



The effects of repetition on allocation of study time and judgements of learning in Alzheimer's disease

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Abstract

Greene et al. [12] suggest that Alzheimer's disease (AD) patients approach repeated trials in a learning test as if they are single unrelated trials. Previous research [7] indicates that AD patients do not have explicit memory for item repetition when asked at test how many times a word was presented, but they do show benefits of repeated presentation in implicit tasks. In this experiment we examine metacognitive judgements made during study for repeated items. It was hypothesised that a lack of awareness of repetition may exacerbate the episodic memory impairment found in AD. To explore this, two measures of metamemory were taken for items presented once, twice or three times in a list: *judgements of learning* (JOLs), which are a declaration of how well an item has been learned, and *recall readiness*, which is the study time allocated by participants to ensure proficient learning of an item. With repetition, age matched controls made recall readiness judgements more quickly and reported higher JOLs. The AD patients showed faster recall readiness, but did not alter their JOLs. This suggests a dissociation in the AD group between judgements of learning and the allocation of study time. We discuss the implications for theories of the learning deficit in AD, and the use of metamemory measurements in clinical populations. © 2000 Elsevier Science Ltd. All rights reserved.

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1. Introduction

Long term memory is the most profoundly affected cognitive domain in AD [13]. In particular, AD is characterised by poor performance on tests of episodic memory, although there is some evidence that a semantic deficit is involved in the episodic breakdown [10]. One prevalent theme in previous research is that the LTM deficit stems from dysfunctional encoding or consolidation processes, as opposed to rapid forgetting [5,11,12]. This marked long term memory failure in

AD is proposed to be due to pronounced cell death in medial temporal and hippocampal regions [8].

In this paper we focus on one aspect of encoding behaviour: the response to repetitions of stimuli. There is much evidence of episodic dysfunction that comes from paradigms that repeatedly present stimuli to participants (e.g., the Californian Verbal Learning Test [6], the Hopkins Verbal Learning Test [4]). A typical finding with such materials is that AD participants' recall does not benefit from repetition to the same extent as controls. This raises the question why AD patients do not benefit from repetition as much as controls. In this paper we explore the possibility that this is due to metacognitive factors that operate during encoding.

Downes [7] investigated awareness of repetition in demented and normal elderly groups. In his study, participants were presented words either once, twice or

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four times. In a version of a yes/no test (i.e. a mixture of old and new words), participants had to estimate how many times a word had been seen. Downes found that although every group showed a significant effect for frequency estimation (i.e. participants estimated higher frequency for the words presented on more occasions), the demented group's mean estimates of frequency only significantly increased between 0 and 1 presentations. Downes suggested that the AD group could not discriminate between singly presented and repeated words, only whether or not a word had been presented or not.

A second phase of Downes' experiment used word fragment completion to assess implicit memory. It was found that relative to baseline, the demented group was not impaired at completing word fragments. Furthermore, although the demented group did not show explicit awareness of repetition, they showed normal levels of benefit from repetition on a word fragment completion task, suggesting a benefit to implicit memory for repetition during encoding. This dissociation shows that an explicit measure (frequency estimation) is not sensitive to repetition (in line with findings for recall) but an implicit measure (stem completion) is sensitive. This supports findings that explicit memory in AD is impaired, whereas implicit memory is intact [28], and extends theory by indicating that judgements like frequency estimates are based on explicit, rather than implicit processes.

