Fast decay of iconic memory in observers with mild cognitive impairments

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In a previous clinical report, unusually fast decay of iconic memory was obtained from a subject who later developed Alzheimer's disease. By using the partial-report paradigm, iconic memory (a form of visual sensory memory) in a group of observers with mild cognitive impairments (MCI) was characterized and compared with that of young college-age adults and older controls. Relatively long stimulus exposures were used for all three groups to ensure that older observers could perceive the stimuli. A set of conventional neuropsychological tests assessed cognitive functions of the MCI and older control groups. We found that iconic memory decayed much faster for observers with MCI than for normal controls, old or young, although the two groups of older observers performed at equivalent levels in precue tests (assay of visibility) and tests cued at long delays (assay of short-term memory). The result suggests that fast decay of iconic memory might be a general characteristic of observers with MCI who are at much higher than average risk of developing Alzheimer's disease later in life.

sensory memory duration | Alzheimer's disease | neuropsychological test

Sensory memory refers to the literal, modality-specific neural representation of sensory stimuli in the human brain (1). Much like registers in a computer, sensory memory provides the initial copy ("buffer") of external stimulation to human sense organs that can be processed by subsequent stages of perception and cognition. In the visual modality, iconic memory (1) was first demonstrated by the partial-report superiority effect (2). After a brief presentation of a 3×3 or 3×4 matrix of letters, observers often can report all of the letters in any cued row if the cue occurs immediately after the visual presentation ("partial report"), even though they can report only four to five letters when asked to recall all of the items in the display ("whole report"). Because all rows of the letter matrix are cued with equal probability, reporting all of the items in a randomly cued row implies that the observer has access to all of the items in the matrix at the termination of the display. The partial-report superiority effect (performance advantage of partial-report over whole-report) suggests that a fast-decaying iconic memory exists that can initially hold at least 9–12 items. Numerous studies have established that iconic memory has a large capacity, decays rapidly, and is destroyed by poststimulus masking (1–4). Best reflected in the partial-report superiority effect, the duration of iconic memory has been estimated to be ≈300–500 ms for young adult observers.

In his dissertation research on the electrophysiological correlates of iconic memory, Yang (5) attempted to relate the duration of iconic memory to the habituation time constant of the N100 component of visual evoked potentials. Behaviorally, he replicated the typical partial-report superiority decay function in most of his observers, but he was surprised to find that one observer's iconic memory was unusually short (<50 ms). Several attempts were made to bring this observer's performance to the normal range, including intensive practice and longer stimulus durations. Yet the same result was obtained: the duration of iconic memory was extremely brief for the observer, although he was able to identify the target item with 75% accuracy (chance, 25%) in partial-report displays with eight items when he was cued to the target location ≈200 ms before the display. The observer reported that he was able to see the stimulus but unable to remember the identity of the item at probe.

Yang's study was conducted in 1997. At the time when the study was conducted, Yang's unusual observer was a healthy 58-yr-old individual who appeared to be normal in every aspect and was performing a very high-profile job. Puzzled by the observation, Yang documented this unusual case in his dissertation without further investigation. We learned in the summer of 1999 that the unusual observer in Yang's study could no longer carry out his job duties because of poor memory functions. He was diagnosed subsequently with Alzheimer's disease (AD).

Although the clinical dementia rating (CDR) and measures of other cognitive abilities of the unusual observer in Yang's study are not available, descriptions in Yang's dissertation suggest that the observer might have had only mild cognitive impairments (MCI) at the time of the partial-report experiments. Was Yang's observation an accidental cooccurrence of restricted iconic-memory function and subsequent development of AD? Or, is fast decay of iconic memory a general characteristic of observers at-risk for or in early stages of AD?

