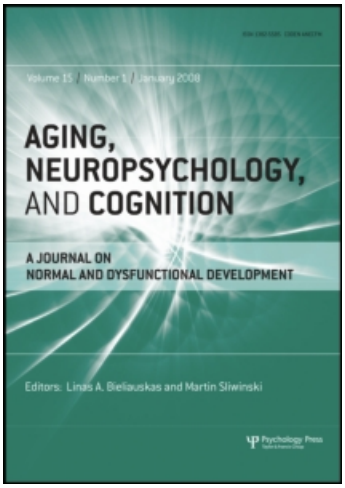

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Does Task Affordance Moderate Age-related Deficits in Strategy Production?

Sara Bottiroli[a]; John Dunlosky[b]; Kate Guerini[b]; Elena Cavallini[a]; Christopher Hertzog[c]
[a] Department of Psychology, University of Pavia, Pavia, Italy [b] Department of Psychology, Kent State University, Kent, OH, USA [c] Department of Psychology, Georgia Institute of Technology, Atlanta, GA, USA

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Does Task Affordance Moderate Age-related Deficits in Strategy Production?

SARA BOTTIROLI[1], JOHN DUNLOSKY[2], KATE GUERINI[2], ELENA CAVALLINI[1], AND CHRISTOPHER HERTZOG[3]

[1]Department of Psychology, University of Pavia, Pavia, Italy, [2]Department of Psychology, Kent State University, Kent, OH, USA, and [3]Department of Psychology, Georgia Institute of Technology, Atlanta, GA, USA

ABSTRACT

According to the *task-affordance* hypothesis, people will be more likely to use a specific strategy as tasks more readily afford its use. To evaluate this hypothesis, we examined the degree to which older and younger adults used a self-testing strategy to learn items, because previous studies suggest that age-related differences in the use of this powerful strategy vary across tasks. These tasks (words affixed to a board vs. pairs on flashcards) differentially afford the use of the self-testing strategy and may moderate the age-related effects on strategy use. Participants performed a recall-readiness task in which they continued to study items until they were ready for the criterion test. As predicted, self testing was used less often on tasks that least afforded its use. Namely, participants used self testing less when they studied single words affixed to a board than when they studied pairs on flashcards. Most important, age-related deficits in strategy use were greater for the former task and nonexistent for the latter one, suggesting that task affordance moderates age differences in strategy use.

Keywords: Self-testing; Task-affordance; Aging; Strategy; Memory.

INTRODUCTION

While studying, people adopt a variety of strategies in hopes of boosting performance on a criterion test (Richardson, 1998). For any given memory task, some strategies are more effective than others, and individual differences in the use of the effective strategies are often highly correlated with criterion

Address correspondence to: John Dunlosky, Department of Psychology, Kent State University, PO Box 5190, Kent, OH 44242-0001, USA. E-mail: jdunlosk@kent.edu

performance (for reviews, see Benjamin & Ross, 2007; Dunlosky, Hertzog, & Powell-Moman, 2005). With respect to aging, although many older adults use effective strategies during study, age-related deficits in the spontaneous use of effective strategies can account for some of the concomitant age-related memory impairments (Dunlosky & Hertzog, 2001; Naveh-Benjamin, Brav, & Levy, 2007). A question arises as to why older adults may be less strategic under some conditions. In the present research, we specifically addressed the crucial role of task features in supporting strategy use – that is, the degree to which a given task affords the use of a particular strategy.