Whilst Downes' study does not directly assess processes that occur during encoding, it raises interesting questions about processing in AD. One interpretation of Downes' study is that AD participants may not monitor memory appropriately during a verbal learning task because they are not aware that items are repeating, even though implicitly, performance may benefit. Further support for indirect benefits from the repetition of information in AD comes from reading time and Event Related Potential (ERP) studies. Wiggs et al. [31] examined participants' monitoring of frequency by an indirect measure of reading time. AD patients were not able to recall as many novel words (Turkish words) as controls (a direct test). However, they did show faster reading times during encoding for items that had been presented more frequently (an indirect benefit). Kazmerski and Friedman [17] presented AD patients and controls with three repeated trials of to-be-remembered words. All subjects produced significant ERP activity that was more positive for repeated items, and which related to their faster reaction time to identifying items as old after more presentations. Another study [30] found that even with an AD group who were impaired in a recognition test, there was still the same speeded response and ERP repetition effect. This suggests that the underlying cognitive and neural functions as measured by ERP are

intact in AD. Therefore, AD participants may not be aware of the benefits of repetition, even if aspects of implicit memory and ERP techniques show that AD patients' performance is facilitated by repeated presentations of items. Importantly, these studies suggest that AD participants are not aware of repetition when asked *at test* to report how many times an item was presented. However, it is not known whether an inability to detect repetition influences factors that operate during study.

The present study concentrates on encoding factors in order to explore why AD patients fail to benefit from repetition as much as controls. This follows the suggestion by Greene, Baddeley and Hodges [12] that people with AD approach multiple presentations of lists as if they are trying to remember a single unrelated trial. Their evidence of this was based on the fact that older adult controls are more reliant on the contribution of primary memory (i.e. the recency portion of a list) in the first trial, but by trial three 'have apparently abandoned a recency strategy' (p. 545). In comparison, the AD group continues, across trials, to rely upon recalling items from the recency portion of the list.

The data upon which Greene et al. draw their conclusions is recall performance and so does not directly address the question of how AD patients encode repeatedly presented words. For example, it may be the case, as Greene et al. argue, that AD patients are unaware of repetition and treat repeated presentations in the same way as novel presentations. Alternatively, they may encode them differently, but a subsequent failure at consolidation or retrieval results in apparent loss of benefit for repetition. The only way to assess the theoretical claims made by Greene et al. is to examine encoding directly, which is the primary aim of the current study.

In particular, we intended to examine two possible repetition-based deficits that AD patients may show during encoding. First, they may be unaware of repetition, and fail to act on this. Second, they may be aware of repetition, but fail to act appropriately. We adopted Nelson and Narens' [26] approach, which focuses on *monitoring* and *control* aspects of metacognition. This framework specifically refers to the cognitive processes that concern memory, and suggests that by means of feedback from memory monitoring, items are mastered through memory control (i.e. the allocation of cognitive resources). In this framework, metacognition can be thought of as a regulatory system by which to-be-remembered items are mastered. We compared two empirical measures that reflect metacognitive functioning: judgements of learning (JOLs) - an explicit measure of metamemory monitoring, and the allocation of study time (recall readiness) - a measure of memory control. Also, recall readiness

relies on memory monitoring, since it is not possible to allocate study time appropriately without memory monitoring. JOLs are ratings of how well an item has been learnt, expressed as a prediction of how likely a given item is to be recalled. The recall readiness paradigm simply offers participants as much study time as they feel is necessary to master an item.

The relationship between JOLs and allocation of study time has been examined in normal populations. Mazzoni and Nelson [19] demonstrated that JOLs are sensitive to aspects of encoding behaviour that are independent of the level of recall, suggesting that JOLs reflect monitoring of encoding processes. It has long been known that participants allocate more time to items that are objectively more difficult [3]. Nelson and Leonesio [25] found that ratings of future recallability were reliably related to study time allocation, with more study time being allocated to the more difficult items. However, a robust finding is that, even when instructed to master every item, and given an unlimited time to study, participants do not recall every item. Nelson and Leonesio suggest that large increases in self-paced study time yield very small increases in recall. They termed this the *Labor In Vain* effect. However, Nelson [24] also suggests that people's JOLs can serve to enhance overall learning by influencing the allocation of study time to the more difficult items. With reference to repetition, Metcalfe [22] suggests that monitoring and control of episodic memory enables the assessment of the familiarity or novelty of incoming events and the subsequent adjustment of attention or effort to those events.