Current cognitive theories explain human memory functions in terms of several independent systems that process different types of information by using distinct encoding, storage, and retrieval operations (6–10). Briefly, sensory-memory systems, including iconic memory and echoic memory, register primary sensation from the environment. Important or relevant sensory information is then selected by attention and further processed in short-term or working-memory systems. Last, information enters long-term memory by means of rehearsal and subsequent encoding in short-term memory. It has been shown that AD does not affect these memory systems uniformly, even though the most prevailing clinical symptoms at beginning stages of the disease are related to various memory failures (11, 12). Mild AD patients generally have significant long-term episodic (13–15) and semantic (16–19) memory deficits, as well as deficits in working-memory tasks (20), but they are, at most, only slightly impaired compared with normal controls in auditory and spatial short-term-memory tasks (12). To our knowledge, no systematic study of iconic memory has been carried out in the AD population, perhaps because of the difficulty of applying the partial-report paradigm to the aging population.

Several studies have attempted to use the partial-report paradigm to investigate effects of aging on iconic memory. In one study, Abel (21) used very long (500 ms) stimulus presentations, but the long duration was well outside of the standard methods for measurements of iconic memory among younger adults (22). By using typical stimulus-exposure durations (50

Abbreviations: AD, Alzheimer's disease; MCI, mild cognitive impairments; CDR, clinical dementia rating; SOA, target-cue onset asynchrony; HSD, honest significant difference.

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ms), Salthouse (23) did not obtain much of a partial-report superiority effect (8% and 3%) with older subjects. He attributed the failure to their inability to process short stimuli. In another attempt, Walsh and Thompson (reviewed in ref. 24) used very short displays, and they found that 80% of the older subjects could not perform the task. By using longer visual-stimulus presentations, Gilmore *et al.* (25) demonstrated that it was possible to measure partial-report superiority effects with older subjects. Moreover, the duration of iconic memory was similar for the younger and older observers, even though very different stimulus durations were used (30 and 200 ms for the younger and older observers, respectively). Gilmore *et al.* attributed the different stimulus-exposure requirements to differences in visual acuity between the two groups, not differences in iconic memory. However, several studies have documented that the duration of iconic memory depends critically on stimulus exposure time (3); to remove stimulus exposure time as a confound, it is more preferable to study effects of aging on iconic memory by using the same stimulus parameters across different age groups.

In this study, we characterized iconic memory by using the partial-report paradigm with the same stimulus parameters and experimental procedures in three groups of observers: college-age young adults, observers with MCI, and older controls. To ensure that older observers could perceive the stimuli, stimuli were presented with relatively long exposure (105 ms). Also, a set of conventional neuropsychological tests assessed cognitive functions of the MCI and older control groups. We found that iconic memory decayed much faster in observers with MCI than normal observers, old or young. The result suggests that fast decay of iconic memory might be a general characteristic of observers with MCI.

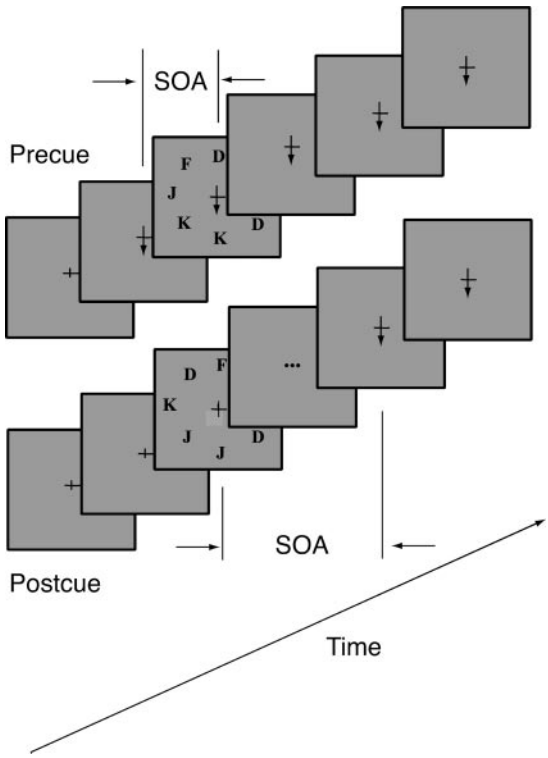

Fig. 1. Display sequence in the precue and postcue (partial-report) conditions.

