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Timing, Instructions, and Inhibitory Control: Some Missing Factors in the Age and Memory Debate

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Circadian arousal · Inhibition · Memory · Aging

Abstract
In response to Luszcz and Bryan, we point to three omitted factors that have been found to influence the presence and size of age differences in memory tasks and that, as such, have important implications for resolving theoretical questions about aging and memory. These include: (1) age differences in circadian rhythms and testing time effects that are associated with such differences; (2) instructions that may have a particularly disruptive effect on older adults, and (3) inhibitory control differences that have an age-related impact on both estimates of working memory span and on performance in multitask studies.

Luszcz and Bryan [1] review several theories whose goal is to explain age-related loss in memory. Our response addresses a number of factors not generally taken into account by these theories, but which recent findings suggest can have an impact on the magnitude of, or sometimes even the presence of, age differences in memory. Three domains are considered: age differences in circadian rhythms; instructions used in memory experiments, and age differences in control over irrelevant information. We suggest that these factors be considered when comparing older and younger adults in memory tasks because current practices place older adults at a differential disadvantage, resulting in overestimates of age differences in memory. As well, these factors impact on theoretical explanations.

Circadian Rhythms and Aging

Circadian cycles of arousal differ between young adulthood and older adulthood [2–7]. In particular, fewer than 7% of North American college students are morning-types and about 40% are evening-types [8]. By contrast, approximately 75% of older adults are morning-types.

Age differences in arousal patterns are important because there are 'synchrony effects' in memory: performance is better at optimal than at nonoptimal times of day [3–5, 9, 10]. For example, morning-type older adults show better memory performance when they are tested in the morning as compared to the late afternoon. Recognition accuracy, span scores, and medical and appointment adherence are all higher in the morning than in the afternoon [5, 10, 11], while false, but related, intrusions are rarer [4, 10]. There is some evidence that many studies are scheduled in afternoon hours, so that older adults are tested at nonoptimal times, while younger adults are tested at their optimal times [5]. The size of age differences in memory may then be exaggerated relative to those seen when all participants are tested near their optimal times. Such problems pertain to all studies including many of the correlational studies used to assess the rela-

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tive contributions of, say, speed and working memory capacity to age differences in memory.

Thus, time of testing may enter into the explicit memory studies that are the focus of the Luszcz and Bryan article. In addition, there is literature on indirect or implicit memory that considers how the past influences current performance when participants are unaware of the relevance of the past. Age differences on indirect tasks range from undetectable to small, at least relative to the age differences found on explicit memory tasks [12]. (Although slowing is an important theoretical concept [1], it is not clear how it would explain the relatively small, but varying age differences seen in many indirect tasks [12] as well as the substantial age differences seen in most, but not all, explicit memory tasks [13].) Little time of day work has been done on implicit memory tasks, but what has been done [14, 15] suggests that there are differences across the day, with superior performance for older adults in the morning as compared to the afternoon.

There are also circadian synchrony effects that have an impact on speed measures [15]. For example, older adults' performance on the widely used Trails Making Test [16] varies across the day on one subtest (Trails B, in which people connect locations by interleaving an alphabet sequence with a numerical sequence) but not on another (Trails A, in which alternation between two sequences is not required). Similarly, older adults' performance on the interference card of the Stroop task is slower in the afternoon than in the morning, while performance on the color and word cards does not differ across the day [15]. These findings have implications for theories that tie age-related memory changes to cognitive slowing. More specifically, to the degree that age differences in speed interact with the (mostly uncontrolled) time of testing and with the type of speed test used, the formulation of direct connections between speed of processing and memory deficits may be premature.

Impact of Instructions to Remember

We now consider the instructions used in memory tasks. Several recent studies suggest that older adults' performance on the identical test can vary with instructions [17; Rahhal and Hasher, Rahhal et al., unpublished data]. As one example, performance on a task that required people to remember the truth versus falseness of facts (e.g., it takes 8 h to boil an ostrich egg) showed the usual age differences when the instructions given during both learning and testing emphasized that this was a memory task. When the instructions emphasized that this was a knowledge task (e.g., 'use the knowledge you acquired in the first phase of the experiment to help you answer these test questions'), age differences were eliminated. Additionally, on a standard source memory task in which one speaker provided true information and the other false information during the learning phase, older adults demonstrated their usual source monitoring deficits [18] when they were asked to remember 'who' stated each item, but not when they were asked to report if each item was true or false [Rahhal et al., unpublished data]. Thus, the typical source memory deficits demonstrated by older adults may also be a product of age differences in responses to particular instructions.