Previous research into metacognitive function in AD suggests that participants monitor their memory performance as accurately as controls for general knowledge stimuli [2]. These studies are all limited in their ability to address functioning during encoding, since they ask participants to make judgements following test, and moreover, concentrate on semantic, not episodic materials. To explore the relationship between memory monitoring, memory control and recall performance, it is necessary to examine metacognition during encoding. The only previous research that does address metacognitive abilities during encoding of episodic stimuli [23] shows that AD patients are sensitive to objective differences in stimuli at encoding. That is, like controls, AD patients allocate more study time to objectively difficult items, and also give JOLs that reflect the differences in difficulty of the words. These findings are for single presentations of to-be-remem-

bered stimuli, and are limited in their ability to address the repetition deficit. Therefore, in the present experiment, we expand on this work by examining whether AD patients are sensitive to the repetition of items during encoding.

To summarise, previous work on awareness of repetition *at test* suggests that Alzheimer's disease patients cannot accurately report how many times an item was presented. This present work aims to establish whether a similar deficit during study could explain AD patients' poor encoding relative to controls in tasks which repeat items during presentation.

2. Method

2.1. Participants

There were two groups of 16 participants; AD patients and older adult controls (OAC) who had volunteered to take part in the study. Diagnosis of AD was made by a clinician using information from neuropsychological examination, Mini-Mental State Examination (MMSE, [9]), family interview, laboratory screening (i.e. haematology; B12 and folate levels; renal, liver and thyroid function; calcium and syphilis serology) and medical examination. Patients were diagnosed as being demented with the DSM III-R criteria [1] and as having AD by the NINCDS-ADRDA criteria [21]. If there was a suggestion of a psychiatric disorder, patients were also assessed by a psychiatrist. Patients with a history of stroke or depression were excluded from this study. Patients were excluded from this study if they had a Hachinski score [14] that indicated they might have a vascular component to their dementia. The older adult controls were screened for dementia before being admitted to the University of Bristol's volunteer panel. The participant characteristics are shown in Table 1. There were no significant differences between groups for age ($F(1,30) < 1$) or education level ($F(1,30) < 1$).

2.2. Stimuli/materials

The word list was composed of 12 items, and four words were assigned to each level of item repetition (1, 2, or 3 presentations). All words were matched for recallability according to recall norms [29], with a mean recallability proportion of 0.65 indicating that these words were relatively easy to recall.¹

2.3. Procedure

Participants were tested individually in a quiet testing room. They were instructed that they would be visually presented some words on a computer screen,

¹ The words used, and their FRA rating (probability of free recall across three trials) were Body (0.63), Dirt (0.63), Elbow (0.66), Flood (0.61), Fork (0.65), Jail (0.69), Kiss (0.65), Law (0.63), Monk (0.66), Oats (0.65), Restaurant (0.64), Tool (0.67).

Table 1
Means (SD) for age, MMSE and education level for Alzheimer's disease and older adult controls groups

Group	Age	MMSE ^a	Years of formal education
Alzheimer's disease	78.3 (5.8)	16.6 (3.9)	11.1 (3.1)
Older adult controls	77.1 (3.9)	–	12.2 (3.3)

^a Mini-Mental State Examination [7].

and would be required to remember as many items as possible. Participants were instructed that they could study each item for as long as they liked in order to maximise their chance of remembering the word later (recall readiness instruction). After they had declared recall readiness, participants were asked to rate the word on a five point Likert scale (JOL instruction). This scale asked the participant to judge how easy the word was to remember on a five point scale (1=very hard to 5=very easy). Participants were instructed that some items would be repeated at presentation, and to treat these repetitions as an opportunity to learn the words better.