Task affordance pertains both (a) to the likelihood that a given task will activate a learner's knowledge about a specific strategy and (b) the degree to which that task affords the application of the strategy. Consider the self-testing strategy, which involves searching memory to determine whether previously studied items can be retrieved. Self testing prior to a final criterion test informs one as to whether to devote more time to learning the items. To illustrate, consider two different memory tasks that have different affordances for using self testing: (a) learning Italian-English vocabulary terms presented on flashcards and (b) learning individual words that are presented on a computer screen. Even though a self-testing strategy can be used in both cases, the task affordance is higher for self testing with flashcards because it is more obvious how to self test when using flashcards; namely, to attempt retrieval from memory, one needs to merely examine each cue by itself by covering the response. By contrast, individual words presented on a computer cannot be manipulated and how to cue retrieval without the target present is less obvious with this task format. The latter task may even be less likely to activate one's knowledge about the self-testing strategy, and even if it were activated, this strategy would be more difficult to apply. The *task-affordance* hypothesis could also explain age-related differences in strategy production. As task affordance decreases, older adults may have more difficulties applying a target strategy to the task, which may ultimately reflect a deficit in self-initiated processing unless environmental support is provided (Craik & McDowd, 1987).

We tested the task-affordance hypothesis by investigating whether the use of self testing varied with task affordance in recall-readiness tasks. We focused on self testing to evaluate readiness for an upcoming test for a variety of reasons. First, self testing is a powerful strategy because it can be used to effectively regulate learning (Dunlosky, Hertzog, Kennedy, & Thiede, 2005) and testing during practice can boost subsequent performance (Pyc & Rawson, 2009; Roediger & Karpicke, 2006). Second, whereas age differences are minimal in the use of other effective mnemonic strategies (for a review, see Hertzog & Dunlosky, 2004), age deficits in the use of self testing during study can be dramatic (e.g., Brown, Bransford, Ferrara, & Campione, 1983; Murphy, Sanders, Gabriesheski, & Schmitt, 1981). Indeed, Murphy,

Schmitt, Caruso, and Sanders (1987) found impressive age-related deficits in the use of a self-testing strategy. Their participants performed a recall-readiness task by studying pictures placed on a board to allow simultaneous presentation of all items. Participants studied the pictures as long as desired and informed the experimenter when they were ready to be tested. Younger adults self tested much more often than did older adults, who rarely used the strategy spontaneously. In contrast, Bailey, Dunlosky, and Hertzog (in press) recently examined older adults' use of this strategy to study paired associates printed on index cards. Many older adults reported spontaneously self testing as they prepared for the upcoming test, which was surprising given Murphy et al.'s (1987) results.

Why might older adults' use of a self-testing strategy differ so dramatically in the two studies? Although numerous differences in method existed between the studies, we hypothesized that the most relevant ones concerned the degree to which the tasks afforded self testing. Murphy et al. (1987) had participants study individual items affixed to a board (so that participants could not easily manipulate them), whereas Bailey et al. (in press) had individuals study paired associates on flashcards that easily afforded a self-testing strategy.

To evaluate this *task-affordance* hypothesis, we compared spontaneous self testing in younger adults and older adults as they studied two kinds of item (single words vs. pairs) presented in two different formats (items attached to a board vs. items printed on index cards). After studying a list, individuals reported whether they had used self testing. Analyses of self testing were guided by three a priori planned comparisons, which were conducted using a non-parametric test (Mann–Whitney *U*-test) given the nature of the dependent variable. First, we compared older and younger adults' self testing for words presented on the board to evaluate whether our results replicated the age-related deficits reported by Murphy et al. (1987). The second and third comparisons evaluated the task-affordance hypothesis, which predicts that people (a) will self test less often when items are fixed to a board than presented on individual cards and (b) will self test less often for words than for pairs. To test these latter two predictions, we conducted two separate planned comparisons on self-testing that focused first on the influence of presentation format (board vs. flashcards) and then on the influence of kind of item (pairs vs. words). Although less relevant to our specific aims, we finish by presenting omnibus analyses of recall performance and self-paced study times.