These findings are important because most explicit memory tasks use instructions alerting participants to the memorial nature of the task. Given the widespread belief among older adults that their memories are worse than they once were [19], it is possible that instructions alone reduce performance.

Inhibitory Attentional Control Problems

We now consider the importance of age differences in control over irrelevant information and the impact of such differences on working memory and in multi-task experiments such as those typically used in individual difference studies. (Since inhibitory processes are seen as a major component of executive function [20], this discussion is tied to Luszcz and Bryan's consideration of the role of executive function decline in age-related memory loss.) There is substantial evidence that younger adults are better able than older adults to inhibit (or suppress from working memory) information that is no longer relevant [21–23]. For example, when the meaning of a sentence or passage changes (because of additional information), young adults suppress the original interpretation, and older adults maintain that interpretation, although both groups accept the new interpretation. Similarly, in directed forgetting studies, older adults have more difficulty than younger adults do in forgetting no longer relevant material [22, 23].

Such findings hold theoretical interest because they suggest an explanation for age differences in memory [21] not considered by Luszcz and Bryan. Consider the impact of differences in inhibitory control on estimates of working memory span, taken by many to be the mental capacity to simultaneously hold some information in memory while processing other information. However, most span tasks are actually multiple-list recall tasks in which (to take the reading span measure as an example [24]), a series of sentences is presented for comprehension while the participant also has to prepare to recall the final word of each. As each recall trial is over, a new series of unrelated sentences is presented. Thus, once a set of sentence-final words is recalled, there is no continuing use for that information on successive trials.

Because older adults are poorer than younger adults at suppressing no longer relevant information, age differences in the maintenance of information from prior span trials are to be expected. A major consequence of the maintenance of no longer relevant information is reduced span scores due to the interference in recalling relevant (current trial) information. Indeed, manipulations intended to prevent interference can eliminate age differences in span [25].

By extension from these considerations, any memory assessment that has multiple trials, multiple lists, or multiple tasks has the potential of creating problems on later trials, lists, or tasks for people who cannot so easily as others delete no longer relevant information from consideration. If this analysis of memory is correct and if older adults do indeed have deficient inhibitory controls, such multi-task studies may overestimate the true extent of memory differences across the lifespan or between younger and older adults.

Conclusion

We have considered three factors – circadian arousal patterns, instructions, and inhibitory attentional controls – that can influence estimates of memory differences between younger and older adults, as well as the interpretation of the sources of those differences. Because these factors have an impact on working memory span and speed tasks, as well as on many memory tasks, they need to be factored into the empirical literature before a clear picture of the mechanisms determining age differences in memory can emerge.