There were three phases to this experiment: presentation, recall and recognition. Words were presented individually on a computer screen, and remained on the screen until the participant declared recall readiness. The computer measured the study time allocated to each item. The three levels of repetition of the items meant that there were 24 trials (i.e. $4 \times 1 + 4 \times 2 + 4 \times 3$). The 24 trials were presented in a pseudo-random order with no word repeated immediately in succession. The list was designed in such a way that there was an even distribution of repetition throughout: for items repeated once, twice or three times, the repetitions were evenly spaced throughout

the list. This meant that an item seen at the end of a list was not necessarily one that had been presented more frequently. Immediately after presentation of each word and whilst it was no longer visible on the computer screen, the participants were prompted by a visual reminder of the Likert scale to rate the recallability of the word. Participants declared both recall readiness and their JOL verbally, and the experimenter advanced the presentation phase at a rate dictated by the participant.

Immediately after the presentation trials there was a free recall test, and following that there was a visually presented yes/no recognition test. This consisted of 12 targets and 12 distracters, matched for recallability from the recallability norms [29] presented in a random order. Participants responded verbally to the test items.

3. Results

3.1. Memory performance

Recall and recognition performance for each level of item repetition is shown in Fig. 1. Memory performance was analysed by 2×3 (group \times item repetition) repeated measures ANOVAs. The respective mean items recalled (and standard deviations) for words presented once, twice and three times were: 0.06 (0.25), 0.19 (0.40), 1.06 (1.24) for the AD group, compared with 1.19 (0.98), 2.44 (0.89), 3.44 (0.81) for the OAC group. There was a main effect of group ($F(1,30)=91.87$, $P < 0.001$), with controls out-performing the AD group. There was a main effect of item repetition ($F(2,60)=42.82$, $P < 0.001$) such that

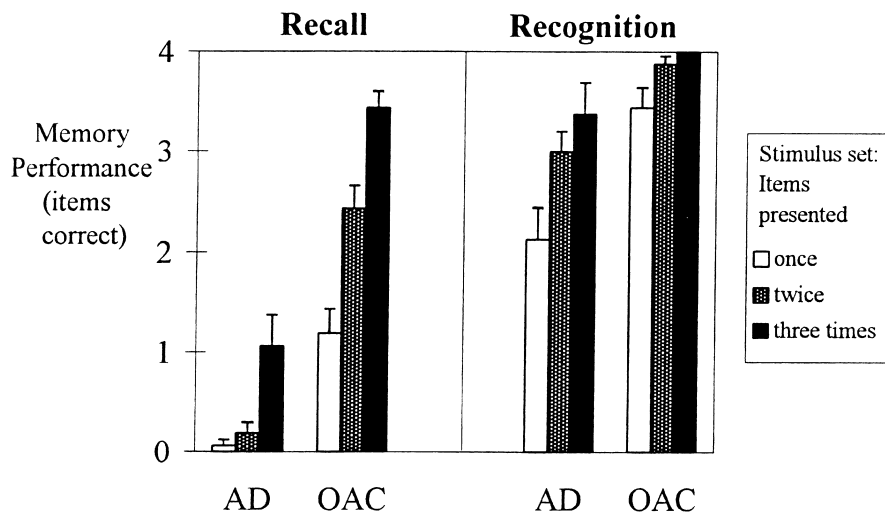


Fig. 1. Mean Memory Performance for item repetition, Alzheimer's disease (AD) and older adult control (OAC) groups. Error bars=1 standard error.