Materials and Methods

Observers. Three groups of observers were tested. The first group of observers consisted of two male and nine female volunteers, with an average age of 84.8 yr (range, 74–98; SD, 7.2), who were referred by the University of Southern California Alzheimer's Disease Research Center. All of them were diagnosed by the Alzheimer's Disease Research Center as having a CDR of 0.5. By using a questionnaire administered by interviewers through interviews of the observer and a reliable informant or collateral source (e.g., a family member), CDR rated observer-impairment levels in the following six categories of cognitive functions: memory, orientation, judgment, community affairs, home and hobbies, and personal care. A five-point scale is used for each category in CDR, ranging from 0 for normal, 0.5 for questionable impairment, 1 for mild impairment, 2 for moderate impairment, and 3 for severe impairment. A person with a CDR of 0.5 is characterized as having consistent slight forgetfulness, partial recollection of events, and "benign" forgetfulness; being fully oriented except for slight difficulty with time relationships; having slight impairment in solving problems, similarities, and differences, as well as in community activities, home-life, hobbies, and intellectual interests; and being fully capable of self-care. Observers with CDR of 0.5 are considered as having MCI.

The second group of observers consisted of six male and 10 female older people recruited from the communities of Long Beach, CA, and La Jolla, CA, with an average age of 81.9 yr (range, 65–99; SD, 9.7). All of the observers in this group had CDR of 0. They were paid an honorarium for their participation in the investigation.

The third group consisted of five male and 18 female undergraduate students from Loyola Marymount University (Los Angeles, CA), with an average age of 20.4 yr (range, 18–27; SD, 2.2). These students volunteered to participate in the experiment for class credit.

All of the observers reported normal or corrected-to-normal vision. They all provided informed consent and were debriefed fully after testing.

Neuropsychological Tests. A range of cognitive functions of all of the older observers was examined by using a subset of the tests from the standard neuropsychological test battery routinely administered in the Alzheimer's Disease Research Center. The tests included digit-span forward and digit-span backward tests for short-term memory, a digit-ordering test for working memory (26), the California verbal learning task for short-term memory (27), a verbal-fluency test for linguistic access (28), a mental rotation test for executive function, the Boston naming task for ability to name object from line drawings (29), and trail-making test for visual–conceptual and visual–motor tracking, including motor speed and attention functions.

Visual Stimuli. Visual stimuli were presented on an iMac computer controlled by a MATLAB program based on PSYCHTOOLBOX (30), and they were viewed by the observers at ≈88 cm in a darkened room. In each trial, eight letters appeared simultaneously for 105 ms on the screen. Each 1.29° × 1.29° letter was chosen randomly and independently from the set ["D," "F," "J," and "K"] and shown in uppercase letters with 0.11°-wide strokes at 0 cd/m^2 on a gray background (24.9 cd/m^2). The eight letters were arranged on a circle (radius, 3.50°) around the fixation point (Fig. 1).

Procedure. For the two groups of older observers, the neuropsychological test battery lasted <1 h, and it was administered on a separate day before the partial-report procedure.

Each partial-report trial started with a fixation cross at the center of the display. After 400 ms, eight letters appeared simultaneously for 105 ms. Observers were cued to report one of the letters with an arrow in the center of the display pointing to the target location. Eight target-cue onset asynchronies (SOA)

Table 1. Neuropsychological test scores for older and MCI subjects

Test	Older normal (n = 16)	MCI (n = 11)	t
Age	76.8 ± 9.7	84.8 ± 7.7	−2.31*
Education	15.3 ± 2.8	15.5 ± 2.0	−0.14
CVLT	52.4 ± 7.3	30.4 ± 11.6	6.06**
DSF	10.6 ± 1.6	8.3 ± 1.9	3.35**
DSB	7.3 ± 1.8	10.2 ± 15.4	2.23*
DO	8.2 ± 1.4	6.6 ± 1.8	2.54*
MRT	83.8 ± 14.2	65.5 ± 17.1	3.04*
FLU	27.9 ± 3.6	16.4 ± 5.7	6.49**
TRL	0.19 ± 0.4	0.64 ± 0.8	−1.91*
BNT	29.5 ± 1.0	24.5 ± 3.8	4.99**