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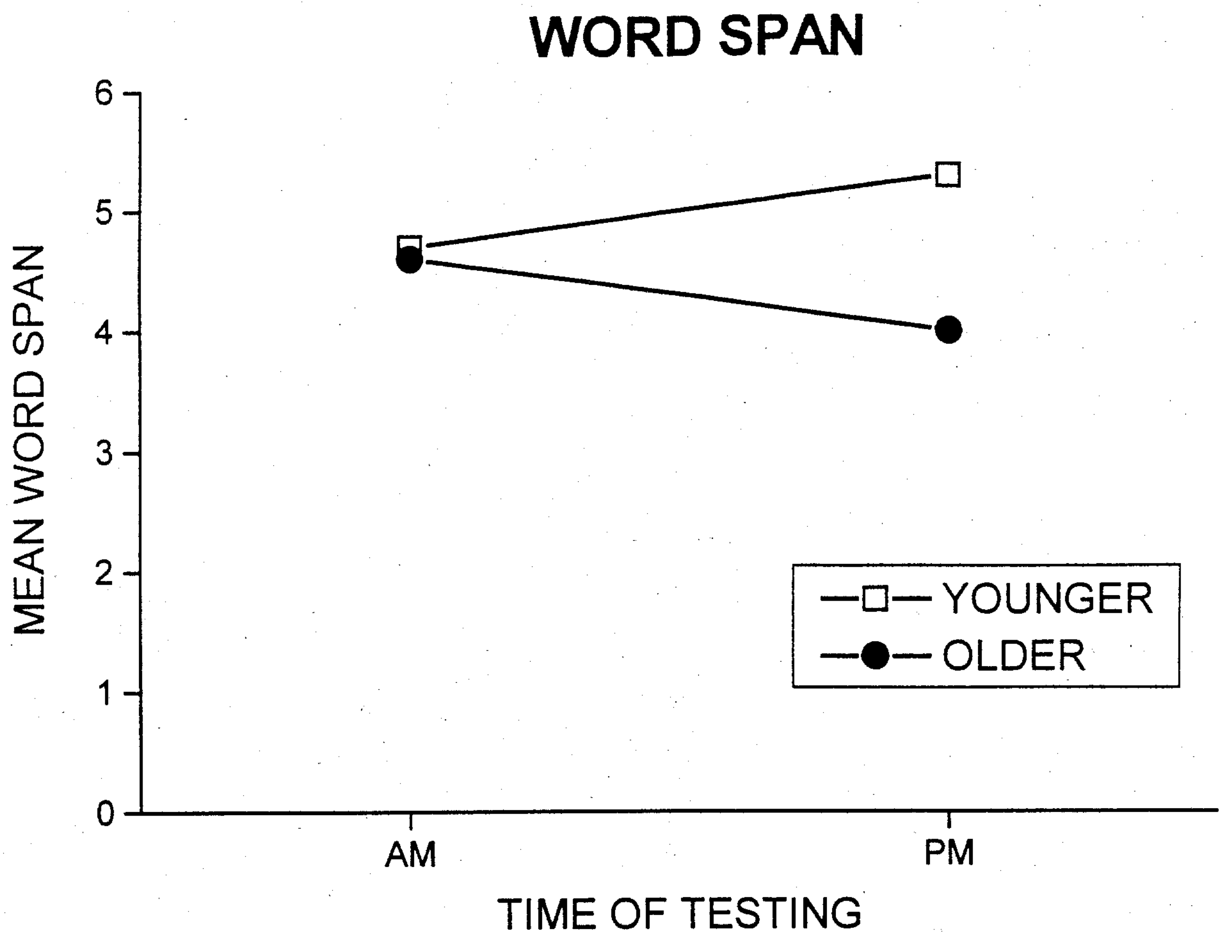
WORD SPAN
MEAN WORD SPAN
