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Aging and implicit memory: Examining the contribution of test awareness

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ABSTRACT

The study examined whether test awareness contributes to age effects in priming. Younger and older adults were given two priming tests (word-stem completion and category production). Awareness was assessed using both a standard post-test questionnaire and an on-line measure. Results from the on-line awareness condition showed that, relative to older adults, younger adults showed higher levels of priming and awareness, and a stronger relationship between the two, suggesting that awareness could account for age differences in priming. In contrast, in the post-test questionnaire condition, there was no age effect in word-stem completion or category production priming, despite the fact that awareness was greater in younger than older adults in the word-stem completion test and that category production priming was dependent on awareness in both age groups. These results suggest that awareness may mediate age effects in priming, but only under conditions of relatively high levels of awareness.

0. Introduction

There are clear effects of aging on memory performance when memory is measured explicitly by using tests that directly require people to recall the past, such as free recall tests (see Light (1996) for review). The picture is less clear when memory is tested implicitly or indirectly. Implicit memory tests require participants to perform a task that is predictably influenced by past experience although participants are presumably unaware of the past's influence on their behavior. The resultant change in behavior (often improvements in accuracy or speed) is called priming (Graf & Schacter, 1985; Tulving, Schacter, & Stark, 1982). Sometimes priming is influenced by aging, but other times priming appears to be entirely unaffected by aging (see Fleischman and Gabrieli (1998), LaVoie and Light (1994), Light, Prull, La Voie, and Healy (2000) for reviews).

Several test factors have been hypothesized to account for the mixed pattern of aging effects on implicit tests, yet no clear support has emerged for any of these explanations. For example, researchers have suggested that age effects occur on implicit tests that require participants to analyze the conceptual (or semantic) features of the stimulus, but not on tests that require participants to analyze the perceptual (e.g., physical word features) of the stimulus (Jelicic, 1995; Jelicic, Craik, & Moscovitch, 1996; Rybash, 1996). However, sometimes age effects do occur on perceptual tests, such as word-stem completion, in which participants are given the first few letters of a word at test and are required to complete the stem with the first word that comes to mind (Chiarello & Hoyer, 1988; Davis et al., 1990; Fleischman et al., 1999; Hultsch, Masson, & Small, 1991; Light & Singh, 1987; Winocur, Moscovitch, & Stuss, 1996). Conversely, sometimes age effects do not occur on conceptual tests such as category verification, in which participants are given categories and are asked to quickly indicate whether target items are members of the category (e.g., Light, Prull, & Kennison, 2000; Small, Hultsch, & Masson, 1995).

With this in mind, researchers have instead suggested that age effects occur on tests that require participants to produce a response, but not on tests that require participants to simply identify the correct response (Gabrieli et al., 1994, 1999; Vaidya

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et al., 1997). However, some research also shows that age effects do not occur on tests that require the production of a response when other factors are held constant (Geraci, 2006; Prull, 2004). Another interpretation is that age effects in priming occur on tests that entail response competition (i.e., where there are many possible correct responses) and not on those that entail little response competition (i.e., where there are very few, or sometimes only one, possible correct response; Gabrieli et al., 1999; Nyberg, Winocur, & Moscovitch, 1997; Vaidya et al., 1997; see also Light et al., 2000)). Yet, when responses competition is selectively manipulated, age effects do not always occur under conditions of high response competition (Geraci & Hamilton, 2009). Finally, several other factors in addition to test factors, including time of day (May, Hasher, & Foong, 2005) and individual differences in older adults' neurological status (Fleischman & Gabrieli, 1998) have been offered as explanations for age effects in priming, but again there are results that appear inconsistent with these views (e.g., Geraci, 2006; Yang, Hasher, & Wilson, 2007).

