pearson's correlations. We use a

9 standard analysis protocol, starting by examining the mean recall (span performance) and the

10 mean prediction values (prediction magnitude). Then, we focus on metacognitive accuracy in

11 a standard fashion, considering the non-directional discrepancy between prediction and

12 performance (e.g., Moulin et al, 2000a). This procedure allows the estimation of

13 metacognitive accuracy independently from the bias (underestimation or overestimation of

14 performance). A score of zero reflects perfect accuracy and the higher the score, the bigger

15 the discrepancy between the metacognitive judgement and the performance (see Table 1).

1   [Following publication we will make the dataset and analysis script available on-line. Data

2   and script are part of the submission.]

3   **Results**

4   **Span performance**

5   The mean span performance for each group is found in Table 1. We conducted linear

6   regressions with group as a between-subjects factor and task as a within-subjects factor. As

7   expected, we found a main effect of group, revealing that Alzheimer's patients have a lower

8   performance than older adult controls, $t(39) = 3.28$, $p = .002$, $d = 1.03$. We also found a main

9   effect of task. Performance on the forward span was higher than performance on the

10 backward span, $t(39) = 6.20$, $p < .001$, $d_z = 0.97$, i.e. spans were significantly longer for

11 forwards rather backwards recall. There was no interaction between the two factors, $t(39) =$

12 1.36, $p = .180$, $d = 0.43$.

13 **Magnitude of metacognitive judgements**

14   **Forward span.** The mean values of predictions are given in Table 1. We conducted

15 linear regressions with, group, prediction time (prospective vs retrospective), and judgement

16 type (global vs item-by-item) as factors. Analyses revealed a significant effect of group, $t(39)$

17 $= 2.61$, $p = .013$, $d = 0.82$, and a non-significant trend of judgement type, $t(39) = 1.82$, $p =$

18 .077, $d_z = 0.28$. Patients made lower judgements overall than controls therefore predict

19 having a lower span, which is appropriate given the differences in performance reported

20 above. The analysis showed neither a significant effect of prediction time, $t(39) = 1.12$, $p =$

21 .269, $d_z = 0.17$, and we found no significant interactions (all $t(39) < 1.43$, and all $p > .05$).

22   **Backward span.** The mean values of predictions are given in Table 1. As for forward

23 span task, we conducted linear regressions with, group, prediction time (prospective vs

24 retrospective), and judgement type (global vs item-by-item) as factors. Analyses revealed

25 only that patients have a non-significant trend for lower judgements than older adults, $t(39) =$

1   1.85, $p = .072$, $d = 0.58$. The analysis again showed neither a significant effect of prediction

2   time, $t(39) = 1.33$, $p = .192$, $d_z = 0.21$, nor a significant effect of judgement type, $t(39) = 1.30$,

3    $p = .203$, $d_z = 0.20$. There were no significant interactions (all $t(39) < 1.29$, and all $p > .05$).

4   Whereas we found significant differences in magnitude of predictions for forward spans, no

5   such pattern was observed for the backwards span.

6

7   **Table 1**. Mean and standard errors for global judgements, item-by-item judgements, and
8   performance for AD patients and older adults.
9

	Forward span		Backward span	
	Older adults	AD patients	Older adults	AD patients
Global prospective	5.17 (1.03)	4.78 (2.02)	4.35 (0.78)	3.89 (1.81)
Item-by-item prospective	5.96 (1.26)	4.67 (1.88)	4.48 (0.95)	3.83 (2.04)
Performance	6.00 (1.09)	4.67 (1.14)	4.61 (1.31)	3.78 (0.94)
Item-by-item retrospective	6.26 (1.60)	4.89 (2.03)	4.96 (1.11)	4.00 (1.50)
Global retrospective	5.61 (1.26)	4.61 (2.00)	4.39 (0.84)	3.83 (1.62)

10
11

12   **Metacognitive accuracy**

13   **Forward span.** We conducted linear regressions with, group, prediction time

14   (prospective vs retrospective), and judgement type (global vs item-by-item) as factors. These

15   analyses showed neither a significant effect of group, $t(39) = 1.09$, $p = .284$, $d = 0.34$, nor a

16   significant effect of prediction time, $t(39) = 1.76$, $p = .086$, $d_z = 0.27$.   We did however, find a

17   main effect of judgement type, $t(39) = 2.18$, $p = .036$, $d_z = 0.34$. Global judgements were less

18   accurate that item-by-item judgments. There was also a significant interaction between

19   judgement type and judgement time, $t(39) = 2.17$, $p = .036$, $d_z = 0.34$. Retrospective

20   judgements are more accurate for global predictions, $t(39) = 2.41$, $p = .021$, $d_z = 0.38$, which

21   is not the case for item-by-item judgements, $t(39) = -0.56$, $p = .582$, $d_z = -0.08$. No other

1   interaction was significant (all $t(39) < 1.59$, and all $p > .05$). As there was no group

2   difference, these results show that patients are as accurate as controls at predicting their short-

3   term memory performance (Figure 2A).

