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# Sensitivity to Expectancy Violations in Healthy Aging and Mild Cognitive Impairment

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In this study, individuals with mild cognitive impairment (MCI) were tested to see if executive dysfunction impacts their implementation of expectancy biases in a priming task. Young adults, healthy older adults, and individuals with MCI made speed-related decisions to sequentially presented word pairs. The proportion of category related (e.g., *apple–fruit*) versus coordinate related (*apple–pear*) pairs was varied to create different expectancy biases. When the proportion of category pairs was high (80%), the control groups showed an expectancy bias: Significant inhibition was observed for coordinate pairs compared with category pairs. The MCI group also demonstrated an expectancy bias but with much larger costs for unexpected targets. The findings suggest that individuals with MCI are inordinately sensitive to expectancy violations, and these findings are discussed in terms of possible executive dysfunction.

Mild cognitive impairment (MCI), a relatively new clinical classification, has generated a great deal of recent research and clinical interest. This condition has been hypothesized to represent preclinical or very early stage Alzheimer's disease (AD; J. C. Morris et al., 2001; Petersen et al., 2001). Individuals with MCI tend to progress to greater stages of dementia at rates dependent on the level of impairment at diagnosis (J. C. Morris et al., 2001). The conversion rates of MCI to AD range from 8% to 15% per year (Kawas, Gray, Brookmeyer, Fozard, & Zonderman, 2000; Larrieu et al., 2002; Petersen et al., 1999), and the median conversion time from diagnosis of MCI to diagnosis of AD is 4.4 years (Kawas et al., 2000). Although some individuals with MCI never develop AD, the conversion rate within 6 years of diagnosis has been estimated to reach 80% (Petersen et al., 2001). Considering this higher risk of progression to dementia, researchers have been closely examining the neuropathological and neuropsychological profiles of individuals diagnosed with MCI.

MCI is generally characterized by episodic memory impairments with relative sparing of other cognitive functions (J. C. Morris et al., 2001). The pattern of memory impairment in MCI is similar to that observed in AD but usually milder in nature (Crowell, Luis, Vanderploeg, Schinka, & Mullan, 2002; Petersen et al., 1999). In neuroimaging studies, MCI individuals have shown patterns of hippocampal atrophy similar to AD patients (Du et al., 2001; Jack et al., 2000). Specifically, researchers have observed atrophy of the parahippocampal gyrus in MCI that exceeds the atrophy observed in healthy aging, but it is generally less severe than that observed in AD (Bottino et al., 2002; De Santi et al., 2001; Pantel, Kratz, Essig, & Schroeder, 2003). During autopsy, most MCI individuals also display the neuropathological features associated with AD, including neurofibrillary tangles and neuritic plaques (J. C. Morris et al., 2001; Price & J. C. Morris, 1999). The hippocampal region, as well as associated temporal areas, is generally associated with episodic memory processes. Thus, the neuropathology reported in MCI is consistent with the episodic memory deficits that are the hallmark of the condition.

Although episodic memory impairment is the primary characteristic of MCI, some researchers have recently reported mild deficits in executive functioning as well. Executive functions include interrelated processes, such as allocation of attention, manipulation of active information, and suppression of inappropriate responses. Tests of working memory are often used to measure executive functioning. Haenninen et al. (1997) found individuals with age-associated memory impairment performed significantly worse than controls on three tests of executive function. Crowell et al. (2002) found that individuals with MCI and AD displayed similar memory deficits relative to unimpaired controls. Moreover, the individuals with MCI also differed from controls on measures of executive functioning. Ready, Ott, Grace, and Cahn-Weiner (2003) also reported impairments in executive function in those with MCI. Similar to the episodic memory deficits, the executive (working memory) dysfunction in MCI seems to subtly mirror the impairments observed in early AD (Collette, Van der Linden, & Salmon, 1999; Greene, Hodges, & Baddeley, 1995; Lafleche & Albert, 1995; R. G. Morris, 1994). Individuals with AD show the most consistent impairments in tasks requiring concurrent manipulation of information or divided attention (Lafleche & Albert, 1995; R. G. Morris, 1996). Based on these findings, it has been argued that the central executive system (CES; Baddeley, 1986) is affected in early AD (R. G. Morris, 1994).