CVLT, Calfornia verbal-learning task test; DSF, digit-span forward; DSB, digit-span backward; DO, digit ordering; MRT, mental rotation test; FLU, verbal-fluency test; TRL, trail-making test; BNT, Boston naming task. *, $P < 0.05$; **, $P < 0.01$, for older and MCI subjects, respectively.

were used. In the precue condition, the onset of the cue was 147 ms before the onset of the target; in the simultaneous cue condition, the cue occurred simultaneously with the target display. In the postcue conditions, the cues occurred 11, 32, 74, 221, 516 or 1,105 ms after the offset of the target display, with corresponding SOAs of 116, 137, 179, 326, 621, or 1,210 ms. In all of the conditions, the cue stayed on until response. To avoid typing errors in the dark room, observers reported the target identity verbally after each presentation. The response was then entered into the computer by the experimenter.

Each observer completed 50 practice trials before the main experiment. During the main experiment, the observers with MCI finished one or more sessions of 400 trials each, whereas observers in the two control groups finished one session of 800 trials. Most observers with MCI completed two sessions with a total of 800 trials. Only data in the main experiment were included in the analysis. Fewer trials per session were used for the observers with MCI to accommodate their pace. Two separate studies with similar partial-report procedures showed that although practice improved overall performance for both young and old normal observers, it did not change the duration of iconic memory (31). Each session lasted <1 h.

Results

Neuropsychological Tests. Table 1 gives performance scores of the two older groups in all of the neuropsychological tests. A series of Student's t tests was conducted to assess group differences. The MCI group performed significantly worse than the older control group in all of the neuropsychological tests ($P < 0.05$), even though there is no significant difference between the two groups in terms of educational level ($P > 0.50$). On average, the MCI group was 8 yr older than the control group ($P < 0.05$). When age was controlled for in a regression analysis, the differences between the two groups remained significant for California verbal learning, digit-span forward, digit ordering, mental rotation test, verbal-fluency test, and Boston naming task, but not for digit-span backward and trail-making tests (see *Regression Analyses*). These results confirmed that the observers with MCI were slightly impaired over a range of cognitive functions, consistent with their interview-based CDR ratings.

Partial Report. Average performance in the partial-report procedure is plotted in Fig. 2 for the three groups. Data were first converted from the percentage correct in four-alternative forced-identification to d' for each observer and then averaged.

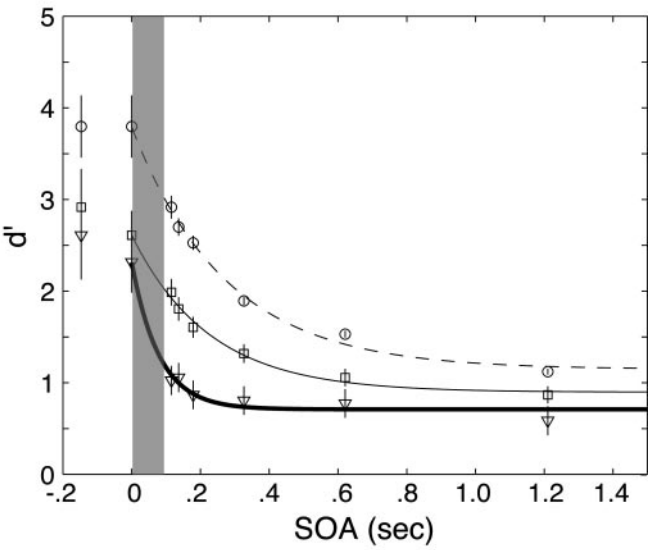

Fig. 2. d' as functions of SOA for the three groups of observers. Young controls (○), old controls (□), and the MCI group (▽) are indicated. The smooth curves represent the best-fitting exponential-decay functions to the three data sets.