4   **Backward span.** As for forward span task, we conducted linear regressions with,

5   group, prediction time (prospective vs retrospective), and judgement type (global vs item-by-

6   item) as factors. The analysis showed neither a significant effect of group, $t(39) = 1.47$, $p =$

7   .149, $d = 0.46$, nor a significant effect of judgement time, $t(39) = 0.51$, $p = .614$, $d_z = 0.08$, nor

8   a significant effect of judgement type, $t(39) = 1.45$, $p = .156$, $d_z = 0.23$. No interaction was

9   significant (all $t(39) < 1.23$, and all $p > .05$). For the backward span task, these results show

10   that patients are as accurate as controls at predicting their performance (Figure 2B).
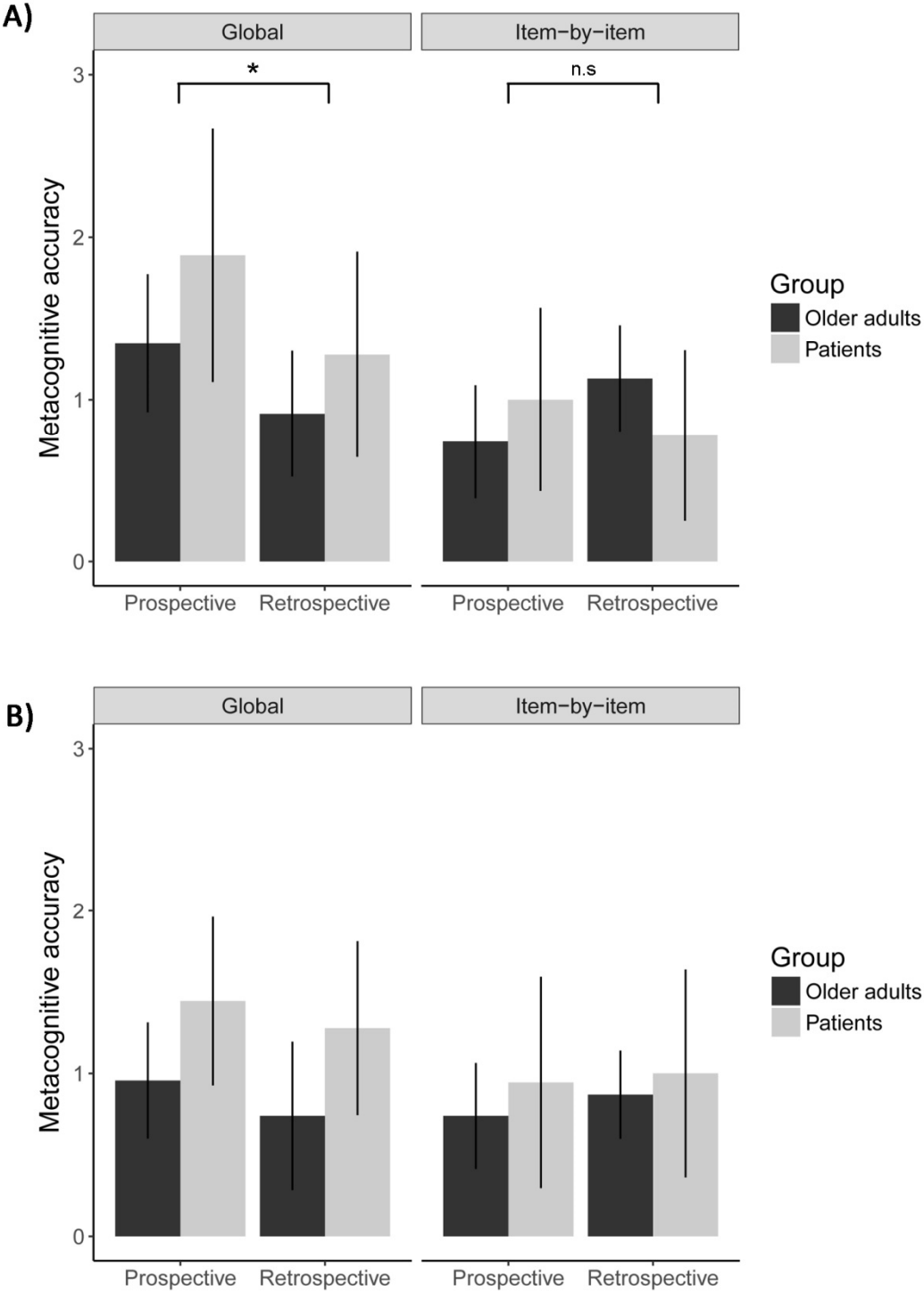
Figure 2. (A) Mean and confidence intervals for metacognitive accuracy according to judgement type, judgement time, and group for the forward span task. (B) Mean and confidence intervals for metacognitive accuracy according to judgement type, judgement time, and group for the backward span task.