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Executive functioning is often localized to the frontal lobes (Baddeley, 1986; Shallice, 1988). However, the executive dysfunction observed in early AD has led some researchers to theorize that the CES is distributed rather than localized (R. G. Morris, 1994, 1996). Information is continuously transferred between different brain regions, including frontal, parietal, and temporal areas. Damage to areas or to their connections can diminish executive function. Indeed, some neuroimaging studies have shown associations between working memory abilities and temporal areas, specifically the hippocampus (Mitchell, Johnson, Raye, & D'Esposito, 2000; Seidman et al., 1998).

In sum, individuals with MCI show episodic memory deficits similar to early stage AD patients, and they also may experience mild executive dysfunction. Although executive deficits in MCI have not yet been widely studied, the available data suggest that such impairments are relatively subtle. As such, deficits may not be revealed in direct tests of working memory. To reveal potentially subtle effects of mild executive dysfunction, indirect tests may be more useful.

## Executive Function and Expectancy Biases

Optimal executive functioning is critical in tasks that require individuals to explicitly (or implicitly) monitor stimuli, appropriately modify their response strategies, and suppress inappropriate responses. For example, expectancy biases are typically induced in semantic priming experiments (Neely, 1991). Although instructions can explicitly bias participants, strategies can also be fostered implicitly throughout an experiment by exposing people to regularities across trials. For example, a common finding is the relatedness proportion effect, wherein the magnitude of semantic priming increases as the proportion of related pairs increases (de Groot, 1984; den Heyer, 1985; den Heyer, Briand, & Dannenbring, 1983; Neely, Keefe, & Ross, 1989; Seidenberg, Waters, Sanders, & Langer, 1984). When a stimulus set contains many related pairs, people come to expect (and respond faster to) related pairs. This relatedness proportion effect is stronger when prime-target stimulus onset asynchronies (SOAs) are longer (de Groot, 1984; den Heyer et al., 1983). Thus, expectancy bias seems to involve conscious, postlexical (late stage) processes, requiring time for implementation. For example, Becker (1980; also Posner & Snyder, 1975) theorized that, on presentation of a prime, people use their expectations to generate a set of possible targets. If the eventual target is a member of the expected set, responses are facilitated. If the target violates expectancy, inhibition occurs (relative to neutral primes, e.g., rows of asterisks).

In most experiments, biasing stimulus patterns are course grained and fairly obvious. That is, people can quickly recognize the disproportionate number of related pairs, compared with unrelated pairs, allowing them to explicitly adapt appropriate response strategies. However, more fine-grained expectancies are also possible, which are based on the types of relations between primes and targets. For example, given many antonyms as related prime–target pairs, people may learn to generate appropriate expectancy sets. When shown the prime *day*, a person may anticipate *night* as the target. If *night* were indeed the target, performance would be fast and accurate. However, given the word *week*, performance might be slow and error prone. In this manner, even semantic associates can cause inhibition if they violate expectations.

In this study, we used fine-grained relations, based on category versus item-specific relations, to invoke response biases. Young adults, healthy older adults, and individuals with MCI made relatedness judgments to word pairs. Half the pairs were unrelated. The related pairs were either exemplar–category (category) pairs (e.g., *dog–animal*) or were exemplar–exemplar (coordinate) pairs (e.g., *dog–cat*). In each trial, words were shown sequentially, with a relatively long (1,050 ms) SOA, allowing potential expectations to develop for the second member of each pair. To induce specific biases, the proportion of category pairs in a session was either low (20%) or high (80%). As this proportion increases, the expectation of category targets (e.g., *animal*) should increase, leading to faster responses. Alternatively, if the target was a coordinate word (e.g., *cat*), this should violate expectancy, potentially slowing responses. This general pattern was anticipated for both the younger and older control groups.