Precuing and Simultaneous Cuing. The precuing and simultaneous-cuing conditions were included in our procedure to test observers' ability to perceive the visual stimuli and to perform the identification task. Average performance of each of the three groups is given in Table 2. All three groups performed at >90% (d', 2.45) accuracy in identification. For each cuing condition, a one-way ANOVA was used to compare their performance levels statistically. Significant differences among groups were found in the precuing condition [F (2, 49) = 22.6, $P < 0.001$] and the simultaneous-cuing condition [F (2, 49) = 6.73, $P < 0.005$]. However, post hoc comparisons using Tukey's honest significant difference (HSD) test showed no significant differences between the MCI and the older control groups ($P > 0.10$), although the young controls performed significantly better than the older groups ($P < 0.05$). The result indicates that the MCI group and the older controls were approximately equally able to see the stimuli and perform the task.

Performance at the Longest SOA. At the longest SOA of 1,210 ms, performance was based on items transferred into short-term memory without benefit of cuing (3). Average performance of each of the three groups is shown in the third row of Table 2. All three groups performed at >40% (d', 0.53) accuracy in identification. A one-way ANOVA was used to statistically compare their performance levels. Significant differences among groups were found [F (2, 49) = 4.81, $P < 0.01$]. However, post hoc comparisons using Tukey's HSD test showed no significant differences between the MCI and the older control groups ($P > 0.10$), although the young controls performed significantly better

Table 2. Performance in short and long SOAs (in d' units)

Condition	Young (n = 25)	Older normal (n = 16)	MCI (n = 11)
Precue	4.23 ± 0.74[a]	3.24 ± 0.83[b]	2.62 ± 0.52[b]
Simultaneous	4.07 ± 0.77[a]	3.01 ± 0.93[b]	3.15 ± 1.38[b]
SOA = 1.2 s	1.14 ± 0.31[a]	0.89 ± 0.31[b]	0.79 ± 0.50[b]

Means in the same row with different superscripted letters differ significantly, as determined by Tukey's HSD test ($P < 0.05$).

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Table 3. Mean parameter performance for three groups of subjects

Parameter	Young ($n = 25$)	Older normal ($n = 16$)	MCI ($n = 11$)
a_0	1.06 ± 0.33^a	0.85 ± 0.23^b	0.75 ± 0.27^b
a_1	2.81 ± 0.39^a	1.78 ± 0.59^b	$2.31 \pm .98^c$
τ	0.34 ± 0.16^a	0.30 ± 0.19^a	0.073 ± 0.06^b

Means in the same row with different subscripted letters differ significantly, as determined by Tukey's HSD test ($P < 0.05$).

than the older groups ($P < 0.05$). The result suggests that the two older groups were approximately equally able to transfer items into short-term memory without the benefit of cuing.

Time Course of Iconic Memory. The following exponential-decay function was fit to the partial-report data to characterize the temporal properties of iconic memory (2):

$$d'(\mathrm{SOA}) = a_0 + a_1 e^{-\mathrm{SOA}/\tau}. \quad [1]$$

In this three-parameter function, a_1 is the fast-decaying sensitivity that reflects the initial visual availability of stimulus information, τ is the time constant of the fast-decay sensitivity that represents the duration of iconic memory, and a_0 is the sensitivity at long delays that reflects the amount of information transferred into short-term memory without the benefit of cuing (2–4). The best-fitting exponential decay functions for the three groups are shown as smooth curves in Fig. 2.