1 **Correlational analyses**

2   In order to examine the accuracy at the group level, we analyzed the correlations

3 between the metacognitive judgements and digit span tasks. In these analyses, individuals'

4 predictions are correlated with individuals' performance, such that as a group, we can see if

5 those people with lower predictions actually have a worse performance (see Connor,

6 Dunlosky & Hertzog, 1997). Table 2 shows that this relationship is always positive except

7 for the global prospective judgements in both tasks where correlations are not significant.

8 The same analysis can be carried out for each group individually, to compare these

9 correlations for AD patients and older adults. Table 3 and Table 4 show that this relationship

10 is overall positive between judgement and performance (although not always significant)

11 except for the global prospective judgements in the forward span where correlations

12 coefficients are near 0. Moreover, there was no difference in the magnitude of correlation

13 across AD patients and older adults (all z value < |1.96|).

14

15 **Table 2**. Bonferroni corrected correlations between metacognitive judgements and
16 performance for both forward digit span and backward digit span. As there are 4 correlations
17 per tasks the significance threshold is equal to $0.05/4 = 0.013$.

	Forward span	Backward span
Global prospective	$r = 0.06, p = .727$	$r = 0.30, p = .057$
Item-by-item prospective	**$r = 0.66, p < .001$**	**$r = 0.45, p = .003$**
Item-by-item retrospective	**$r = 0.72, p < .001$**	**$r = 0.49, p = .001$**
Global retrospective	**$r = 0.47, p = .002$**	**$r = 0.43, p = .005$**

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21 **Table 3**. Bonferroni corrected correlations between metacognitive judgements and
22 performance for the forward digit span. As there are 4 correlations for each group the
23 significance threshold is equal to $0.05/4 = 0.013$.
24

	Forward span		
	AD patients	Older adults	*z* value
Global prospective	*r* = -0.03, *p* = .914	*r* = 0.04, p = .854	-0.21
Item-by-item prospective	**_r_ = 0.60, _p_ = .009**	**_r_ = 0.56, _p_ = .005**	0.18
Item-by-item retrospective	*r* = 0.47, *p* = .049	*r* = 0.20, *p* = .362	0.93
Global retrospective	**_r_ = 0.77, _p_ < .001**	**_r_ = 0.55, _p_ = .007**	1.21

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4 **Table 4**. Bonferroni corrected correlations between metacognitive judgements and
5 performance for the backward digit span. As there are 4 correlations for each group the
6 significance threshold is equal to 0.05/4 = 0.013.
7

	Backward span		
	AD patients	Older adults	*z* value
Global prospective	*r* = 0.26, *p* = .297	*r* = 0.37, *p* = .087	-0.37
Item-by-item prospective	*r* = 0.28, *p* = .256	**_r_ = 0.60, _p_ = .003**	-1.22
Item-by-item retrospective	*r* = 0.56, *p* = .015	*r* = 0.36, *p* = .098	0.77
Global retrospective	*r* = 0.17, *p* = .508	**_r_ = 0.65, _p_ < .001**	-1.82

8

9 **Discussion**

10   Previous studies of metacognition in Alzheimer's disease have focused on long term

11 memory. Here we investigated the awareness of short term memory and working memory.

12 We replicated the documented deficits in both digit span forward and digit span backward in

13 Alzheimer's disease (e.g. Morris & Baddeley, 1988). In addition, we showed that people with

14 Alzheimer's disease are as accurate as controls at assessing this function, despite the deficit in

15 performance. To consider the importance of this finding for our understanding of

16 metacognition and anosognosia in Alzheimer's disease, we must consider how participants

17 are able to make accurate judgements on these tasks.