To achieve optimal performance in this task, a person requires both vigilance and flexibility in executive functioning. First, attentional vigilance is required to recognize stimulus patterns across trials. That is, the person must explicitly (or implicitly) notice the frequency disparity for each pair type (category or coordinate). This vigilance will improve performance in bias-consistent trials, which represent the majority of related trials. However, flexibility is also required for those related trials that do not conform to expectancy. If a presented target violates expectations, but still requires a "yes" response, working memory resources will be required to suppress the anticipated candidate and to resist making a hasty "no" response. As executive function degrades with progressive dementia, either or both aspects of context-sensitive processing may suffer.

Bell, Chenery, and Ingram (2001) manipulated relatedness proportion and SOA duration in a semantic priming task to induce response biases in AD patients and healthy elders. Although the control group showed typical expectancy effects, the AD patients did not. Bell et al. proposed that the generation of expectancies was hindered by attentional deficits due to AD, an assertion supported by other research (Balota & Duchek, 1991; Chenery, Ingram, & Murdoch, 1994). Strategy formation and implementation require a person to appreciate statistical regularities across trials and to create candidate sets based on those regularities. If attention and working memory are seriously compromised, as they seem to be in AD, such expectancy biases cannot be induced.

If individuals with MCI experience relatively mild executive dysfunction, as previous research suggests, a more complex pattern may arise. We hypothesized that they would generate expectancies similar to the control groups and would benefit from bias-consistent word pairs. However, we further expected this benefit to come at a substantial cost when flexible processing is required. Specifically, deficits should become apparent when working memory resources are particularly taxed, such as when the targets violate expectations. As noted earlier, such violations would require the active suppression of erroneously activated candidates as well as the access of the correct item. For example, if they are biased to expect category-related pairs and are subsequently confronted with a coordinate pair, then they may require extra time to respond. Even among healthy young people, working memory capacity is correlated with sensitivity to expectancy violations (Conway, Tuholski, Shisler, & Engle, 1999) and the ability to suppress inappropriate information (Conway & Engle, 1994; Rosen & Engle, 1998). Therefore, we hypothesized that individuals with MCI would show heightened sensitivity to expectancy violations even when unexpected targets were semantic associates to the primes.

## Method

### Participants

Participants included 80 young adults, 22 healthy elders, and 10 individuals with MCI. All participants spoke English as their first language, were able to read words in a 20-point font, had no history of drug or alcohol abuse, had no history of traumatic brain injury, and had no other psychiatric or neurologic disorders. The young adults were between the ages of 18 and 30 and were recruited from an undergraduate introductory psychology course at Arizona State University. They received partial course credit for their participation. The healthy elderly adults were recruited from the Greater Phoenix community and the Sun Health Research Institute in Sun City, Arizona. They all scored above 27 on the Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975) and had no self-reported history of cognitive decline, memory problems, or brain damage. All performed within the normal range on the Rey Auditory Verbal Learning Test (RAVLT; Rey, 1964) and on a backward digit-span task.

The MCI participants were recruited from the Sun Health Research Institute. The diagnosis of MCI was made on the basis of clinical examinations by the project neurologist (Marwan N. Sabbagh) and/or neuropsychologist (Donald J. Connor), both specialists in geriatric neurological disorders. The criteria used were consistent with the guidelines established by Petersen et al. (1999). These individuals showed specific impairment on a verbal recall (e.g., RAVLT) or visual recall test, but their other cognitive abilities were intact. The MCI participants scored above 24 on the MMSE and were screened for severe depression using the Geriatric Depression Scale (Sheikh & Yesavage, 1986). All MCI individuals were diagnosed less than 1 year prior to testing, and at the time of testing, none had progressed to AD or was diagnosed with any other neurological disorders. Table 1 shows the demographic information for the older control and MCI groups.