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TIME OF TESTING
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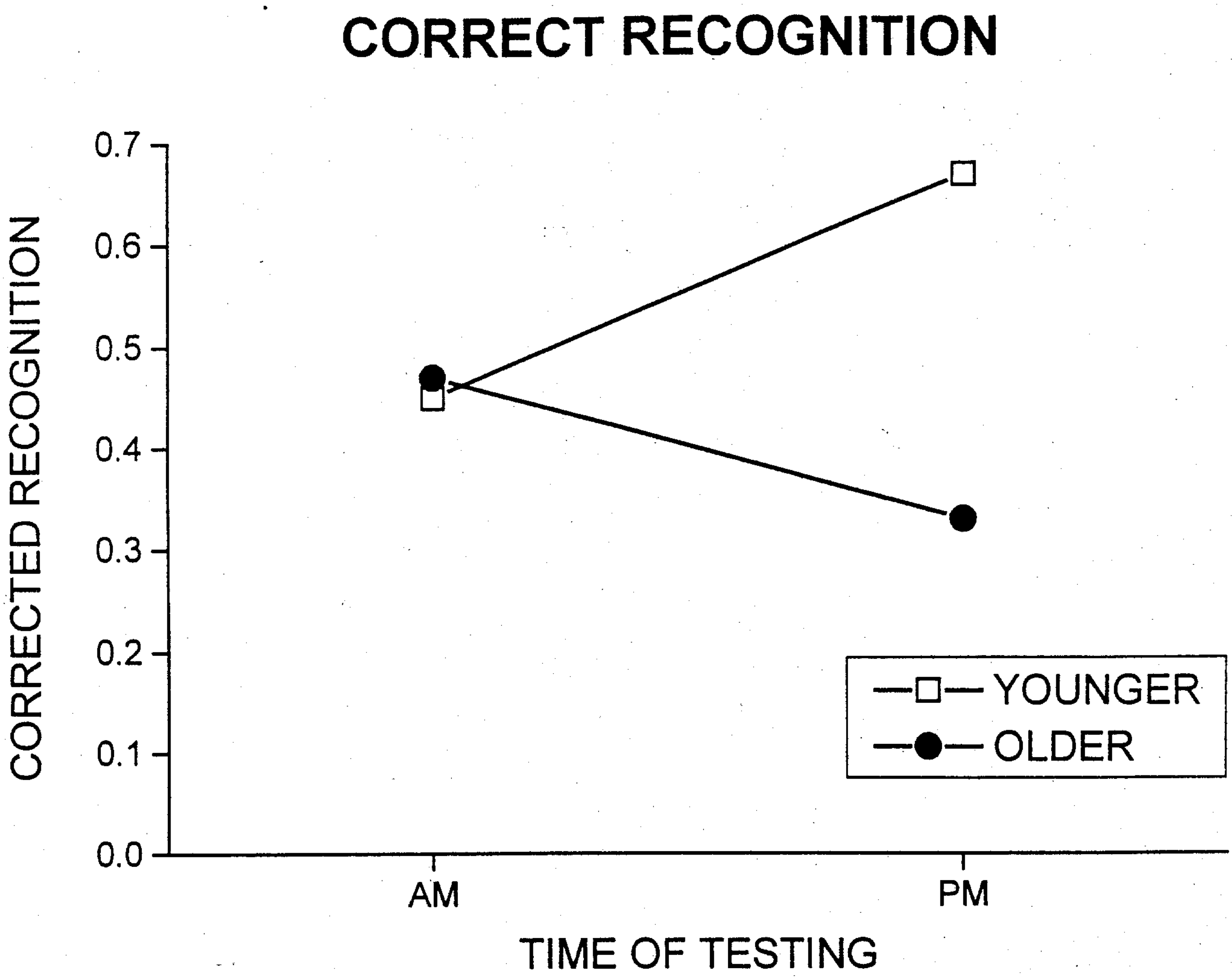
OLDER


