Supplemental Materials for

Divided Attention Selectively Impairs Value-Directed Encoding

Blake L. Elliott

Gene A. Brewer

Arizona State University

Experiment 1

In addition to the analyses reported in the main text, we examined whether the effect of value changed over time as a function of study-test block. A 2 (Value: High versus Low) x 5 (Block: 1-5) repeated measures ANOVA on hit rates with appropriate Greenhouse-Geisser corrections revealed a main effect of value, $F(1,39) = 26.66$, $p < .001$, $\eta^2_p = .406$, a main effect of block, $F(1,39) = 2.94$, $p < .05$, $\eta^2_p = .070$, and an interaction, $F(1,39) = 3.87$, $p < .01$, $\eta^2_p = .090$. Although higher valued words were recognized better than lower valued words across all blocks, a linear trend analysis of the interaction revealed the size of this effect decreased over time, $F(1,39) = 9.66$, $p < .01$, $\eta^2_p = .199$. The data reveal that this is from participants recognizing more lower-value words over time, and not from remembering less higher-valued words (supplemental figure 1A).

When hit rates were conditionalized on the subjective state of awareness, we find similar results for “remember” responses. A 2 (Value: High versus Low) x 5 (Block: 1-5) repeated measures ANOVA on “Remember” responses revealed a main effect of value, $F(1,39) = 40.49$, $p < .001$, $\eta^2_p = .509$, a main effect of block, $F(1,39) = 3.58$, $p < .05$, $\eta^2_p = .084$, and an interaction, $F(1,39) = 5.19$, $p < .01$, $\eta^2_p = .117$. Although higher valued words were given more “remember” responses than lower valued words across all blocks, a linear trend analysis of the interaction revealed the size of this effect decreased over time, $F(1,39) = 14.52$, $p < .001$, $\eta^2_p = .271$. The data reveal that this is from participants remembering more lower-value words over time, and not from remembering less higher-valued words (supplemental figure 1B).

A 2 (Value: High versus Low) x 2 (Block: 1-5) repeated measures ANOVA on “know” responses with appropriate Greenhouse-Geisser corrections revealed no main effect of value, $F(1,39) = 3.36$, $p = .074$, no main effect of block, $F(1,39) = .46$, $p = .714$, and no interaction, $F(1,39) = .20$, $p = .938$. Together, these data again show that value affects encoding processes leading to recognition memory performance, and that this effect is localized to “remember” responses.

Interestingly, selectivity in the current experiment decreased over time. Previous research using value-based free recall paradigms has found the opposite pattern of results (Ariel & Castel, 2014). One possible interpretation is that participants were more selective in the first blocks when they were unsure of their overall memory ability, but as they completed more blocks they were able to refine their strategies and improve their overall memory performance. This is supported by an increase in total hit rates across block. A repeated measures ANOVA with appropriate Greenhouse-Geisser correction on total hit rates revealed a main effect of block, $F(1,39) = 2.939$, $p < .05$, $\eta^2_p = .070$, and a linear trend, $F(1,39) = 4.64$, $p < .05$, $\eta^2_p = .106$. Given this finding is incidental and inconsistent with previous research using free recall paradigms, we caution against interpreting it further. Future studies should address this finding.

Additionally, since Experiment 1 was examined use raw hit rates, we also examined the experiment using a false alarm correction method. This method subtracts the false alarm rate from the total hit rate. When false alarm corrections were applied, higher-valued words were remembered better than lower-valued words ($t_{(39)}$ = 5.163, p < 0.001, Cohen's d = 0.83). When hit rates were conditionalized on the subjective state of awareness supporting those decisions, the value-driven gain in memory performance was due to an increase in "remember" responses ($t_{(38)}$ = 6.447, p < 0.001, Cohen's d = 1.01). Importantly, no effect of value was observed for words given "know" responses ($t_{(38)}$ = -1.886, p = 0.067).

Experiment 2

The analyses from Experiment 2 were replicated using the aforementioned false alarm correction method. A 2 (Value: High versus Low) x 2 (Divided Attention: Random Number Generation versus Articulatory Suppression) repeated measures ANOVA on hit rates revealed a main effect of value, $F(1,39) = 12.96$, $p = .001$, $\eta^2_p = .249$, a main effect of divided attention condition, $F(1,39) = 76.13$, $p < .001$, $\eta^2_p = .661$, and an interaction, $F(1,39) = 6.81$, $p < .05$, $\eta^2_p = .149$. Post-hoc t-tests revealed that this interaction was driven by a difference between high and low value in the articulatory suppression condition ($t_{(39)}$ = 4.211, p < 0.001, Cohen's d = 0.67) with no difference in the random number generation condition ($t_{(39)}$ = 1.158, p = .254).