### Stimuli

The stimuli included two lists, each consisting of 120 prime–target pairs. In each list, half (60) of the prime–target pairs were related, and half were unrelated. The related pairs included 24 critical pairs and 36 filler pairs. Twelve critical pairs were category related (e.g., *apple–fruit*), and 12 were coordinate related (e.g., *nickel–penny*). The critical pairs were the same for both lists. The critical category and coordinate pairs were roughly matched on associative frequency as estimated by Nelson, McEvoy, and Schreiber's (1998) association norms. To create the expectancy bias, the 36 filler pairs consisted of either all category pairs (e.g., *salmon–fish;* high category proportion) or all coordinate pairs (e.g., *spoon–fork;* low category proportion). The filler prime–target pairs had associative frequencies similar to those of the critical pairs. The unrelated pairs (e.g., *flute–sink*) were the same for both lists and shared no primes or targets with the related pairs.

To ensure that any observed effects were not item specific, an alternate pair of stimulus lists was created in which the critical targets were the same but the primes were changed, placing each pair in the opposite condition. Thus, the targets of critical category pairs were now primed with coordinate words, and vice versa. These pairs were similarly matched for associative frequency. Other than changes to the critical pairs, the alternate lists were identical to the original lists. The alternate lists were given to half of the young adults ($n = 40$), and their performance was compared with that of the young adults given the original lists. The older control and MCI groups were only given the original lists.

Table 1
*Mean Demographic Data for Elderly Control and Mild Cognitive Impairment (MCI) Participants*

| Group and measure | Age (years) | Education (years) | MMSE | RAVLT learning | RAVLT delayed |
|---|---|---|---|---|---|
| Elderly controls[a] | | | | | |
| *M* (*SD*) | 74.3 (6.3) | 16.2 | 29.5 | 12.00 (2.3) | 10.14 (3.2) |
| Range | 64–89 | 12–19 | 29–30 | | |
| MCI participants[b] | | | | | |
| *M* (*SD*) | 80.1 (6.7) | 15.2 | 27.5 | 7.5 (2.1) | 3.75 (2.2) |
| Range | 67–87 | 12–18 | 25–29 | | |

*Note.* MMSE = Mini-Mental State Examination; RAVLT = Rey Auditory Verbal Learning Task; RAVLT learning = number of words recalled on Trial 5; RAVLT delayed = number of words recalled after delay (Trial 7). RAVLT data were incomplete for 1 MCI participant and are not reported.
[a] $n = 22$ (12 women, 10 men). [b] $n = 10$ (5 women, 5 men).

### Procedure

Young adults were tested in groups of two to seven in a large room with separate booths. They were tested on personal computers with standard monitors and made keyboard responses using keys labeled YES and NO. Elderly adults and MCI participants were tested individually on a laptop computer with screen dimensions of 8.5 × 11 in. They made their responses on a response box using keys labeled YES and NO. All stimuli were presented in 20-point font in black on a white background. Participants were told they would see two consecutively presented words and should decide whether they were related, pressing the YES or NO key as appropriate. On each trial, a fixation point (***) was presented for 750 ms, followed by the prime word in lowercase letters for 750 ms. After a 300-ms blank screen, the target word was presented in uppercase letters; it remained until the participant responded or 7 s elapsed. Another blank screen was presented for 750 ms between trials. Participants were given six practice trials prior to the experimental trials, and they were asked to respond as quickly as possible. Response times and errors were recorded. Sessions lasted approximately 15 min, and midway through the session, there was a rest break of 20 s for young adults and of self-controlled duration for older adults and MCI participants.

Individuals in the young and elderly control groups were randomly assigned to either the high or low category proportion condition. The MCI participants were tested twice, once in each condition. The order of conditions was counterbalanced, and the tasks were separated by an unrelated task.

## Results

The response times for correct decisions were analyzed using a mixed 3 × 2 × 2 analysis of variance (ANOVA), including the following factors: Group (young control vs. elderly control vs. MCI) × Category Proportion (low vs. high) × Pair Type (category vs. coordinate).[1] Responses longer than 4,000 ms were excluded. All results were significant at $p < .01$, unless otherwise noted.

[1] As noted earlier, the MCI group was administered both category proportion conditions in counterbalanced order. In the analyses, category proportion was treated as a between-subjects variable for the MCI group (providing more conservative tests). Subsequent analyses were performed to verify that the pattern of results for the MCI group were not due to order or repetition effects (see Footnote 4).