CORRECT RECOGNITION
CORRECTED RECOGNITION
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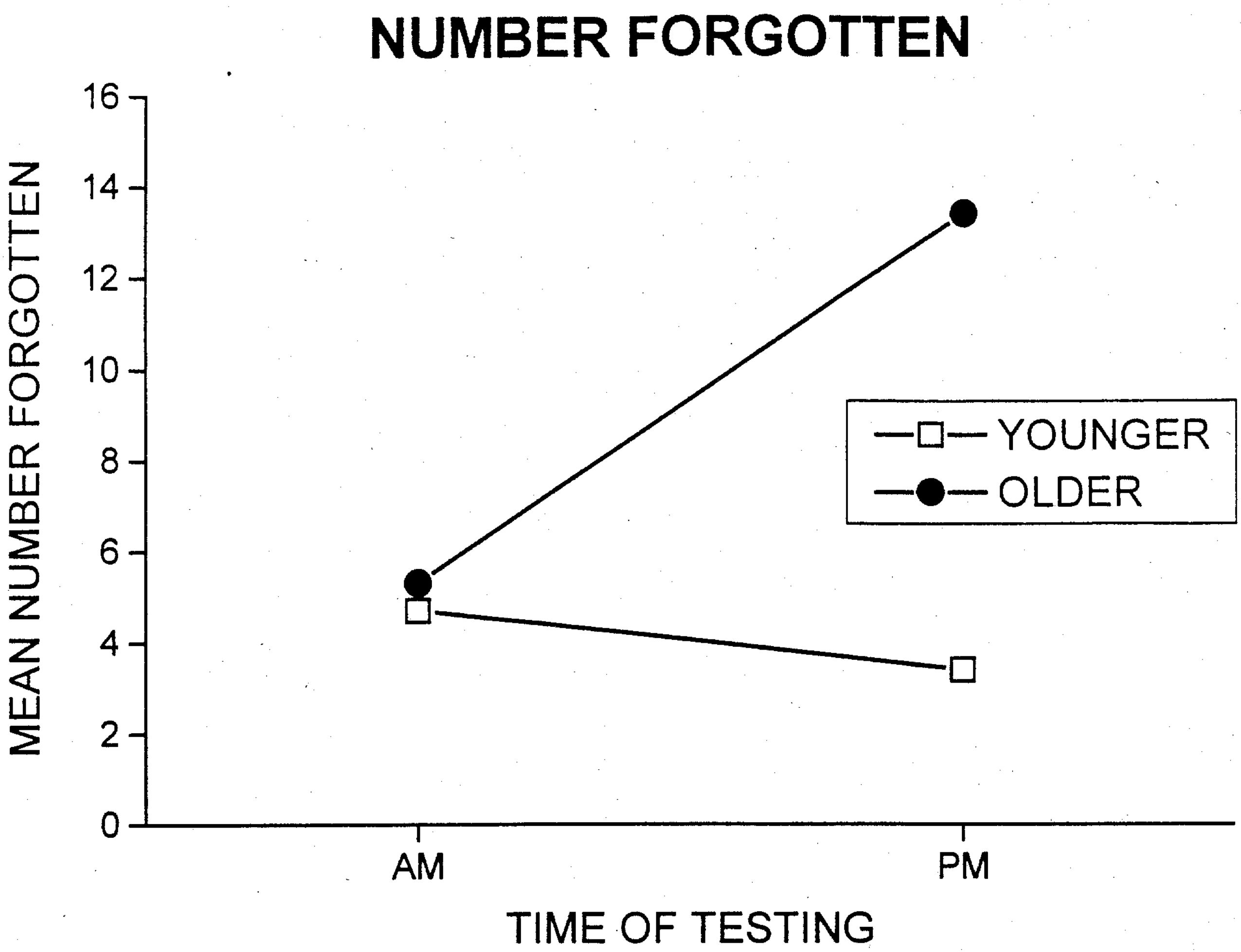
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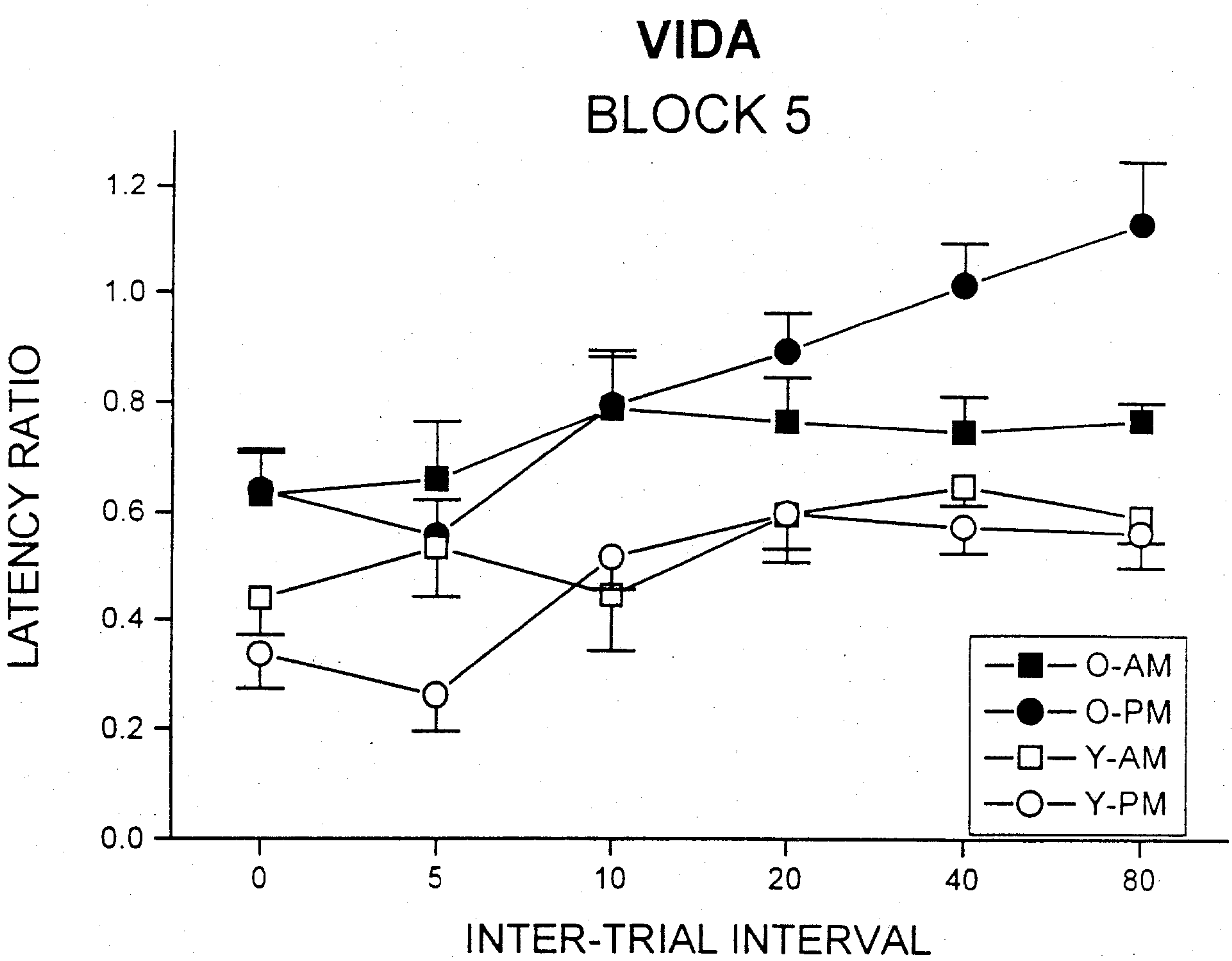
