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RESEARCH REPORT

# The Production Effect: Costs and Benefits in Free Recall

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The production effect, the memorial benefit for information read aloud versus silently, has been touted as a simple memory improvement tool. The current experiments were designed to evaluate the relative costs and benefits of production using a free recall paradigm. Results extend beyond prior work showing a production effect only when production is manipulated within subject, not between, using a free recall paradigm. Furthermore, the results also indicate that the production effect is primarily driven by decreased memory for items read silently, not increased memory for items read aloud.

*Keywords:* production effect, free recall, explicit memory

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The production effect, the memorial benefit of reading aloud compared with reading silently, has recently received considerable attention in the literature (Bodner & Taikh, 2012; Bodner, Taikh, & Fawcett, 2013; Fawcett, 2013; Forrin, MacLeod, & Ozubko, 2012; Lin & MacLeod, 2012; MacLeod, 2011; MacLeod, Gopie, Hourihan, Neary, & Ozubko, 2010; Ozubko, Gopie, & MacLeod, 2012; Ozubko, Hourihan, & MacLeod, 2012; Ozubko & MacLeod, 2010; Richler, Palmeri, & Gauthier, 2013) and has been touted as an easy memory improvement tool (MacLeod et al., 2010). However, Bodner and colleagues (2013) recently demonstrated that with recognition tests of memory, the effect may actually be due to both a memory decrement to items read silently and an enhancement to memory for items read aloud. The goal of the current study was to further examine the costs and benefits of production using a free recall paradigm.

In coining the term, MacLeod et al. (2010) demonstrated that this simple manipulation has a robust effect on memory. Although the production effect has been demonstrated across a number of studies, it typically only obtains when the manipulation occurs within subject (but see Fawcett, 2013; for earlier demonstrations see Conway & Gathercole, 1987; Gathercole & Conway, 1988; Hopkins & Edwards, 1972). Production does not need to be overtly auditory; simply mouthing (MacLeod et al., 2010) or spelling (Forrin et al., 2012) half of the to-be-remembered items results in higher recognition accuracy compared with reading words silently. The production effect is additive to the benefits of generation and semantic processing (MacLeod et al., 2010), extends to a delayed retention interval (Ozubko, Hourihan, & MacLeod, 2012), and has been demonstrated with nonwords (MacLeod et al., 2010), word pairs, and sentences (Ozubko, Hourihan, & MacLeod, 2012).

Although the production effect is robust in that it has been demonstrated under a variety of encoding conditions and following different retention intervals, it is not clear that the effect is due specifically to increased memory for items read aloud. In fact, in Experiment 3 reported by MacLeod et al. (2010) in which participants either read half of the items aloud and half silently (mixed lists), all items aloud, or all items silently (pure lists), there was a 7.2% decrease in accuracy for silent items when comparing pure lists to mixed lists and only a 2.9% increase in accuracy for aloud items. Although statistical tests were not reported, it seems that the benefit of production given mixed lists may instead be due to a memory decrement for silent items. In fact, in the original investigation of the production effect, Hopkins and Edwards (1972) found significant decrements in recognition accuracy for silent items, but no significant benefits to production. Furthermore, Bodner et al. (2013) recently demonstrated that the effect is due both to an increase in memory for aloud items and a decrease in memory for silent items in mixed lists relative to pure lists.

The idea that both costs and benefits contribute to the production effect is consistent with the mechanism proposed to underlie the effect, distinctiveness. Distinctive processing refers to "the processing of difference in the context of similarity" (Hunt, 2013, pg. 10). In the distinctive processing literature, the processing of differences is encouraged through having participants engage in item-specific processing during encoding; the processing of similarities is encouraged through having participants engage in relational processing (for a review, see Hunt, 2012). For example, Hunt and Einstein (1981) had participants either make pleasantness ratings or categorize lists of words containing members of either natural (e.g., fruits, professions) or ad hoc (e.g., things that are green: crayon, lettuce, money; things that fly: mosquito, airplane, kite) categories. When given a list of items belonging to different natural categories, participants naturally engaged in relational processing and organized the materials based on category membership. However, when given a list composed of items

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belonging to different ad hoc categories, only item-specific processing occurs as the categorical nature of the list composition is unclear. The processing that individuals naturally engage in during encoding can be altered by engaging in tasks such as making pleasantness ratings or sorting list items into categories. Making pleasantness ratings promotes item-specific processing by encouraging participants to focus on individual item characteristics, whereas categorization promotes relational processing by encouraging participants to focus on item similarities. Hunt and Einstein (1981) found that recall was greatest either when relational processing (categorization) was added to items that naturally elicited item-specific processing (ad hoc category members) or when item-specific processing (pleasantness ratings) was added to items that naturally elicited relational processing (natural category members). Thus, processing that included both item-specific and relational processing led to the best memory performance.