18   Regarding item-by-item predictions, we propose that when given the digits to

19 memorise, even in the 'dry-run' prediction phase, participants test themselves. People with

1   Alzheimer's disease run through the digits presented, as do controls, and have access to

2   whether or not they will be able to complete the task. Because there are no dual demands of

3   performance and prediction, participants are able to directly report this information: in the

4   here-and-now they can accurately gauge whether they can retain (or retain and manipulate, in

5   the case of digits backward) the information. For retrospective judgements, where there is a

6   preservation in Alzheimer's disease in long term memory (e.g., Gallo, Cramer, Wong, &

7   Bennett, 2012; Moulin, James, Perfect, & Jones, 2003), patients are able to use correctly the

8   feedback arising from this self-test to make accurate predictions.

9   Turning to global predictions, we found that for the forward span the first prediction is

10   less accurate than the retrospective one and item-by-item judgements (for both patients and

11   older adults). This effect is also typically observed in long term memory tasks for Alzheimer

12   patients (e.g., Silva et al., 2017). Moreover, correlational analyses at the group level bring

13   additional evidence to this. It has been shown in both Alzheimer's disease (Silva et al., 2017)

14   and with older adults (Connor, Dunlosky, & Hertzog, 1997) very low correlations between

15   initial global predictions and performance. This was not the case for later retrospective

16   predictions. Thus, when they can experience the task, both older adults and Alzheimer's

17   disease patients update their knowledge about the task and make accurate judgements.

18   Although results are clear for the forward span task (i.e., significant difference and very low

19   correlation, $r = 0.06$), this is less the case for the backward digit span. We did not find a

20   significant difference in terms of accuracy for this task, and correlational analyses showed no

21   significant relationship between global prospective judgement and performance. However,

22   this low correlation was not different from the other three (Fisher's z, all $p > .05$). The

23   backwards digit span data do not therefore follow exactly the pattern of overestimation and

24   initial inaccuracy found in the Alzheimer's group on previous long term memory tasks and

25   here in our own experiment. Critically, we find no evidence for any group differences in

1   accuracy or magnitude of predictions on this task either. We might hypothesise in general

2   that people anticipate the backwards digit span is a difficult task.

3   It is important to discuss the large variability for accuracy in patients. It is possible

4   that more patients overestimate their performance (see supplementary results). We counted

5   the number of participants who overestimated and indeed found that patients overestimate

6   more than controls for the prospective global prediction. For the forward span, 33% of

7   patients overestimate their performance compared to 17% for controls. The same is observed

8   for backward span, 56% of patients overestimate their performance compared to 26% for

9   controls.

10   Overall, patients and controls have the same judgement accuracy distributions (see

11   supplementary results). This result has implications for metacognition and anosognosia more

12   generally in Alzheimer's disease. Despite having a deficit in short-term and working

13   memory, the patients with Alzheimer's are nonetheless able to reliably report their difficulties

14   with this task: the magnitude of judgements is different from controls (although a trend for the

15   backward span). This is in direct contrast with tasks which require memory retrieval. On

16   (long term) episodic memory feeling of knowing tasks (e.g. Souchay et al., 2002), patients are

17   unable to reliably gauge whether a previously studied word is available or not when tested by

18   recognition. This is proposed to be due to the impoverished information available to the

19   person with Alzheimer's disease: they cannot evaluate their memory accurately, because they

20   cannot retrieve from memory enough pertinent information on which to base their judgement.

21   In contrast, even for a relatively complex task, such as reversing and repeating a series of

22   digits as tested here, in the here-and-now patients with Alzheimer's disease are aware of their

23   difficulties.

24   Taken together, these results support the idea of a preservation of online monitoring in

25   Alzheimer's disease. When they can test themselves or when they have already performed

1   the task, both older adults and patients are able to use the performance feedback to adjust their

2   metacognitive judgements. Naturally, this has major clinical implications. On-line, whilst

3   struggling with a task, a patient with Alzheimer's disease will be aware of their difficulties,

4   even if when asked later they are not aware of how difficult the task was, or indeed, when

5   encountering the same task again, they will not beforehand know how difficult they will find

6   it. It would be important to replicate the likely deficit for patients in initial global prediction

7   and to add a second trial after a delay. If this impairment is also found for a second trial, this

8   would be in line with the failure to transfer information from online evaluations into long-

9   term representations (Morris & Mograbi, 2013). Interestingly, Stewart et al. (2010) show that

10   whilst global judgements may be accurate for long term memory tasks, the accuracy that is

11   acquired is forgotten as soon as one hour later. We add another task to the literature for which

12   people with Alzheimer's can accurately gauge their performance. The impact of this work is

13   that people with Alzheimer's are able to reflect upon their performance in a task which is

14   critical for daily function: short term memory.