VIDA
BLOCK 5
LATENCY RATIO
1.2
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INTER-TRIAL INTERVAL
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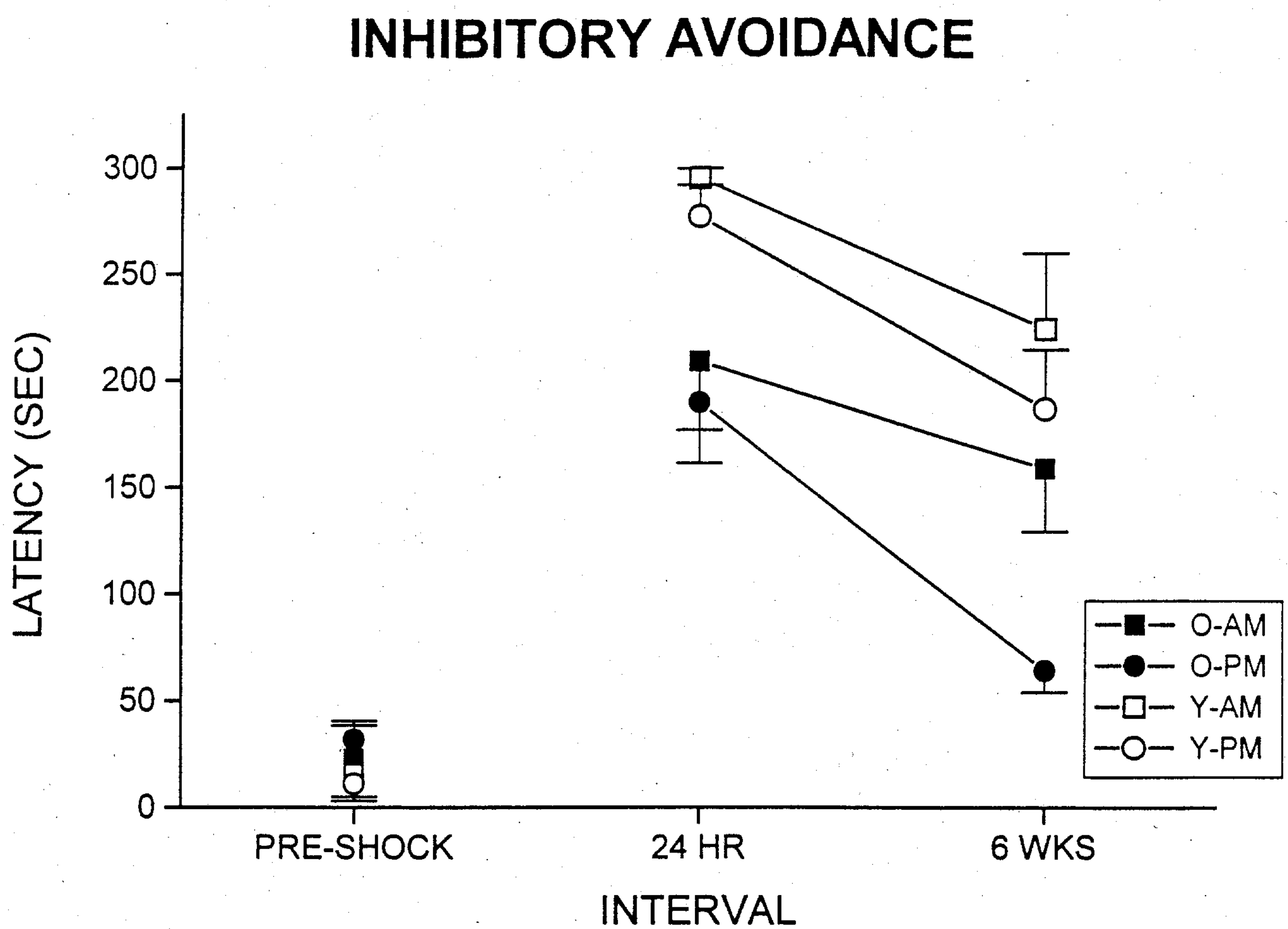