Table 3 summarizes the best-fitting parameters for each of the three groups. A one-way ANOVA was conducted to compare each of the three best-fitting model parameters among the three groups. All three parameters varied significantly across the three groups [a_0, $F(2, 47) = 5.00$ and $P < 0.01$; a_1, $F(2, 47) = 12.87$ and $P < 0.001$; τ, $F(2, 47) = 11.71$ and $P < 0.001$]. Tukey's HSD post hoc tests indicated that (*i*) there was no significant difference between the MCI and the older control groups ($P > 0.25$) in terms of a_0, although the younger group was significantly better than both the older normal ($P < 0.05$) and MCI ($P < 0.01$) groups; (*ii*) all three groups are significantly different in terms of a_1 ($P < 0.05$); and (*iii*) the MCI group had significantly shorter iconic memory than the young ($P < 0.001$) and older normal ($P < 0.001$) groups, even though the duration of iconic memory was not significantly different between latter two groups ($P > 0.25$). Compared with the older control group, the MCI group showed a significant deficiency in iconic memory duration (τ), defined as the time constant of the exponential decay of iconic memory (Eq. **1**); i.e., after a delay of τ, d' in partial report reduces to 37% of that of simultaneous cueing. Averaged across observers, the mean iconic memory duration for the MCI group was ≈0.07 s, less than one-fourth of that of the young (0.34 s) and the older normal (0.30 s) groups. Box plots of the best-fitting parameters for individual observers are shown in Fig. 3.

Regression Analyses. Regression analyses were performed to study the potential residual influences of age in comparing the observers with MCI and the older controls. In the first set of analyses, both groups of the older observers were included. The first two rows of Table 4 give correlations between all of the test scores and CDR [which was either 0 (for normal controls) or 0.5 (for observers with MCI)] and between all of the test scores and age, respectively. Partial correlations between the test scores and CDR were computed by using both CDR and age as predictors in a regression analysis. With age factored out, the partial correlations between the test scores and CDR gauge the amount of variance accounted for by CDR alone (Table 4, third row). The partial correlations are significant for California verbal learning, digit-span forward, digit ordering, mental rotation test, verbal-fluency test, Boston naming task, but not for digit-span backward and trail-making tests. Most important, the partial correlation between iconic memory duration (τ) and CDR remained significant after age was factored out. We plot iconic memory duration (τ) as a function of age for the two older groups of observers in Fig. 4.

Summary and Discussion

In this study, we found that (*i*) consistent with their interview-based CDR rating, observers with MCI performed significantly worse in a number of neuropsychological tests including California verbal learning, digit-span forward, digit-span backward, digit ordering, mental rotation test, verbal-fluency test, and Boston naming task, even after age was factored out; (*ii*) both the MCI and the older control groups performed >90% correct in the precuing and simultaneous-cuing conditions with no significant difference, indicating approximately equal visual and task abilities. There was also no significant performance difference between the two groups at the longest target-cue SOAs, indicating approximately equal ability in transferring items to short-term memory; and (*iii*) the decay of the iconic trace was much faster for the observers with MCI (0.07 s versus 0.30 s). This difference between the MCI and the older normal control groups remained significant after age was statistically controlled. The combined results suggest that the two older groups of observers are approximately equivalent in terms of visual letter recognition and the ability to transfer items into short-term memory, but the MCI group has significantly shorter iconic memory.

Studies have shown that visual acuity and spatial frequency contrast sensitivity decline in similar ways in aging and AD (e.g., ref. 32). Many studies have found it difficult or impossible for old observers to perform the partial-report procedure (22–25). By using displays with relatively long durations, we made it possible

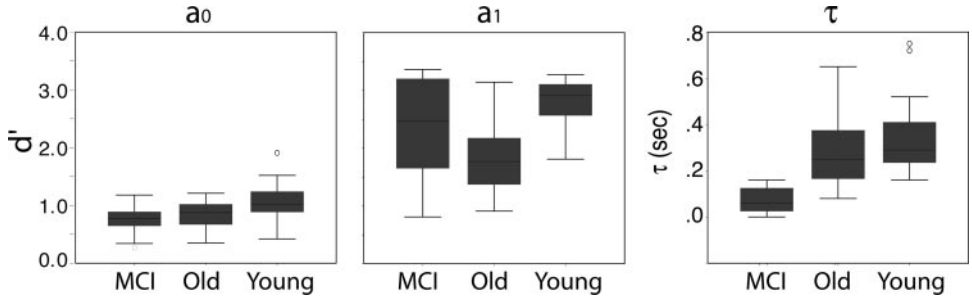

Fig. 3. Box plots of the best-fitting parameters for the three groups of observers. The plots are based on the median, quartiles, and extreme values. The box represents the interquartile range, which contains 50% of the values. Whiskers extend from the box to the highest and lowest values, excluding outliers. A line across the box indicates the median.