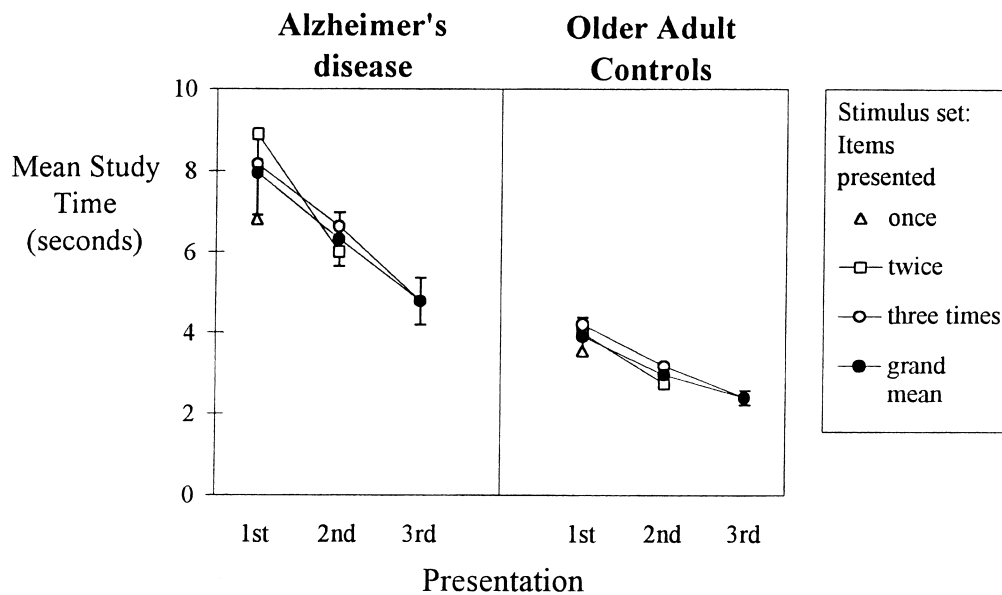


Fig. 2. Mean study time by stimulus set and presentation, Alzheimer's disease and older adult control groups. Error bars = 1 standard error.

both groups' recall increases with repetition: both AD and OAC groups benefit from repeated presentation of to-be-remembered items. There was also a significant interaction ($F(2,60)=7.63$, $P < 0.005$), suggesting that there are differences between the groups memory performance at different levels of item repetition. Simple main effects explored this interaction. It was found that both groups significantly discriminated between item repetition in their recall performance (AD: $F(2,60)=9.55$, $P < 0.001$; OAC: $F(2,60)=40.89$, $P < 0.001$). However, Bonferroni corrected paired sample t -tests show that in the AD group the difference between recall for items presented once and twice is not significant ($t(15)=-1.0$, n.s.), whereas there was a significant difference between words presented twice and three times ($t(15)=-2.78$, $P < 0.025$). For the OAC group there was a significant difference between recall for items presented once and twice ($t(15)=-5.84$, $P < 0.001$) and items presented twice and three times ($t(15)=-4.14$, $P < 0.005$).

For recognition, we analysed the number of correct responses, that is, participants judging an old word as one they had seen before. The respective means (and standard deviations) for items presented once, twice and three times were: 2.12 (1.25), 3.00 (0.82), 3.37 (1.26) for the AD group and 3.43 (0.63), 3.87 (0.81), 4.0 (0.00) for the OAC group. There was a main effect of group ($F(1,30)=18.72$, $P < 0.001$), with the OAC group performing better, in line with the results for recall. There was a main effect of item repetition ($F(2,60)=11.89$, $P < 0.001$), indicating better recognition performance with repetition. However, the interaction was not significant ($F(2,60)=1.64$, n.s.). This indicates that all groups' recognition performance ben-

efits from item repetition to the same degree. However, as the means show, it is difficult to compare recognition performance in the OAC group since all members of the control group recognise all items that were presented three times. Thus, ceiling effects are problematic in the recognition task, whereas floor effects were a problem (for the AD group) in the recall task. Because of this it is difficult to compare the two groups' responses to repetitions of stimuli directly. Nevertheless, it is clear that when each group is within an acceptable range of performance (i.e. AD recognition, OAC recall), both groups show a benefit in their recall performance as a result of repetition.

It is worth mentioning the error rates in each group. Here we describe false alarms made by each group — where a participant erroneously judges a new word as being seen before. The mean false alarm rate in the AD group was 2.37 (SD=2.53), whereas the OAC group did not make any false alarms. This suggests that the AD group was more prone to guess an answer, but it is reasonable to assume that guessing was constant across the three levels of repetition, and as a result does not influence the recognition results.