INHIBITORY AVOIDANCE
LATENCY (SEC)
300
250
200
150
100
50
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6 WKS
INTERVAL
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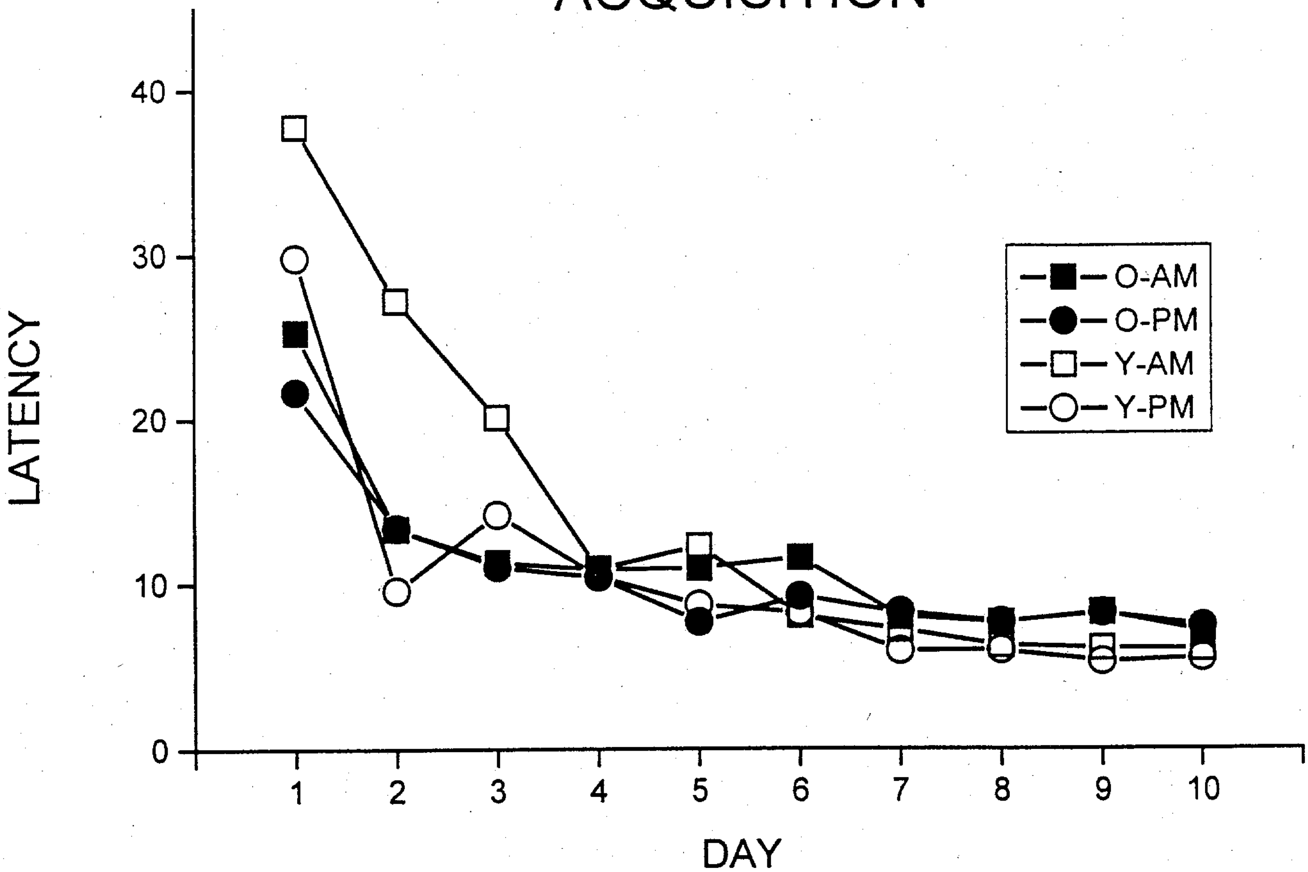