Table 2
*Mean Correct Reaction Times (RTs) and Accuracy Rates for All Groups*

| | Low category proportion | | High category proportion | |
|---|---|---|---|---|
| Group and measure | Coordinate pairs | Category pairs | Coordinate pairs | Category pairs |
| Young adults | | | | |
| *M* RT (*SD*) | 871.7 (268) | 828.3 (229) | 1,013.1 (248) | 807.5 (184) |
| *M* Accuracy (*SD*) | 97.2 (4.8) | 95.2 (4.9) | 93.3 (7.6) | 98.0 (3.6) |
| Elderly adults | | | | |
| *M* RT (*SD*) | 937.1 (300) | 963.5 (294) | 972.1 (206) | 825.8 (152) |
| *M* Accuracy (*SD*) | 99.3 (2.4) | 99.3 (2.4) | 98.6 (3.3) | 99.3 (2.4) |
| Mild cognitive impairment | | | | |
| *M* RT (*SD*) | 953.3 (187) | 910.9 (217) | 1,345.6 (477) | 917.1 (246) |
| *M* Accuracy (*SD*) | 95.9 (8.1) | 95.9 (5.9) | 95.9 (5.9) | 96.7 (5.9) |

Accuracy rates were also analyzed, but they were not the primary variable of interest.[2] Overall reaction time (RT) and error data are summarized in Table 2.

The ANOVA revealed a significant main effect of pair type, $F(1, 76) = 54.69$. Overall, participants were faster to verify category pairs (876 ms) than coordinate pairs (1,015 ms). Neither the main effects of group nor category proportion were significant, $F(2, 76) = 2.62$, and $F(1, 76) = 1.53$, respectively, but there were significant interactions of Group × Pair Type, $F(2, 76) = 6.17$, and Category Proportion × Pair Type, $F(1, 76) = 40.31$. Of primary importance was the significant three-way Group × Category Proportion × Pair Type interaction, $F(2, 76) = 3.375$, $p < .05$, which indicated differing effects of category proportion on priming across groups.

Subsequent two-way ANOVAs were conducted to assess effects within and across groups. For the young adults, there was a significant main effect of pair type, $F(1, 38) = 36.18$, and a reliable Category Proportion × Pair Type interaction, $F(1, 38) = 15.35$. Similar patterns were found for the older control group for pair type, $F(1, 20) = 7.37$, $p < .05$, and the Category Proportion × Pair Type interaction, $F(1, 20) = 15.27$, and for the MCI group for pair type, $F(1, 18) = 17.08$, and the Category Proportion × Pair Type interaction $F(1, 18) = 11.48$. For all groups, the two-way interactions revealed the same pattern: In the high category proportion condition, responses to coordinate pairs were slower than those to category pairs.

The nature of the three-way interaction was further elucidated when the two category proportion conditions were examined independently. Given a low category proportion, there were no significant main effects of group or pair type and no Pair Type × Group interaction (*F*s < 1). Figure 1 shows mean RTs for all groups as a function of pair type and category proportion. Given a high category proportion, the main effects of pair type, $F(1, 38) = 68.17$, and the Group × Pair Type interaction, $F(2, 38) = 6.41$, were significant.[3] Group differences for each pair type were assessed using Fisher's least significant difference (LSD) test. For category pairs, no significant differences emerged among groups. However, for coordinate pairs, the MCI group was significantly slower than both young and older control groups (Fisher's LSD, $p < .01$). The young and older control groups did not significantly differ from each other (Fisher's LSD, $p > .05$). An additional *t* test, comparing only the MCI and older control groups on coordinate pairs in the high category proportion condition, was also significant, $t(19) = 2.37$, $p < .05$.

The data in Figure 1 show a clear pattern: For both the young and older control groups, responses to coordinate and category pairs were equivalent when the category proportion was low, but responses to coordinate pairs were inhibited relative to category pairs when the category proportion was high: for young controls, $t(19) = -7.36$, $p < .01$; older controls, $t(10) = -3.61$, $p < .01$. The MCI group showed a similar pattern, but the magnitude of the inhibitory effect was much greater.[4] In the high category proportion condition, RTs to coordinate pairs were significantly slower than RTs to category–exemplar pairs, $t(9) = -4.21$, $p < .01$. Additionally, coordinate pair responses in the high category proportion condition were slower than those in the low category proportion condition, $t(9) = 3.68$, $p < .01$.