METHOD

Participants

Participants were 48 young adults (ages 18–24 years; $M = 19.21$, $SEM = 0.20$) and 48 older adults (ages 60–88 years; $M = 70.21$, $SEM = 1.04$). The

young adults were undergraduate students at Kent State University and received course credit for participation. Older adults were recruited through a newspaper advertisement in northeast Ohio and were paid for their participation. The group of young adults consisted of 22 men and 26 women, and the group of older adults consisted of 20 men and 28 women. On average, older adults had 15.62 years of education (*SEM* = 0.54) and younger adults had 11.83 (*SEM* = 0.12). Measures of vocabulary knowledge and perceptual speed (i.e., letter and pattern comparison) were administered to all participants. Older adults had higher vocabulary scores ($M = 21.57$, $SEM = 1.03$) than did younger adults ($M = 12.65$, $SEM = 0.45$), $t(94) = 7.93$, $p < .001$, whereas younger adults had higher scores on the letter comparison and pattern comparison tasks ($M = 21.17$, $SEM = 0.57$ and $M = 41.73$, $SEM = 0.88$, respectively) than did older adults ($M = 16.34$, $SEM = 0.53$ and $M = 30.67$, $SEM = 0.77$, respectively), $t(93) = 6.21$, $p < .001$ and $t(94) = 9.46$, $p < .001$.

Memory Tasks and Testing Procedures

All participants had two trials of studying either twenty randomly assigned pairs or single words, so that equal numbers of younger and older adults studied pairs or single words. Participants were randomly assigned to study pairs or single words, with age and composition of gender approximately balanced within each age group. All items consisted of nouns, taken from Paivio, Yuille, and Madigan's (1968) word norms, which were randomly assigned to pairs and single word lists while balancing imagery, concreteness and frequency of use. One study trial presented items on 5×7 inch flashcards that participants could manipulate in their hands; the other presented items on a board within hands reach. The order of task exposure was counterbalanced. Two lists of words were assigned at random to the paired-associate and single word learning tasks, with single words being the response terms for the paired-associates. Different participants received the two lists of words in a randomly-assigned counterbalanced order across formats, so that list was not confounded with experimental conditions.

Associative Learning

Participants in the pairs group were presented with 40 word pairs, with 20 presented in the card format and 20 presented during the board format. Each pair was printed in the middle of a 5×7 index card. In the card format, randomized pairs were printed on flashcards that were handed to participants, who were instructed to study them any way they chose and for as long as they chose. In the board format, cards were attached (in a random order) to a board backing to allow simultaneous presentation of all items. Participants were instructed to study pairs any way they chose and as long as they chose, but without handling them. For both formats, recall was tested by computer presentation of each stimulus word in a random order. Participants

were asked to type the response term that had been paired with each stimulus during study.

List Learning

Participants in the single word group were presented with 40 single words, with 20 presented in the card format and 20 presented in the board format. Each word was printed in the middle of a 5×7 index card. Both the card and board formats of the task were administered in the same manner as the associative learning group. During both recall phases participants were asked to recall words by typing them on a blank screen of a computer. When recalled words were typed into the computer, a window appeared listing the typed in responses so that participants could view previously recalled words.

Self-testing Measures

Two self-testing measures were used during both card and board formats of the memory tasks. An experimenter unobtrusively observed participants while studying trial of each memory task format and inferred whenever they were self testing by observing diagnostic behaviors (e.g., covering responses or looking away from the items), checking off the behaviors on a list as they occurred (as in Murphy et al., 1987). Participants also were asked to complete a questionnaire that was focused on whether they used self testing to guide study for a given memory task. In detail, the questionnaire asked participants about whether they self tested their memory as they prepared to be tested on a given task; the participants answered 'yes' or 'no' as to whether they self-tested during study. This questionnaire was administered separately for each task, but after both tasks were completed. The experimenter was present while participants completed the questionnaire and clarified 'self testing' when needed (i.e., it involves searching memory to determine whether previously studied items can be retrieved). Participants were categorized as testers or non-testers based on whether they answered 'yes' or 'no', respectively.