3.2. Analysis of study time and judgements of learning

There are two ways in which the recall readiness and JOL data can be analysed. One can examine the means at each level of item repetition for all items (i.e. the 1st presentation of each word vs the second presentation vs the third presentation). For both recall readiness and JOLs this analysis was conducted first. However, because this analysis confounds presentation frequency with items (all 12 items are presented once,

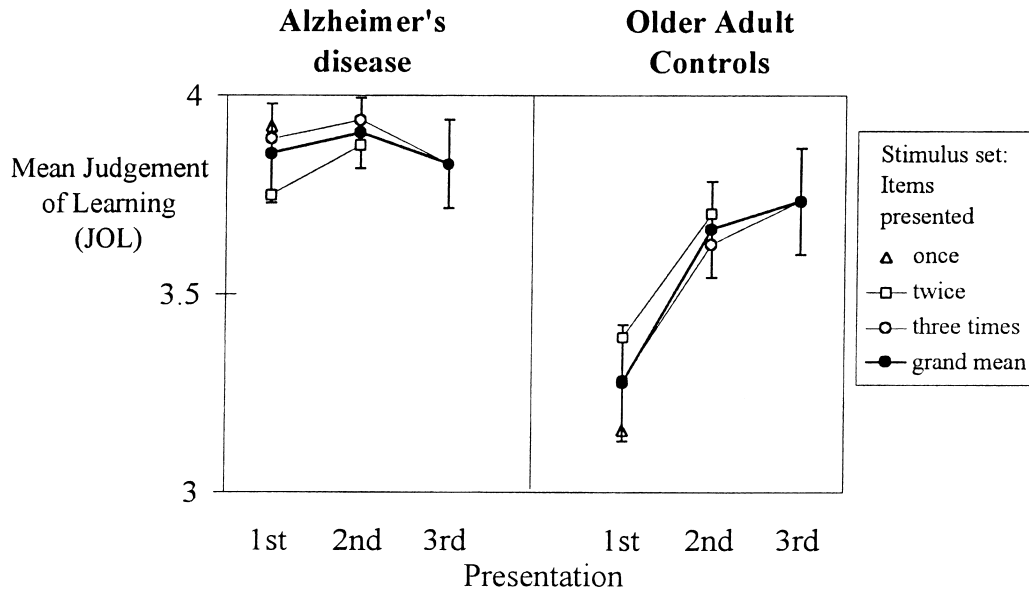


Fig. 3. Mean judgement of learning (JOLs) by stimulus set and presentation, Alzheimer's disease and OAC groups. Error bars=1 standard error.

but only eight are shown twice, and four shown three times), we also analysed the effects of repetition only for those items that were presented three times in all. In fact, the results are entirely consistent whichever way they were analysed, and so we only report the former. In order to clarify the effects of repetition on the different items, Figs. 2 and 3 show the means for each set of items separately (i.e. items presented once, twice or three times) as well as the overall mean at each level of repetition.

3.2.1. Allocation of study time

Fig. 2 shows the time allocated to studying words before recall readiness was declared. The mean study time in seconds (and standard deviations) for items presented once, twice, and three times (respectively) were: AD 7.96 (4.13), 6.17 (2.86), 4.78 (2.30); OAC 3.85 (1.96), 2.92 (1.08), 2.25 (0.62). There was a main effect of group ($F(1,30)=18.88$, $P < 0.001$), with longer study times for the AD group, and of trial ($F(2,60)=22.64$, $P < 0.001$), with study time decreasing with repetition. The interaction approached significance ($F(2,60)=2.86$, $P = 0.065$) suggesting a difference in the groups' allocation of study time across repetition. However, as Fig. 2 shows, the interaction is such that the AD group are more sensitive to repetition than the OAC group.

3.2.2. Judgements of Learning (JOLs)

Fig. 3 shows the mean JOL rating given at each level of item repetition. The mean JOL (and standard deviations) for items presented once, twice and three times (respectively) were: AD 3.85 (0.50), 3.91 (0.35), 3.83 (0.44); OAC 3.27 (0.59), 3.66 (0.49), 3.73 (0.44).