As stated earlier, a second group of young adults received an alternate version of the stimulus lists to assess possible stimulus-specific effects. A 2 × 2 × 2 mixed factor ANOVA, including the variables version (original vs. alternate), category proportion (high vs. low), and pair type (category vs. coordinate), was conducted to examine performance on original and alternative lists. The analysis revealed no significant effect of version and no interactions with category proportion or pair type (*F*s < 1). Thus, it is unlikely that the foregoing effects of category proportion were restricted to our specific stimulus lists.

[2] A 3 × 2 × 2 ANOVA conducted on the accuracy data revealed only two significant findings: a main effect of group, $F(2, 76) = 5.09$, $p < .05$, in which the healthy elders were more accurate than the young group, and a Pair Type × Category Proportion interaction for the young group. This interaction mirrored that observed in the RT data: Given a high category proportion, responses were less accurate to coordinate pairs than to category pairs, $F(1, 19) = 6.26$, $p < .05$.

[3] Because the older controls were slightly younger than the MCI individuals, an analysis of covariance was conducted on the high category proportion data, including age as a covariate. The Pair Type × Group interaction remained significant, $F(1, 18) = 6.42$, $p < .05$.

[4] Because individuals in the MCI group were tested in both conditions, we reanalyzed the data using only their first session data. The same patterns were observed, with the critical cell (MCI group, high category proportion, and coordinate pairs) showing a larger effect. Additionally, the data for the MCI individuals were examined for possible order effects using a 2 × 2 × 2 (Category Proportion × Pair Type × Presentation Order) ANOVA. The main effect of presentation order was not significant ($F < 1$) and did not significantly interact with any other variables (*p*s > .05). Although order effects were not significant in the analysis, the low number of participants limited the power of the analysis (increasing the possibility of a Type II error).

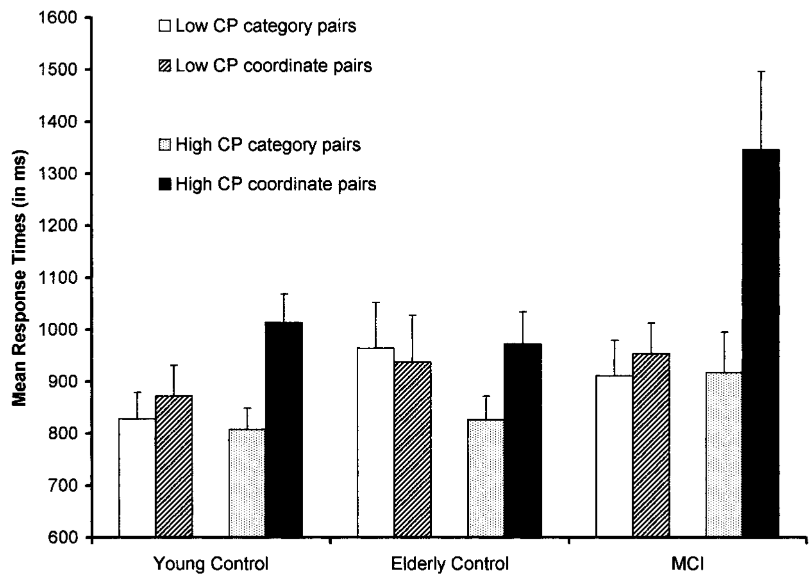


*Figure 1.* Mean reaction times (in milliseconds) and standard errors for all groups in the low and high category proportion (CP) conditions. MCI = mild cognitive impairment.