The questionnaire was administered after both memory tasks were completed; by delaying the questionnaire until both tasks were completed, it could not have any reactive effects on how participants completed the tasks. Such questionnaires self-report questionnaires have been validated with older adults (for discussion, see Saczynski, Rebok, Whitfield, & Plude, 2007). Moreover, although the reports were retrospective and hence may have been influenced somewhat by forgetting, the reports did occur soon after the test trials, the act of self testing itself is easy to verbalize during study, and it would be heeded in memory as it occurred. For all these reasons, we expected the verbal reports to have acceptable validity (Ericsson & Simon, 1984); and as important, any limits to the validity of these measures would work against obtaining evidence that is consistent with the task-affordance hypothesis. Finally, we first conducted analyses on both measures (experimenter check

list and participant reports) of the use of self testing during study. Both measures yielded the same substantive conclusions, so unless noted otherwise, we present analysis of the subjective reports in part because some of the objective indicators of self testing (e.g., looking away from an item) may reflect other behaviors (e.g., merely rehearsing an item or daydreaming). The data from the checklist measure, however, are available upon request.

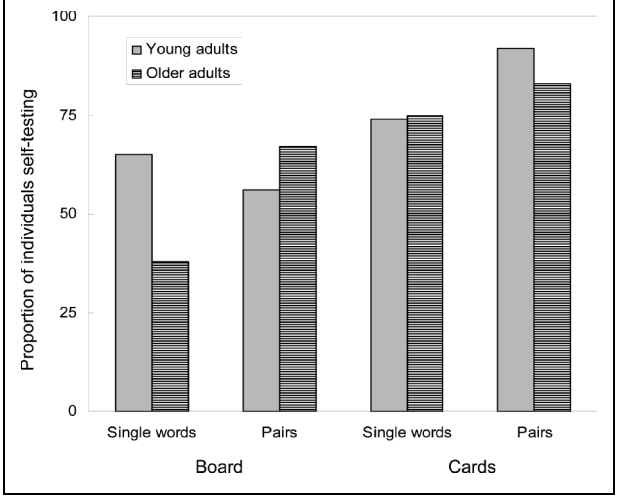
RESULTS

Self Testing

The proportion of individuals who reported self testing across the various conditions is reported in Figure 1. All the predicted outcomes from the planned comparisons were obtained. First, we replicated the main outcome of Murphy et al. (1987). When participants studied single items presented on a board, older adults reported self testing less than did younger adults (see the two left-most bars of Figure 1), Mann–Whitney $U = 199.5$, $p = .03$. Consistent with this outcome, experimenter observation (checklist measure) also indicated that self testing single words on a board was used less often by older adults ($M = 0.33$) than by younger adults (0.56), $U = 212.0$, $p = .056$. Age-related differences were negligible for the three other conditions, ps $> .05$.

Second, self testing was reported significantly more often when items were presented on cards than when they were presented affixed to a board, sign test, $p < .001$. Finally, participants self tested significantly more often when studying pairs than words, but only when the items were presented on

FIGURE 1. Proportion of individuals self testing as a function of age group and task as measured by the subject reports of self testing.



cards, $U = 998.5$, $p = .049$; this same trend was not significant when items were affixed to the board, $U = 1034.5$, $p = .159$.

Due to age differences in vocabulary and perceptual speed, we conducted a logistic regression analysis on self-testing reports, which was carried out separately for each testing format, with these factors as predictor variables. For the board format, no significant effects were found for any predictor: vocabulary, χ^2 (1, $N = 96$) = 0.12; letter comparison, χ^2 (1, $N = 96$) = 0.56; and pattern comparison, χ^2 (1, $N = 96$) = 3.0. The same pattern resulted for the card format: vocabulary, χ^2 (1, $N = 96$) = 0.43; letter comparison, χ^2 (1, $N = 96$) = 0.74; and pattern comparison, χ^2 (1, $N = 96$) = 0.02.

Recall Performance

Mean recall performance is presented in Table 1. Self testers had higher levels of recall. For instance, for older adults who studied pairs of words presented on the board, recall was 65% for self testers and only 29% for non testers. Across all 8 comparisons, 6 were in this expected direction, including all four comparisons involving older adults.