Yet another possibility is that age effects in priming depend on whether explicit memory processes inadvertently contribute to implicit memory performance (Habib, Jelicic, & Craik, 1996; Light, 1991; Mitchell, 1995; Mitchell & Bruss, 2003; Russo & Parkin, 1993). The idea is that a certain number of participants become aware of the connection between the studied and test items and then begin to use explicit or intentional memory processes to perform the ostensibly implicit task (see MacLeod (2008) for review). This phenomenon is sometimes referred to as "explicit contamination". The contribution of explicit memory to implicit test performance is particularly problematic for understanding age effects in priming because younger and older adults differ in their ability to use explicit memory strategies (see Light (1996) for review). If younger adults are more likely to become test aware and/or engage in explicit memory strategies, then it is possible that age effects (when they are obtained) are driven by younger adults' use of explicit memory strategies to augment performance on a supposedly implicit test. This possibility makes it difficult to interpret age differences in implicit test performance. Do they reflect true differences in priming or differences in explicit memory performance? Unfortunately, test awareness is not always assessed in age comparisons of priming.

For test awareness to mediate age effects in priming, awareness would need to lead to more priming in general. In addition, either awareness would need to be greater in younger adults than it is in older adults or, when awareness occurs, it would have to increase priming more for younger adults than older adults. There is some evidence for the first idea that awareness increases priming. For example, when younger adults are given a post-test questionnaire to assess their awareness of the connection between studied and test items, younger adults who are classified as "test aware" on the basis of their responses to the questionnaire show more priming than "test unaware" participants (e.g., Barnhardt, 2004; Barnhardt & Geraci, 2008). In addition, some memory effects that are typically obtained on explicit tasks, such as free recall, are obtained for test aware participants, but not test unaware participants (e.g., Geraci & Rajaram, 2002). Together, these two types of evidence (i.e., showing that awareness leads to increases in priming and that awareness leads to differential priming effects) suggest that awareness can influence priming, at least in younger adults.

There is less research examining awareness in older adults, but some studies show that older adults are less likely to report test awareness than younger adults. In a recent study examining the effects of aging and frontal lobe functioning on priming, over half of the younger adults reported test awareness on a post-test questionnaire, while only three (all with relatively high frontal functioning) of the 56 older adults reported test awareness (Geraci, 2006). Because there were so few test aware older adults, the effect of awareness on priming for this group could not be statistically examined. However, awareness did appear to change the level of priming for younger adults, although the difference was not significant. Other studies have also found relatively high levels of awareness in younger adults and low levels of awareness in older adults using post-test questionnaires (Geraci & Hamilton, 2009). Older adults may report less test awareness than younger adults because older adults actually experience less test awareness than younger adults or because older adults are less able to accurately recall their mental state than younger adults when the awareness questionnaire is administered sometime later. We return to this second possibility shortly.

The final possibility—that awareness in younger adults leads to increases in priming whereas awareness in older adults does not—is difficult to test because so few older adults report awareness using the post-test questionnaire method of assessment. A handful of studies have compared age effects in priming by awareness using post-test questionnaires, but the data are mixed (e.g., Light & Albertson, 1989; Mitchell & Bruss, 2003; Park & Shaw, 1992). And again, lower reports of awareness from older adults may indicate less test awareness or poor awareness recall.

One way to circumvent the potential problem of recalling one's state of awareness from the past is to assess awareness at the time of testing, rather than waiting until some time later. In the current study, younger and older adults were given both an on-line awareness measure and a standard post-test questionnaire. For the on-line measure, participants were given standard implicit memory instructions to complete the task with the first word that comes to mind. They were also asked to note immediately after producing a word whether they thought the response they wrote might have been presented in the earlier study list (see Richardson-Klavehn and Gardiner (1996), for a similar paradigm used to assess involuntary awareness). If older adults' relatively low frequency of awareness is not attributable to older adults forgetting their past mental state, then we would expect greater levels of awareness in younger than in older adults in the on-line condition.

Further, using the on-line measure allowed us to examine age effects in priming under conditions in which participants are, by definition, test aware. Participants in the on-line condition can be considered test aware because the on-line test instructions essentially inform participants that the implicit memory test can be completed with previously studied words. Thus, the use of both the on-line assessment and the post-test questionnaire allowed us to contrast the pattern of age effects in priming under conditions of relatively high awareness (in the on-line condition) and relatively low awareness (in the post-