Given the production effect paradigm, the items used for encoding only lend themselves to item-specific processing as they are unrelated. However, when part of a mixed list, items can be relationally organized in terms of whether they are read aloud or silently. Producing the aloud words adds item-specific processing (MacLeod et al., 2010). As such, aloud items are better remembered than silent ones in mixed lists because they get a degree of relational processing as well as item-specific processing.

Specifically related to the issue of costs and benefits, Burns (1993, 1999) found that item-specific processing promotes item gains (benefits) and relational processing protects against item losses (costs). Again considering the production effect paradigm, the relational processing that is afforded by an aloud versus silent distinction is certainly not as strong as the relational processing afforded by item categorization. Thus, the increases in recognition accuracy for items read aloud may be the result of the item-specific gains associated with production, and the costs to silent items may be the result of minimal relational encoding afforded by the typical production effect paradigm.

## Experiment 1

The primary goal of Experiment 1 was to evaluate the costs and benefits underlying the production effect. To do so, in addition to including a mixed list (including both silent and aloud items), Experiment 1 also included two pure lists (entire list was either read silently or aloud) to enable an evaluation of the relative costs and benefits underlying the production effect. After items were initially encoded, participants completed a free recall final test (as in MacLeod, 2011).

Although several production effect studies have included a pure list manipulation with a final recognition test (e.g., Bodner et al., 2013; Hopkins & Edwards, 1972; MacLeod et al., 2010), we are unaware of any studies that have investigated the influence of a pure list manipulation given a free recall final test. Aside from allowing us to assess the costs and benefits of production, the inclusion of a pure list manipulation was important for at least one other reason. Fawcett (2013) recently demonstrated in a meta-analysis that a production effect is present for pure lists given a recognition test. This has not been examined in studies in which a free recall paradigm was used, and patterns of performance have been demonstrated to vary depending upon the type of final test (e.g., MacLeod & Kamp, 1996). Therefore, it is important to examine the influence of a pure list manipulation with free recall.

### Method

**Participants.** Forty-eight John Carroll University undergraduates participated in exchange for course credit.

**Materials and procedure.** During the encoding phase, participants studied 30 items, a subset of those used by MacDonald and MacLeod (1998), which have been used in several investigations of the production effect (e.g., Bodner & Taikh, 2012; Hourihan & MacLeod, 2008; MacLeod et al., 2010; Ozubko & MacLeod, 2010). Each item was presented one at a time for 2 s. Half of the items were in red font, the other half in blue. Seventeen participants read words of one color aloud and the other silently (mixed list). Sixteen participants read all words silently, regardless of color (pure silent), and 15 read all words aloud (pure aloud). Following encoding, participants completed a 2-min unrelated filler task (in which no new words were introduced). Participants were then prompted to recall, by typing, all of the words they remembered from the encoding phase.

### Results and Discussion

To evaluate the production effect, we conducted a 2 (production: read aloud, read silently) × 2 (list type: mixed, pure) mixed factor analysis of variance (ANOVA). As in MacLeod et al. (2010), production was treated as a within-subject manipulation and list type was treated as a between-subjects manipulation. There was no effect of list type, $F(1, 30) < 1$; mixed or pure list reading did not influence recall. However, there was a main effect of production, $F(1, 30) = 6.376$, $p < .05$, $\eta^2 = .14$, indicating greater recall for words read aloud versus those read silently. Most important, though, was the significant interaction of list type and production, $F(1, 30) = 8.468$, $p < .01$, $\eta^2 = .19$. Consistent with MacLeod et al.'s (2010) findings with recognition, production only yielded a benefit for the mixed list group, $t(16) = 3.281$, $p = .005$, $d = 1.6$; there was no production effect for the pure list groups, $t(14) < 1$. Thus, we replicated MacLeod et al.'s (2010) results using a free recall final test.

Of greater interest for present purposes, we evaluated the relative costs and benefits underlying the production effect. Results indicate that the production effect observed for the mixed list group may be driven primarily by costs to silent items, as illustrated by Figure 1. The proportion of items correctly recalled was significantly lower for the silent mixed list items than for the silent pure list items, $t(31) = 2.741$, $p = .01$, $d = 0.98$. However, the benefit in recall of the aloud mixed items compared with aloud pure items did not reach significance, $t(30) = 1.499$, $p = .144$.