These observations were supported by a 2 (age group: young adults and older adults) × 2 (item type: single words and pairs) × 2 (self-testing use: self tester vs. non tester) analysis of variance (ANOVA) carried out on recall performance. To simplify analyses, we conducted this ANOVA separately for each testing format (board and cards). For items presented on the board, performance was higher for younger adults than older adults, $F(1, 88) = 35.17$, $p < .001$, $MSE = 508.07$, and for self testers than non testers, $F(1, 88) = 7.75$, $p = .003$, $MSE = 508.07$. The main effect of item type was not significant, $F = 0.15$, $MSE = 508.03$. The Age group × Self-testing use interaction was significant, $F(1, 88) = 4.80$, $p = .015$, $MSE = 508.07$. As is evident from inspection of Table 1, older adults who self tested consistently outperformed

TABLE 1. Recall Performance as a Function of Age Group, Self-testing Use, Item and Format

	Board				Card			
	Pairs		Single words		Pairs		Single words	
	M	(*SEM*)	*M*	(*SEM*)	*M*	(*SEM*)	*M*	(*SEM*)
Older adults								
Testers	65	*(6.2)*	52	*(9.7)*	67	*(5.7)*	61	*(5.0)*
Non testers	29	*(6.8)*	41	*(3.7)*	58[a]	*(11.3)*	47[a]	*(9.2)*
Young adults								
Testers	76	*(5.7)*	77	*(5.4)*	85	*(3.9)*	80	*(4.4)*
Non testers	70	*(8.2)*	78	*(8.0)*	68[a]	*(32.5)*	81[a]	*(8.6)*

Note: SEM, standard error of the mean; Testers, participants who reported self testing during study; Non testers, participants who did not report self testing during study.
[a]Six or fewer participants contributed to performance in these cells.

older adults who did not, whereas younger adults did not consistently benefit from self testing. All other interactions were not significant, *F*s < 2.84.

For items presented on cards, a main effect occurred for age group, $F(1, 88) = 10.57$, $p = .001$, $MSE = 469.35$, indicating that performance was higher for younger adults than for older adults. The main effect of self testing use approached reliability, $F(1, 88) = 2.72$, $p = .05$, $MSE = 469.35$, revealing that performance was higher for self testers than non testers. The main effect of item and all interactions were not significant, *F*s < 1.03.

Study Times

For each individual, we analyzed the overall study time, which was the amount of time that a participant inspected items during study before indicating that he or she was ready to be tested. We computed the mean study time across participants (Table 2). As with recall performance, study time was analyzed by a 2 (age group: young adults and older adults) × 2 (item type: single words and pairs) × 2 (self-testing use: self tester vs. non tester) ANOVA, which was conducted separately for each testing format.

For items presented on the board, a main effect occurred for item type, $F(1, 88) = 5.62$, $p = .01$, $MSE = 18.62$, indicating that participants studied pairs longer than single words. The main effects of self-testing use and age group were not significant, *F*s < 7.37. The Age group × Self-testing use interaction was significant, $F(1, 88) = 7.37$, $p = .004$, $MSE = 18.62$. Older adults who self tested consistently used more time studying than did older adults who did not self test, whereas younger adults spent about the same amount of time studying under each format condition regardless of whether they self tested or not. All other interactions were not significant, *F*s < 2.02.

TABLE 2. Self-paced Study Times (minutes) as a Function of Age Group, Self-testing Use, Item and Format

	Board				Card			
	Pairs		Single words		Pairs		Single words	
	M	(*SEM*)	*M*	(*SEM*)	*M*	(*SEM*)	*M*	(*SEM*)
Older adults								
Testers	10.1	*(2.3)*	4.2	*(6.7)*	12.9	*(1.9)*	5.3	*(0.48)*
Non testers	3.9	*(0.38)*	3.1	*(5.0)*	7.3[a]	*(1.6)*	5.1[a]	*(0.43)*
Young adults								
Testers	4.9	*(0.48)*	3.9	*(0.38)*	7.6	*(.75)*	6.9	*(0.72)*
Non testers	6.3	*(1.3)*	5.3	*(0.99)*	8.9[a]	*(3.3)*	6.0[a]	*(1.6)*

Note: SEM, standard error of the mean; Testers, participants who reported self testing during study; Non testers, participants who did not report self testing during study.
[a]Six or fewer participants contributed to study times in these cells.