15   Anosognosia, however, is likely to remain a multifaceted construct, with varying

16   causes and manifestations. Whilst it is clear memory mechanisms are pertinent to tasks which

17   involve memory, different domains should be compared (Chapman, Colvin, Vuorre, et al.,

18   2018) and the involvement of other process such as executive function (Scherling, Wilkins,

19   Zakrezewski, et al., 2017) perspective taking (Serino & Riva, 2017) , and emotion (need to be

20   examined in detail (Bertrand, Dourado, Laks, et al., 2016).

21

3

4   **Conflict of interest**

5   The authors have no conflict of interest to report.

6

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1   **Supplementary results**

2   To explore more deeply the accuracy of metacognitive judgements in both patients and

3   older adults we calculated the signed difference between judgements and performance. For

4   all judgements we then plotted the number of patients and older adults according to the signed

5   accuracy score (Figure 3). We computed Chi² to compare distributions of accuracy in both

6   group. These analyses revealed no difference for the forward span task, $X^2 = 56.83$, $p = .179$,

7   and the backward span task, $X^2 = 41.25$, $p = .251$.

8   Using the signed difference between judgements and performance for global

9   prospective judgement only, we classified both patients and older adults in 3 categories:

10   accurate (when accuracy was equal to 0), underestimators (when accuracy was negative), and

11   overestimators (when accuracy was positive). Table 2 and 3 show the frequency of each

12   category for patients and controls.

13

14   **Table 2**. Frequency of overestimators, accurate estimators, and underestimators for patients
15   and older adults for the forward span task.

	Underestimators	Accurate	Overestimators
Older adults	0.61	0.22	0.17
Patients	0.44	0.22	0.33

16

17   **Table 3**. Frequency of overestimators, accurate estimators, and underestimators for patients
18   and older adults for the backward span task.

	Underestimators	Accurate	Overestimators
Older adults	0.43	0.30	0.26
Patients	0.27	0.17	0.59