In addition to assessing the possible benefits of production by comparing performance between aloud mixed and pure groups, we carried out two further analyses as done by Bodner et al. (2013). Comparing aloud mixed performance to silent pure performance, termed *benefits-over-silent*, there was no benefit, $t(31) = 1.211$, $p = .235$. Furthermore, comparing *net benefits*, or overall recall accuracy, of the mixed group with that of the pure silent group also yielded no benefit, $t(31) < 1$.

These results are generally consistent with Bodner et al.'s (2013) findings. Their experimental data and meta-analytic results

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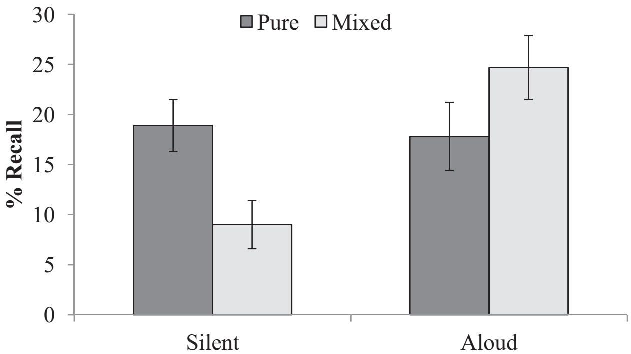


*Figure 1.* Percentage of items recalled in pure and mixed lists in Experiment 1. Error bars indicate standard errors.

indicated no benefits or net benefits; however, they did find significant benefits-over-silent. This is most likely because unlike us, they had a significant between-subjects production effect (pure lists). Our nonsignificant benefits-over-silent analysis may be due to the fact that performance here was equivalent on the pure lists. Furthermore, these results are also consistent with predictions of a distinctive processing account regarding costs and benefits (e.g., Burns, 1999). Because list construction did not promote strong relational processing, there was little to protect the silent items, and performance for these items suffered.

## Experiment 2

The purpose of Experiment 2 was to both replicate and extend results from Experiment 1. To replicate Experiment 1, we again evaluated the costs and benefits of production. To extend results from Experiment 1, word frequency was manipulated. Since MacLeod et al.'s (2010) production effect work, we are aware of 18 separate experiments in which the production effect has been examined with a simple word list learning paradigm (Bodner & Taikh, 2012; Bodner et al., 2013; Forrin et al., 2012; Lin & MacLeod, 2012; MacLeod, 2011; Ozubko, Gopie, & MacLeod, 2012; Ozubko, Hourihan, & MacLeod., 2012; Ozubko & MacLeod, 2010). Of these, 17 used the same stimulus set, which included only high-frequency words. The only experiment that did not use items from the same stimulus set also used high-frequency items. Therefore, it is important to investigate whether the production effect extends to low-frequency words, and if it does, is the effect primarily driven by costs to silent items or benefit for aloud items?

### Method

**Participants.** Sixty-nine John Carroll University undergraduates participated in exchange for course credit; none had participated in Experiment 1.

**Materials and procedure.** Participants studied 36 five-letter words, presented one at a time for 3 s. Eighteen words were high frequency, and 18 were low frequency. Items were generated from the English Lexicon Project (Balota et al., 2007). See Appendix for the list of items. For both word types, half were presented in red font, and half were presented in blue font. Font color and order of presentation were randomized. Twenty-three participants read words of one color aloud and words of the other color silently (mixed list). Twenty-three read all words silently (pure silent), and 23 read all aloud (pure aloud), regardless of font color. As in Experiment 1, participants completed a 2-min filler task before the free recall final test.

### Results and Discussion

As in Experiment 1, there was a main effect of production, $F(1, 44) = 15.716$, $p < .001$, $\eta^2 = .22$, and no effect of list type, $F < 1$. The interaction between production and list type, $F(1, 44) = 11.011$, $p < .005$, $\eta^2 = .16$, indicates that aloud items were better recalled than silent ones in mixed lists (aloud: $M = 27.3\%$, $SE = 0.023$; silent: $M = 12.3\%$; $SE = 0.019$), $t(22) = 4.436$, $p < .001$, $d = 1.89$, but not in pure lists (aloud: $M = 21.6\%$, $SE = 0.02$; silent: $M = 20.2\%$, $SE = 0.017$), $t < 1$. There was also a main effect of frequency, $F(1, 44) = 20.616$, $p < .001$, $\eta^2 = .32$. Recall was higher for low-frequency words ($M = 24.2\%$, $SE = 0.011$) than for high-frequency words ($M = 16.5\%$, $SE = 0.016$), replicating other work showing a low-frequency recall advantage when high- and low-frequency items are in mixed lists (e.g., Gregg, Montgomery, & Castaño, 1980; Merritt, DeLosh, & McDaniel, 2006). Frequency did not interact with any of the other variables, all $F$s $< 1$. Figure 2 illustrates the similar pattern of performance for high- and low-frequency words.