Table 4. Correlations for older normal and at-risk observers

Measurement	CDR	CVL	DSF	DSB	DO	MRT	FLU	TRL	BNT	a_0	a_1	τ
CDR	—	−0.72**	−0.58**	−0.43*	−0.49**	−0.48**	−0.75**	0.38*	−0.62**	0.43*	0.31	−0.51**
Age	0.43*	−0.51**	−0.54**	−0.44*	−0.26	−0.43*	−0.57**	0.34	−0.44*	−0.34	−0.10	−0.22
CDR (age-controlled)	—	−0.65**	−0.46*	−0.29	−0.43*	−0.37*	−0.68**	0.28	−0.61**	0.34	−0.30	−0.47*

CVL, California verbal-learning task; DSF, digit-span forward; DSB, digit-span backward; DO, digit ordering; MRT, mental rotation test; FLU, verbal-fluency test; TRL, trail-making test; BNT, Boston naming task. *, $P < 0.05$; **, $P < 0.01$, for normal and at-risk observers, respectively.

for older observers to perform the partial-report task. However, the exposure duration of 100 ms is still reasonably short as far as strong retinal afterimages are concerned (22). We also controlled for potential effects of stimulus duration on iconic memory lifetime by using the same stimulus exposure time across the three groups of observers. In addition, the precuing and simultaneous-cuing conditions provided important controls for potential perceptual differences in letter recognition across the three different groups. That the MCI and the older control groups performed at equivalent levels in precuing and simultaneous-cuing conditions suggests that their differences in partial-report superiority were not due to any difference in visual letter identification.

In a broad sense, sensory memory exists in every stage of sensory processing. There have been many attempts in the literature to distinguish different forms of visual sensory memory (for review, see refs. 3 and 33). One well recognized distinction is between eye-specific visual persistence and iconic memory that resides after the site of binocular combination. Many researchers have debated on the interpretations of results from information-based assessments (e.g., the partial-report procedure) and some more direct sensory measures of visual sensory memory. Coltheart (3) concluded that the partial-report procedure mostly reflected iconic memory after the site of binocular combination (but see ref. 34). In the literature on aging, visual persistence has been found to generally increase with age (35–37; also see ref. 38). One potential factor is age-related diminishing of retinal illumination, which reduces the intensity of the proximal stimulus (39) and, therefore, increases visual persistence, which is known to increase as the intensity of the inducing stimulus decreases (40–42). Factors other than aging optics have also been suggested (37, 38, 43). In this study, we found that the duration of iconic memory, unlike that of visual persistence, decreased with age. The opposite effects of aging on iconic-memory duration and visual persistence are consistent with the dissociation of visual persistence and iconic memory (3).