The main effect of group approached significance ($F(1,30)=3.78$, $P = 0.061$), with the AD group more confident of their future performance than the OAC group. There was a main effect of trial ($F(2,60)=7.78$, $P < 0.005$), with participants rating words that they had seen more frequently as being easier to recall. There was also a significant interaction ($F(2,60)=7.55$, $P < 0.001$). This interaction was explored using simple main effects. It was found that although the OAC group did discriminate significantly across trials in their JOLs ($F(2,60)=14.95$, $P < 0.001$), the AD group did not ($F(2,60) < 1$).

These results suggest that OAC participants display more sensitivity to repetition in their JOLs than AD participants do. The OAC group starts off making more conservative predictions of performance, rating the words as being more likely to be recalled with greater item repetition. The AD group, on the other hand, is entirely insensitive to repetition in their explicit predictions of performance (JOLs).

4. Discussion

This experiment was concerned with the effects of repetition on the memory performance of older adults and AD patients. In terms of explicit memory performance, there was a clear benefit of repetition, with repeated items being recalled and recognised better by both groups. However, the data indicate that the two groups differ with regards the effects of repetition at encoding. The older adults show repetition effects for both study time and their explicit judgements of how well they have learned the items. This is not the case

for AD patients. Whilst they show the normal pattern of performance for study time — they allocate less time for repeated items — their explicit rating of how well they have learned the item is insensitive to repetition. This pattern of findings cannot be ascribed to an inability to make valid predictions of performance using the JOL scale, since previous research has shown that AD patients can make JOLs which are sensitive to other factors that operate during encoding [23]. Thus we conclude that although their explicit memory performance and their study time are affected by repetition of items, the AD patients do not appear to be aware of this when they judge how likely it is that they will recall an item.

As well as being insensitive to repetition, we found a strong trend that the AD groups' JOLs were more confident than the control groups', indicating that they expected a higher level of subsequent memory performance than the control group did. The typical finding of studies into metacognition in AD is that AD patients are less confident than controls for item-judgements made after test [27]. The incongruity between our findings and previous metacognitive judgements could result from the fact that our judgements are made before, rather than following test. When AD patients predict their performance before test on an episodic task using a list based procedure (i.e. predicting how many items from a list they will recall), the typical finding is that the AD group significantly overestimate performance [20]. Therefore, this study has extended the previous findings of over-confidence for list-based predictions of performance to an item-by-item procedure.

In terms of the monitoring and control framework [26], the results of the present study are problematic because the control of memory (e.g. as measured by allocation of study time) is theorised to be reliant upon proficient memory monitoring (e.g. as measured by JOLs). This framework suggests that by monitoring an item it is possible to judge how much study time should be devoted to it. We have found that a measure of memory control is related to repetition, whereas a measure of memory monitoring is not. Consequently, it is argued that the monitoring measure (JOLs) used in this task are tapping a different aspect of memory monitoring than is captured by the allocation of study time. What appears to be happening is that both memory performance and study time are affected by the number of times an item has been presented, but for AD participants there is no conscious awareness of this at study. Therefore, the results of this study support the findings found for judgements of frequency made at test [7]. In the same way that judgements of frequency at test are inaccurate in AD, JOLs made at encoding are not sensitive to item repetition.

Explicit memory may therefore be improved by fac-

tors that are not necessarily being monitored at encoding. This conclusion is consistent with other research showing that memory performance can benefit from factors that are non-monitored. For example, Jameson et al. [16], using a near-threshold priming paradigm with a student population introduced the idea that there were both non-monitored and monitored components of memory that can be combined in the successful retrieval of an item. In their study they found that metamemory judgements (feeling of knowing) were not sensitive to near-threshold priming, although the priming did significantly improve participants' memory performance. Conscious memory monitoring (or memory awareness), therefore, is not a necessary component of improving memory performance. If one continues to use a control and monitoring approach, this suggests that there are control and monitoring processes that are not necessarily available for the participant to report. In this present study, the older adult controls are consciously aware of the benefit of repetition, but the AD group appear not to be.