Because it did not interact with any of the other variables, we collapsed across word frequency and assessed the relative costs and benefits of production. Replicating Experiment 1, there were significant costs of production, $t(44) = 2.907$, $p < .01$, $d = 0.876$. As assessed by comparing aloud mixed and aloud pure, the benefit of production was again nonsignificant, $t(44) = 1.766$, $p = .084$; there was also no evidence of net benefits, $t < 1$. However, there was a significant advantage for aloud mixed items compared with silent pure (benefits-over-silent), $t(44) = 2.345$, $p < .05$, $d = 0.707$. This pattern of results replicates Bodner et al.'s (2013) findings with recognition.

## General Discussion

In two experiments, we replicated the basic production effect findings using a free recall paradigm—reading words aloud re-

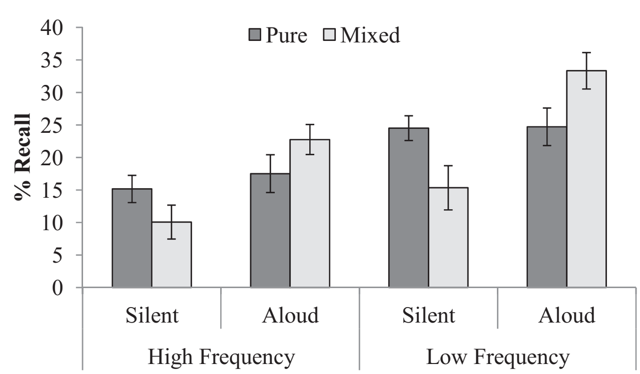


*Figure 2.* Percentage of items recalled in Experiment 2 as a function of word frequency. Error bars represent standard errors.

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sulted in better memory than reading silently when production was manipulated within subject. When manipulated between subjects, there was no benefit of production. More important, we demonstrated that the production effect is not simply the result of enhanced memory for items read aloud but instead results primarily from a cost to memory for items read silently. In fact, in both experiments, the costs to silent items were greater than the benefits of production. These findings with free recall are consistent with analyses from Bodner et al. (2013) that showed that both costs to silent items and benefits to produced ones lead to the production effect in recognition memory, and our data indicate that the impact of costs may be more robust than the benefits.

Although significant costs were observed in both experiments, only one analysis (benefits-over-silent analysis in Experiment 2) indicated that there were significant benefits to production. The discrepancy in results regarding the benefits of production in the current study may have been due to statistical power. However, it may also have been due to the difference in items used in Experiments 1 and 2. Although frequency did not interact with any of the variables, it could be that inclusion of low-frequency materials led to the effect being more robust in Experiment 2.[1] Regardless, current results with free recall replicate those of Bodner et al. (2013) whose experimental and meta-analytic work with recognition has shown that benefits are only found when comparing aloud mixed and silent pure items. Thus, the finding in the current study that the benefits of production were nonsignificant when examined by comparing aloud mixed and pure items is unlikely to be related to issues with statistical power.

These findings are also consistent with another effect that the production effect has been compared with—generation. The *generation effect*, referring to enhanced memory for items generated from a cue compared with simply reading items, occurs for mixed list, but not pure list, designs (e.g., Begg & Snider, 1987; Slamecka & Katsaiti, 1987). Furthermore, the benefit of generation given a mixed list design has been demonstrated to be the result of costs to read items, not a memory enhancement to generated items, given mixed versus pure list comparisons (Begg & Roe, 1988; Begg & Snider, 1987; Slamecka & Katsaiti, 1987).

In addition to demonstrating that the production effect, like the generation effect, is primarily driven by costs, the current findings also bear relevance to the recent demonstrations that production may yield a between-subjects benefit (Fawcett, 2013). Although MacLeod et al. (2010) suggested that the production effect only obtains given a mixed list design, Gathercole and Conway (1988) and Bodner et al. (2013) showed a production effect with pure lists (a between-subjects manipulation). Furthermore, in a meta-analysis, Fawcett (2013) demonstrated that despite inconsistencies regarding whether a between-subjects production effect occurs in individual experiments, there is a significant effect of production overall on recognition accuracy. The current results are the first in the literature to examine the between-subjects effect of production on free recall accuracy, and we found no benefit of production. In fact, in Experiment 1, there was a 1.1% benefit to silent items, and in Experiment 2 there was only a 1.4% benefit to aloud items.