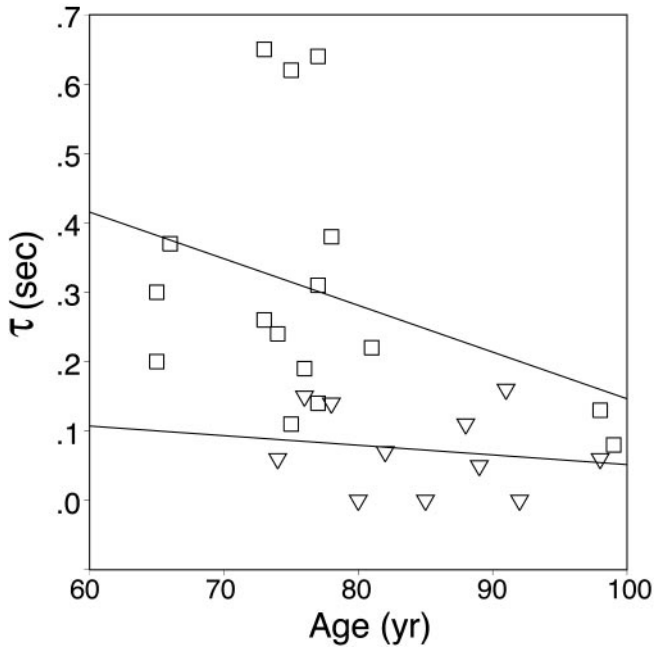

Fig. 4. Plot of estimated iconic-memory lifetime versus age for the two groups of old observers. Old controls (□) and the MCI group (▽) are indicated. The two straight lines represent the best linear-regression functions for the two groups.

Several processes are involved in performing the partial-report task (4), namely, iconic storage of the stimulus array, including both identity and location; decay of iconic storage; cue interpretation and shift of attention; information transfer to short-term memory; and letter recognition and report. The equivalent performance in precuing and simultaneous cuing and in long-target-cue SOAs suggests that the MCI and older control groups had similar abilities in encoding visual items in iconic memory and in transferring items into short-term memory; they only differed in terms of iconic-memory duration.

Can the observed shorter iconic memory be a consequence of slower attention switching in observers with MCI? Although many studies suggest that aging and MCI reduce attention capacity and slow down attention switching (44, 45), our results cannot be accounted for by the slower-attention-switching hypothesis. Slower attention switching would have generated a rightward shift of the entire partial-report function, as well as possible deficits in precue conditions. This finding would have resulted in reduced iconic-memory capacity but not a shorter time constant. Neither prediction is supported by the data.

Several recent studies suggest that sensory memory resides in sensory cortices (5, 46, 47) and that the duration of sensory memory reflects dynamic properties of a series of cascaded cortical neural units that habituate over time (48). Therefore, according to this view, shorter iconic-memory duration found in observers with MCI may reflect abnormal functions in the early visual pathway. However, this interpretation is inconsistent with results from histological studies that suggest that the primary visual cortices are spared in MCI and early stages of AD (49). However, the partial-report procedure is a spatial-cuing procedure in which both item identity and location information is required to perform the task. For example, when observers are required to report only items of a particular color from briefly exposed letter matrices, their partial reports are not much better than whole reports (50). Therefore, the observed shorter iconic-memory duration in observers with MCI may reflect difficulties in creating and/or maintaining the binding of item identity and location, which depends critically on the functioning of the hippocampus and association cortices (L. M. Reder, personal communication). Therefore, fast decay of iconic memory in the MCI group may reflect abnormal functions in hippocampus and/or higher-level association cortices, which are affected in MCI and early stages of AD (49).

In the case study reported in Yang's dissertation, fast decay of iconic memory was obtained from a subject who later developed AD. Our finding that the observers with MCI have shorter iconic memory is completely consistent with Yang's observation. Fur-

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ther work is required to conclude that fast decay of iconic memory is a possible precursor for AD; tracking subsequent AD outcomes will be required. However, observers with MCI are much more likely to develop AD later in life. Although figures vary among reports, the average conversion rate from MCI to AD is 12% per yr; in contrast, the conversion rate to MCI or AD in healthy old controls is ≈1–2% per yr (51, 52). In fact, >80% of patients with MCI develop AD within 10 yr (53). The standard neuropsychological tests that are commonly used in the diagnosis of AD are relatively insensitive to cognitive changes in the early stages of the disease. An observation of impaired iconic memory without deficits in perception or short-term memory may add important information to the evaluation. In nonclinical settings, AD may be incorrectly diagnosed clinically in 25–40% of cases (54, 55). There has been renewed interest in developing more sensitive tests. Is an abnormally short iconic-memory lifetime a reliable early sign of AD? The results of the current study are highly suggestive. A careful longitudinal study of observers with MCI and their definitive AD diagnosis is necessary to fully assess the potential clinical value of using the duration of iconic memory in predicting AD.

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