This suggests that in AD explicit memory monitoring and control may be impaired, but the automatic aspects of metacognitive functioning that occur during study are intact. This parallels the distinction between implicit and explicit memory in Alzheimer's disease. In general it has been shown that whereas explicit memory is in deficit in AD, the automatic, or implicit aspects of memory are preserved [18,28]. Just as AD patients show speeded response for words that have been repeatedly presented but do not consciously recall them, here AD participants show differences in metamemory processing as measured by study time, but not as measured by participants' declarations of level of learning (JOLs). This suggests that the allocation of study time does not necessarily reflect deliberate memory control processes, but is rather an automatic response to repetitions of stimuli. Nelson and Narens [26] suggest that metacognitive research proceeds through "... *monitoring constructs typically being operationalized via an introspective report (e.g. EOL [ease of learning] judgement) and control constructs being operationalized by some other empirical outcome (e.g. elapsed time during self-paced study)*" (p.131). The results of the present study indicate that in memory impaired populations, the comparison of explicit declarations of memory monitoring with less direct measures of control is not a useful means of understanding the separate contributions of memory monitoring and memory control.

One possibility is that the AD group does not show an effect in their JOLs for ratings because they have forgotten the item in between repetitions of presentation. If a participant has forgotten an item, then presumably they will rate it as they would a novel stimulus. The contrast between the implicit and explicit

measures of metacognition would arise from the fact that the AD participant cannot recognise the item as being presented before, although they do show implicit memory for the item in their allocation of study time. As such our findings would support the research into reading time in Alzheimer's disease described above [31]. However, a fast-forgetting account seems unlikely because if items were being forgotten in-between each presentation, then we would not expect to see the benefit of repetition in the memory performance of people with AD as shown here.

If there is a metacognitive deficit as evidenced by this work, then it is that the AD group is not consciously aware of the benefits of repetition. This suggests that an explanation of the encoding deficit observed in AD is that participants may not be able to consciously control memory in a verbal learning task. Although there is no evidence of a deficit in memory control as shown in the allocation of study time in the present experiment, it is not clear whether this finding is due to memory control being an indirect measure of metacognitive processes. Because of this, future research should compare metacognitive variables with implicit and explicit tests of memory, and crucially, compare monitoring and control measures that are both deliberate declarations of performance. In their framework, Nelson and Narens [26] suggest several different control processes that occur during encoding, and we have just measured one of these here (allocation of study time). Future research could explore other more deliberate control procedures — such as the selection of strategy (for example making associative links between items), the termination of study or the ability to use semantic knowledge to enhance episodic memory. It is conceivable that a deficit in these more effortful processes that control encoding performance lies behind the episodic memory problem in AD. This would explain why AD patients fail to benefit from semantically related lists over unrelated lists [15], and why there is the strong relationship between semantic and episodic memory functioning [10]. However, as suggested in the introduction, it is possible that AD patients are capable of these more effortful control processes, but that the memory monitoring mechanisms on which their implementation relies is deficient. This second account of the encoding deficit is consistent with the results of the present study: the control processes are intact, but the explicit awareness of repetition is not.

The most important aspect of this work is that the dissociation found between these two measures of metamemory forces us to think more carefully about the nature of metacognition, especially with reference to clinical populations. In populations where participants appear unaware of their level of performance, it is simplistic to conclude that they are not therefore

successfully processing the items in a memory test. Within clinical populations it is necessary to be specific about metacognitive aspects of performance in order that we may isolate problems with certain aspects of memory processing. This study provides evidence that supports the view that encoding processes are in deficit in Alzheimer's disease but qualifies this by suggesting that it is the explicit aspects of encoding that are in deficit, rather than automatic response to stimuli. The study also suggests that a deficit in explicit awareness of repetition at encoding, as well as at test, is found in Alzheimer's disease.

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