19

1
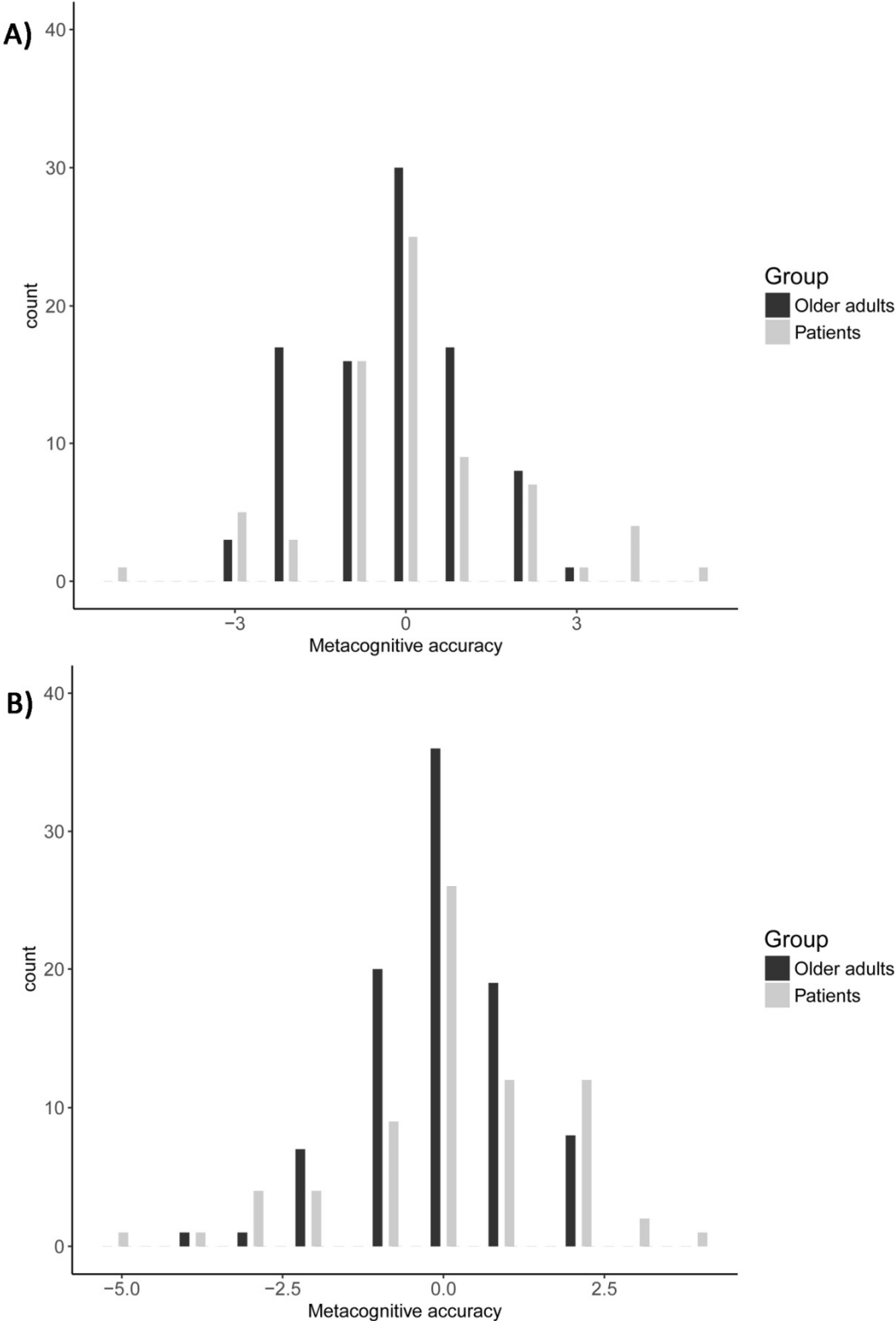
Figure 3. (A) Distribution of metacognitive accuracy for all judgements for patients and older adults for the forward span task. (B) Distribution of metacognitive accuracy for all judgements for patients and older adults for the backward span task.

1   Finally, we focus here on analyses regarding accuracy of judgement we outliers

2   exclusion. We chose to report them here as the excluded participants are two patients (i.e.,

3   one for forward span and one for backward span). We understand that excluded patients

4   might be tricky in a sense that they might have a non-normal behaviour by definition. These

5   outliers were excluded because they had a gap in Cook's distance more that three and a

6   Studentized Deleted Residuals < |4|.

7   **Forward span.** Analyses showed neither a significant effect of group, $t(38) = 0.98$, p

8    $= .335$, $d = 0.31$. We did however, find a non-significant trend main effect of judgement type,

9    $t(38) = 1.96$, $p = .058$, $d_z = 0.31$, and a main effect of judgements time, $t(38) = 2.62$, $p = .012$,

10   $d_z = 0.41$. Prospective judgements were less accurate than retrospective judgements. There

11   was also a significant interaction between judgement type and judgement time, $t(38) = 3.42$, p

12   $= .002$, $d_z = 0.54$. Retrospective judgements are more accurate for global predictions, $t(38) =$

13   4.16, $p < .001$, $d_z = 0.66$, which is not the case for item-by-item judgements, $t(38) = -0.69$, $p =$

14   $.494$, $d_z = -0.11$. We also find a significant interaction between judgement time and group,

15   $t(38) = -2.42$, $p = .020$, $d = -0.77$. However, when we observed simple main effects, we just

16   find a trend for a less accurate prospective judgements for patients, $t(38) = -1.88$, $p = .068$, $d =$

17   0.60, and no difference for retrospective judgements, $t(38) = 0.41$, $p = .688$, $d = 0.13$. No

18   other interaction was significant (all $t(38) < 1.01$, and all $p > .05$).

19   **Backward span.** As for forward span task, we conducted linear regressions with,

20   group, prediction time (prospective vs retrospective), and judgement type (global vs item-by-

21   item) as factors. The analysis showed neither a significant effect of group, $t(38) = 1.47$, $p =$

22   $.149$, $d = 0.47$, $d_z = 0.01$, nor a significant effect of judgement time, $t(38) = 0.09$, $p = .929$, nor

23   a significant effect of judgement type, $t(38) = 1.14$, $p = .261$, $d_z = 0.18$. No interaction was

24   significant (all $t(38) < 0.84$, and all $p > .05$).