For items presented on cards, a main effect occurred for item type, $F(1, 88) = 6.16$, $p = .007$, $MSE = 22.63$, demonstrating that participants studied pairs longer than single words. The main effects of self-testing use and age group and all interactions were not significant, Fs < 1.97.

DISCUSSION

Our findings supported the task-affordance hypothesis. Participants self tested more often (a) when items were presented on index cards than fixed to a board and (b) when they were studying pairs than single words. Furthermore, as expected, age differences in self testing occurred when single items were fixed to a board, which replicated Murphy et al. (1987), whereas age groups did not differ in self testing for the other task formats.

It is crucial to understand how task features are involved in encouraging strategy production and why older adults are less likely to self test when task affordance is low. Concerning age-related differences, one explanation involves strategy knowledge (e.g., Price, Hertzog, & Dunlosky, 2008); namely, older adults may be less likely to know that a self-testing strategy could be used in recall-readiness tasks. Although plausible, we believe such a metamemory knowledge deficiency cannot fully explain older adults' deficient strategy use, because they demonstrated knowledge about this self-testing strategy when using it to the same degree as younger adults under the other task formats.

We advance two alternative explanations for differences in strategy use. One possibility is that participants may not even think about using a self-testing strategy while they were studying the items under some formats. In this case, some other strategy to learn the words was activated among the set of alternative strategies available from long-term memory. This process, according to Lemaire and Siegler (1995), could be related to previous experience and relative strategy strengths. Another possibility is that individuals considered using this strategy (i.e., it was activated from long-term memory), but they did not know how to implement it or it required too much cognitive resource to implement. This explanation could be particularly useful for explaining the age-related deficits for the low-affordance task, considering that (a) processing resources decline with age (e.g., Park et al., 1996; Salthouse, 1991, 1996) and that (b) age differences are usually more evident when tasks require more self-initiated processing (Craik & Jennings, 1992). However, some evidence runs counter to this explanation: (a) processing speed did not predict self-testing use when participants studied words affixed to the board and (b) older adults instructed to self test by Murphy et al. (1987) successfully used this strategy in this task format. Of course, these factors – strategy knowledge, activation of a given strategy, and strategy implementation – may jointly explain how task features afford a given strategy and why task

affordance moderates age-related differences in strategy use. A challenge for future research will be to develop methods that can be used to estimate the relative contribution of these factors to strategy production.

Within the older adult group, recall performance was better for those who used the self-testing strategy (see also Dunlosky, Kubat-Silman, & Hertzog, 2003; Murphy et al., 1987). Why did self testing benefit older adults' recall performance? In Murphy et al. (1987), older adults instructed to self test spent more time studying (in comparison to non-instructed older adults) and had better memory performance. However, increases in study time are not always responsible for the benefits of self testing. For instance, Dunlosky et al. (2003) trained older adults to self test in preparation for an upcoming exam, and a time limit was imposed on overall study. As compared to older adults who did not receive training, trained adults recalled reliably more items but used the same amount of time during study. In this case, self testing presumably boosted performance because it allowed trained adults to isolate unlearned items and to focus additional study time on just those items. Alternatively, self testing itself (without a chance for further self-regulated study) can enhance performance in that retrieval practice usually has a greater positive effect on future retention than spending an equivalent amount of time restudying the material (see Bjork, 1988; Pyc & Rawson, 2007; 2009; Roediger & Karpicke, 2006).

In summary, our main outcomes contribute to the literature in three ways. First, we resolved the apparent empirical inconsistency between Murphy et al. (1987) and Bailey et al. (in press) by demonstrating age-related differences and equivalence under the conditions used in their research. Second, the findings generally supported a task-affordance hypothesis for strategy production. Third, and most important, we demonstrated the crucial role of task features in explaining age-related differences in the use of a self-testing strategy; task affordance appears to moderate age deficits in strategy production.

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