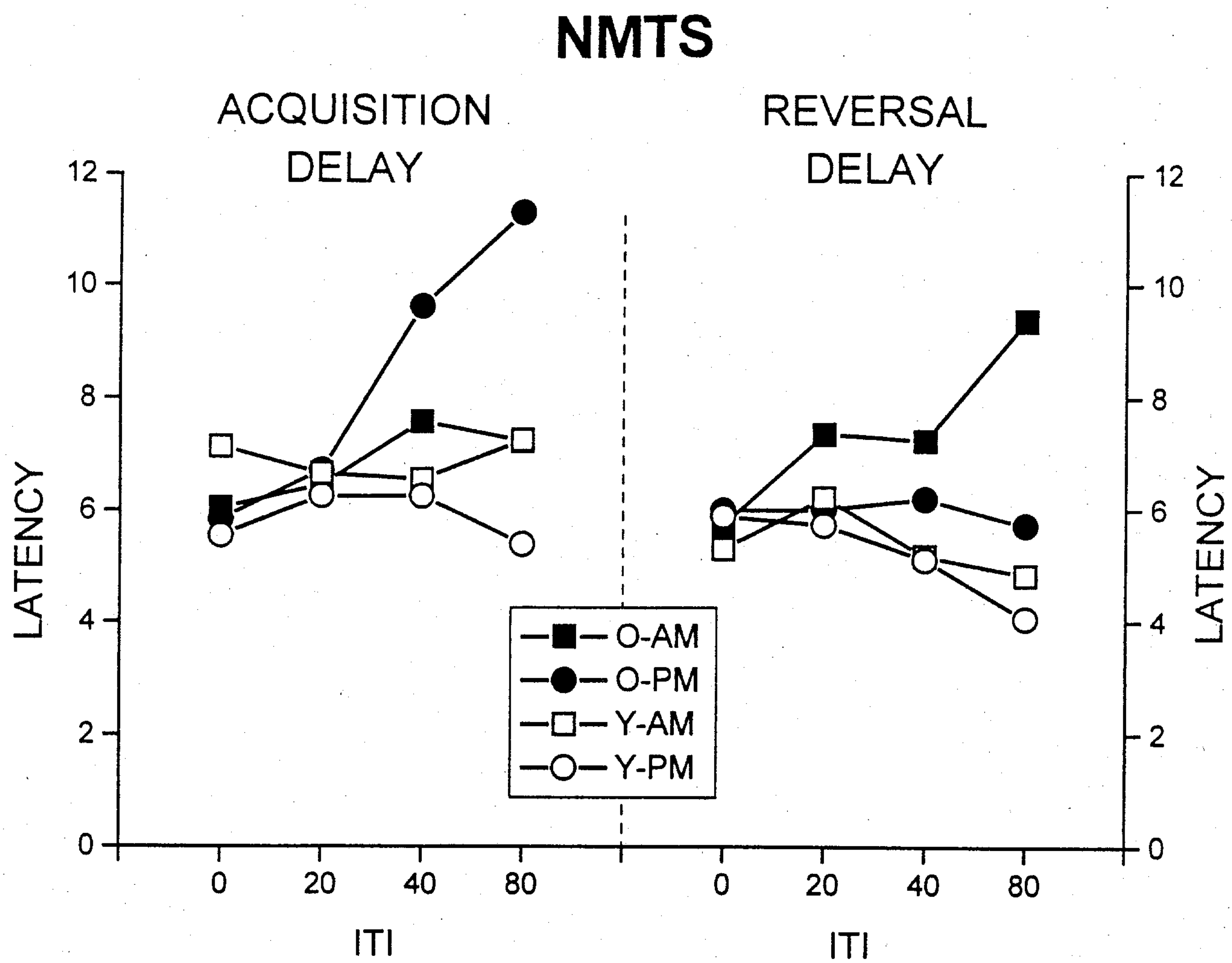
Y-AM
Y-PM

NMTS
ACQUISITION





NMTS
ACQUISITION
DELAY
REVERSAL
DELAY
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80
O-AM
O-PM
Y-AM
Y-PM