When hit rates were conditionalized on the subjective state of awareness, we find similar results for "remember" responses. A 2 (Value: High versus Low) x 2 (Divided Attention: Random Number Generation versus Articulatory Suppression) repeated measures ANOVA on "remember" responses revealed a main effect of value, $F(1,39) = 5.25$, $p < .05$, $\eta^2_p = .119$, a main effect of divided attention condition, $F(1,39) = 38.78$, $p < .001$, $\eta^2_p = .499$, and an interaction, $F(1,39) = 6.50$, $p < .05$, $\eta^2_p = .143$. Post-hoc t-tests revealed that this interaction was driven by a difference between high and low value in the articulatory suppression condition ($t_{(39)}$ = 2.794, p < 0.01, Cohen's d = 0.45) with no difference in the random number generation condition ($t_{(39)}$ = .361, p = .720).

A 2 (Value: High versus Low) x 2 (Divided Attention: Random Number Generation versus Articulatory Suppression) repeated measures ANOVA on "know" responses revealed no main effect of value, $F(1,39) = 2.06$, $p = .159$, a main effect of divided attention condition, $F(1,39) = 5.968$, $p < .05$, $\eta^2_p = .133$, and no interaction, $F(1,39) = .054$, $p = .817$. These analyses dovetail the results reported in the main text, with the exception of a now significant main effect of divided attention condition for "know" responses.