As this was the first study examining a between-subjects production effect in free recall, more work is clearly needed before it can be concluded that a between-subjects manipulation will never yield a production effect for free recall measures, despite evidence that it obtains with recognition (Fawcett, 2013). However, given that production is suggested to enhance item-specific encoding (MacLeod et al., 2010), it would not be surprising that the effect does not occur for free recall measures. Recognition tests measure item-specific processing more than free recall measures do (e.g., Einstein & Hunt, 1980; Rawson & van Overschelde, 2008). Therefore, recognition tests would be more sensitive in detecting the benefit of production than recall tests. Given that recognition tests do not consistently yield a between-subjects production effect, it may be unlikely that one would occur for free recall tests.

Although the goal of the current research was neither to test the distinctiveness account of the production effect nor to adjudicate between it and the other proposed mechanism, a memory-strength account (Bodner & Taikh, 2012; Fawcett, 2013), the current results are consistent with the suggestion that distinctive processing underlies the production effect in two ways. First, in both experiments, memory was greater for items that benefited from item-specific processing (reading aloud) only when placed in a context in which similarity could also be assessed (mixed lists). Both item-specific and relational (similarity) processing are crucial for distinctive processing (e.g., Hunt, 2013). Second, the observed costs to silent items can be attributed to relatively poor relational encoding among items in this paradigm compared with other studies manipulating relational encoding (e.g., categorization). Because relational encoding protects against item losses (e.g., Burns, 1999), silent items are at a disadvantage. This overall pattern of recall performance is a new piece of evidence consistent with other research suggesting that distinctive processing underlies the production effect (e.g., Lin & MacLeod, 2012; Ozubko & MacLeod, 2010).

In summary, although the production effect has been touted as a simple memory improvement tool, current results indicate otherwise. A memory decrement was observed for silently read items in both experiments. There was a numerical trend for produced items to result in better memory, but it reached significance with only one analysis in Experiment 2. Therefore, because the observed costs were consistently greater than the benefits, the production effect should not be considered “a simple but quite powerful mechanism for improving memory” (MacLeod et al., 2010, pg. 671).

[1] Separate cost–benefit analyses were conducted on high- and low-frequency words in Experiment 2. Costs were apparent for both high- and low-frequency words—high frequency: $t(44) = 1.877$, $p < .07$, $d = 0.55$; low frequency: $t(44) = 2.737$, $p < .01$, $d = 0.81$. Replicating Experiment 1, for high-frequency items, none of the analyses indicated that there was a significant benefit—benefits: $t < 1$; benefits-over-silent: $t(44) = 1.363$, $p = .18$; net benefits: $t < 1$. However, for low-frequency items, there were both benefits, $t(44) = 2.125$, $p < .05$, $d = 0.63$, and benefits-over-silent, $t(44) = 2.332$, $p < .05$, $d = 0.69$ (no net benefits, $t < 1$).

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(*Appendix follows*)

## Appendix

### Low- and High-Frequency Items Used in Experiment 2

| Item | Log HAL frequency |
|---|---|
| Low frequency items | |
| daunt | 2.48 |
| chive | 2.56 |
| frizz | 3.64 |
| pleat | 3.71 |
| spurn | 3.74 |
| poach | 3.83 |
| blare | 3.87 |
| amble | 3.95 |
| muggy | 3.97 |
| pilaf | 4.01 |
| croon | 4.17 |
| chide | 4.23 |
| primp | 4.3 |
| mooch | 4.32 |
| frock | 4.39 |
| elope | 4.44 |
| clank | 4.48 |
| scone | 4.49 |
| High frequency items | |
| coast | 10.01 |
| grant | 10.01 |
| teach | 10.02 |
| catch | 10.03 |
| label | 10.04 |
| score | 10.05 |
| shape | 10.05 |
| train | 10.06 |
| birth | 10.06 |
| horse | 10.08 |
| tower | 10.08 |
| clock | 10.11 |
| adult | 10.14 |
| plant | 10.14 |
| sleep | 10.15 |
| dance | 10.17 |
| waste | 10.21 |
| river | 10.21 |

*Note.* Items were generated from the English Lexicon Project (Balota et al., 2007). None of the high frequency words from Experiment 2 were used in Experiment 1. HAL = hyperspace analogue to language.

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