## Discussion

In this study, participants made speed-related decisions to word pairs; related pairs were either of the coordinate–coordinate form (e.g., *apple–pear*) or the coordinate–category form (e.g., *apple–fruit*). The participants were young adults, older adults, and individuals with MCI. Of primary interest, the ratio of category-related pairs to coordinate-related pairs was manipulated to induce expectancy biases. In the low category proportion condition, no differences were observed either among groups or across pair types. In the high category proportion condition, all groups were slow to verify coordinate-related pairs compared with category-related pairs. This was especially true for the MCI group, which showed evidence of hyperinhibition with expectancy violations.

Interestingly, in all groups, coordinate pairs were more sensitive to the expectancy manipulation compared with the category pairs. This likely reflects inherent differences in category and exemplar labels. For example, many semantic memory models (e.g., Warrington, 1975) assume that category names are accessed faster than specific exemplars. Thus, verification of exemplar–category pairs should be easy compared with exemplar–exemplar pairs. Alternatively, exemplar–category pairs may be easier because the most likely (category) targets are so easily anticipated. Although primes are associated with multiple coordinate terms, most are associated with single category terms. In this task, participants first identify prime words and then anticipate targets, preparing to confirm or disconfirm semantic relations. According to Becker (1980), people quickly learn to use primes to generate target candidates. With an expectancy bias for category targets, primes should immediately activate category labels, allowing quick verification.

Further, given the organization of many semantic memory models (e.g., Collins & Loftus, 1975; McClelland & Rumelhart, 1985), it seems unavoidable that category terms will always be activated, even in conditions that strongly favor coordinate–term biases. This prediction naturally emerges from both automatic and controlled views of priming (Neely, 1991). With an automatic view, seeing the first member of a coordinate pair (e.g., *apple*) initiates spreading activation to related terms (e.g., *pear*). However, all exemplars should have strong connections to the shared category term (e.g., *fruit*), which will accrue activation faster than any other concept. With a controlled view, seeing the first member of a coordinate pair prompts the assembly of an expectancy set. In this case, category terms will still accrue activation, as they logically constrain the candidate sets. For example, given the prime *apple*, optimal participants will generate other coordinate terms (e.g., *pear* and *banana*). This is likely achieved by searching the category fruit, making category activation integral to item activation. This framework easily accounts for our findings: Category verification RTs are equivalent across expectancy conditions because category terms are always activated, even when coordinate terms are more likely targets. The converse is not true: Coordinate terms should receive little activation when a category bias exists. Therefore, verification of coordinate pairs is selectively slowed.[5]

Similar to the control groups, MCI participants showed clear sensitivity to the expectancy bias manipulation. Thus, individuals with MCI seem to appreciate and utilize statistical regularities across trials. In fact, the MCI group was inordinately sensitive to expectancy: Given a high proportion of category pairs, their performance disparity between coordinate and category pairs was quite large relative to the disparities observed in control groups. As hypothesized, individuals with MCI experienced extra difficulty when faced with expectancy violations. As suggested earlier, substantial attentional resources may be required to shift away from expected targets to different, correct associates. The large inhibitory effect may thus reflect a selective reduction in working memory resources.

[5] Note that the coordinate pairs in this study were not only semantic associates, but many were also lexical associates. Thus, connections due to lexical associations (i.e., co-occurrences in linguistic experience) may have contributed to the inhibitory effects we observed.

Although individuals with MCI had trouble overcoming expectancy violations when the proportion of category pairs was high, they seemed to perform normally when the proportion of coordinate pairs was high. This finding was not totally unexpected. Given a bias to coordinate targets, working memory impairments would less likely impact performance. In this case, the expectancy bias would spread priority among coordinate candidates, keeping many potential targets (including the category label) in a state of partial readiness. Given a large slate of candidates, all receiving a little activation, none should require effortful suppression when the actual target is presented.

## Conclusion

Currently, researchers are trying to establish an accurate, comprehensive profile of the neuropsychological impairments in MCI. Although MCI is primarily characterized by episodic memory impairments, several recent findings have implicated executive dysfunction as well (Crowell et al., 2002; Haenninen et al., 1995, 1997; Ready et al., 2003). Our results also suggest mild executive dysfunction in MCI. We recommend that working memory and attention deficits be further examined in individuals with MCI.

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