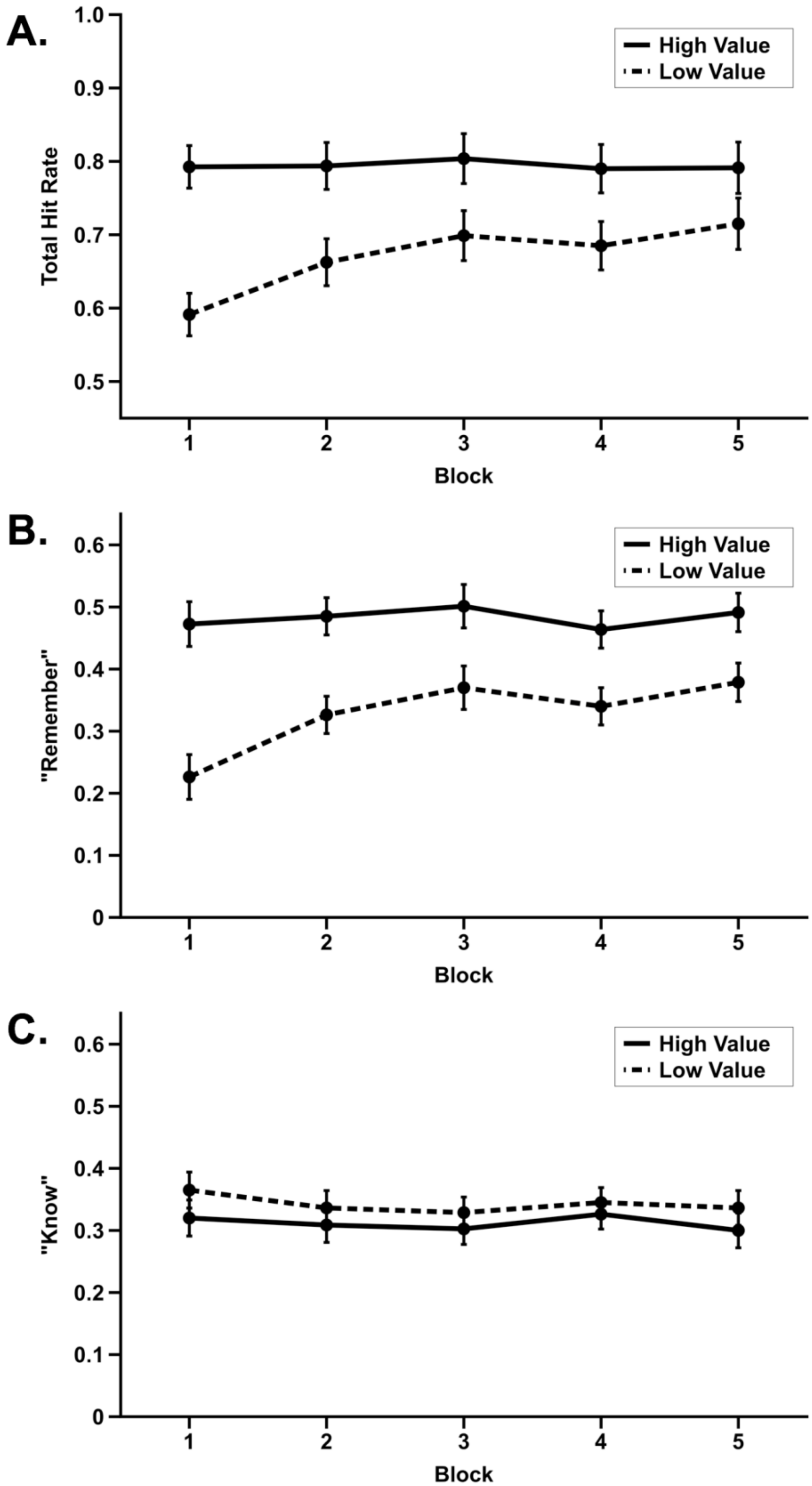
Experiment 3

The analyses from Experiment 2 were replicated using the aforementioned false alarm correction method. A 2 (Value: High versus Low) x 2 (Divided Attention: easy tone detection versus difficult tone detection) repeated measures ANOVA on hit rates revealed a main effect of value, $F(1,39) = 24.05$, $p < .001$, $\eta^2_p = .381$, a main effect of divided attention condition, $F(1,39) = 30.44$, $p < 001$, $\eta^2_p = .438$, and an interaction, $F(1,39) = 9.64$, $p < .01$, $\eta^2_p = .198$. Post-hoc t-tests revealed that this interaction was driven by a difference between high and low value in the easy tone detection condition ($t_{(39)} = 5.136$, $p < 0.001$, Cohen's $d = 0.85$) with a markedly smaller difference in the difficult tone detection condition ($t_{(39)} = 2.188$, $p = .035$, Cohen's $d = 0.36$).

When hit rates were conditionalized on the subjective state of awareness, we find similar results for "remember" responses. A 2 (Value: High versus Low) x 2 (Divided Attention: easy tone detection versus difficult tone detection) repeated measures ANOVA on "remember" responses revealed a main effect of value, $F(1,39) = 12.35$, $p = .001$, $\eta^2_p = .241$, a main effect of divided attention condition, $F(1,39) = 14.36$, $p = .001$, $\eta^2_p = .269$, and an interaction, $F(1,39) = 6.35$, $p < .05$, $\eta^2_p = .140$. Post-hoc t-tests revealed that this interaction was driven by a difference between high and low value in the easy tone detection condition ($t_{(39)} = 3.583$, $p = 0.001$, Cohen's $d = 0.63$) with no difference in the difficult tone detection condition

($t_{(39)}$ = 1.764, p = .085).

A 2 (Value: High versus Low) x 2 (Divided Attention: easy tone detection versus difficult tone detection) repeated measures ANOVA on “know” responses revealed no main effect of value, $F(1,39) = 2.22$, $p = .145$, no main effect of divided attention condition, $F(1,39) = 1.10$, $p = .30$, and no interaction, $F(1,39) = .464$, $p = .50$. These data again show that value affects encoding processes leading to enhanced “remember” responses. In addition, a difficult secondary task at encoding eliminated this effect, while an easy secondary task at encoding did not. This pattern of results replicates Experiments 1 and 2 while further supporting the view that executive resources are necessary for value-directed encoding effects on memory.



A.
1.0
0.9
0.8
0.7
0.6
0.5
Total Hit Rate
High Value
Low Value
1
2
3
4
5
Block
B.
0.6
0.5
0.4
0.3
0.2
0.1
0
"Remember"
High Value
Low Value
1
2
3
4
5
Block
C.
0.6
0.5
0.4
0.3
0.2
0.1
0
"Know"
High Value
Low Value
1
2
3
4
5
Block

Figure 1: Memory performance across time (as a function of study-test block). A. Total hit rates for high and low value words across block. B. "Remember" hit rates for high and low value words across block. C. "Remember" hit rates for high and low value words across block. Error bars represent 95 percent confidence interval.

Table 1. SDT Descriptive Statistics

Experiment and condition	Total		High value		Low value	
	D' (SE)	C (SE)	D' (SE)	C (SE)	D' (SE)	C (SE)
Experiment 1						
Full attention	1.54 (.09)	.09 (.07)	1.75 (.10)*	-.02 (.06)*	1.35 (.10)	.18 (.07)
Experiment 2						
AS	1.10 (.07)	.12 (.06)	1.24 (.07)*	.02 (.06)*	1.00 (.08)	.14 (.05)
RNG	.55 (.06)	.22 (.06)	.58 (.06)	-.07 (.06)*	.52 (.07)	.05 (.05)
Experiment 3						
Easy	1.02 (.07)	.19 (.06)	1.14 (.06)*	.13 (.06)*	.91 (.07)	.24 (.07)
Hard	.65 (.06)	.21 (.07)	.68 (.06)*	.19 (.07)*	.61 (.06)	.23 (.07)

Note. * Denotes significant difference from low value at $p<.05$