

# How Do Stimulus Difficulty and Amount of Delay Impact Judgments of Learning Made by Younger and Older Adults?

The Power of

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## INTRODUCTION

Learning is most effective when we monitor our progress and direct our efforts toward unlearned material. The concept of being aware of our learning is referred to as metacognition, and we are interested in what causes a change in judgements of learning (JOLs). JOLs are estimates of how well material has been learned (e.g. when studying for an exam, a student may determine that they know Chapter 3 very well but do not know Chapter 4 as well). Prior research has supported the idea that JOLs are more accurate predictors of learning when there is a delay between study and judgement (e.g., Rhodes & Tauber, 2011). Additionally, a delay of at least 30 seconds has been found to increase the accuracy of JOLs (Sikström & Jönsson, 2005).

The delayed JOL effect is our primary focus, and in this study we investigated whether there is a change in accuracy between immediate JOLs and JOLs taken after either a 20-, 40-, or 60-second delay. UWEC undergraduates aged 18-25 years and "workers" on Amazon's Mechanical Turk aged 57 years and older were compared in terms of their performance on a task administered using Qualtrics online survey software. They completed a paired-associate task, wherein individual paired-associates (e.g. APPLE-CART) were studied. For nonzero delays, study was followed by a distractor task involving the mental rotation of 3-D objects, where participants decided whether two objects were identical when one object may be slightly rotated (Hayward et al., 2006). The normative difficulty of paired-associates was also manipulated within-subjects; pairs were either normatively easy, moderate, or difficult-to-learn.

We hypothesized that JOLs would decrease in response to longer delays and greater difficulty. We also predicted that JOLs would decrease most following a 60-second delay in comparison to no delay and when comparing normatively-easy and difficult-to-learn stimuli. Difficulty of stimuli was also expected to impact cued-recall performance more than size of delay. Lastly, we anticipated similar memory monitoring accuracy for younger and older adults in terms of both JOLs and post-test confidence judgements (CJs).

## METHOD

Younger adult data was gathered from UWEC undergraduate students who participated through the SONA online research pool; participants received course credit or extra credit for participation. Older adult data was gathered using Amazon's Mechanical Turk, where participants were paid. Participation followed informed consent and ended with debriefing. All participants were native English speakers with a U.S. high school degree, and all participants were located in the United States.

### Participant Demographics:

	Number of Participants	Gender	Average Age	Shipley Vocabulary	Race	Ethnicity
Younger Adults	36	12 Men 24 Women	$M = 20.00$ yrs $SD = 3.80$ yrs	$M = 29.42$ $SD = 3.54$	1 American Indian/Alaska Native 1 Asian 34 White/Caucasian	
Older Adults	39	10 Men 29 Women	$M = 62.66$ yrs $SD = 4.59$ yrs	$M = 35.57$ $SD = 3.23$	38 White/Caucasian 1 Black/African American	1 Hispanic or Latino/a

### Paired Associates Construction:

Difficulty was varied according to normative forward association strength (Nelson, McEvoy, & Schreiber, 2004). The forward association for Easy (.075 - .125), Medium (.01 - .03), and Hard (None) paired associates varied according to standards used by Cohen, Yan, Halamish, and Bjork (2013).

### Part 1: Study:

- A randomized sequence consisting of 16 stimuli from each difficulty (easy, moderate, and difficult) was displayed with word pairs staying on the screen for 1.5-seconds for younger adults and older adults.
- After each word pair was studied, a delay of either 0, 20, 40, or 60-seconds commenced. For nonzero delays, participants engaged in a 3-D mental rotation distractor task, where two objects were displayed and participants were asked to determine whether the two objects were identical or not. They used a computer mouse to select either "Yes" or "No", after which new image pairs were shown until the time delay was fulfilled.
- Participants were asked to give a judgement of learning (JOL) based on their confidence in remembering the previous word pair in about 15 minutes, scaled from 0-100%. Only the stimulus portion of the word pair was shown during JOL reporting (e.g. APPLE-\_\_\_\_\_).

### Part 2: Test

- During cued recall testing, the first portion of each word pair was shown without the target (e.g. APPLE - \_\_\_\_). Participants were asked to type the second portion of the word pair. We scored responses based on the first three letters being correct.
- After each word pair, participants gave a confidence judgement for their response on a scale from 0-100%.

## Judgements of Learning

Effect	Num DF	Den DF	F Value	p-value
age	1	73	3.58	0.0623
diff	2	146	48.48	<.0001
JOLs decreased as difficulty increased. JOLs were highest for easy ( $M = 64.59\%$ , $SD = 20.87\%$ ), moderate for medium ( $M = 56.87\%$ , $SD = 21.30\%$ ), and lowest for hard word pairs ( $M = 54.69\%$ , $SD = 22.08\%$ ).				
age*diff	2	146	1.54	0.2172
delay	3	219	5.32	<b>0.0015</b>
JOLs were statistically higher after 60s ( $M = 61.60\%$ , $SD = 19.39\%$ ) than 0s ( $M = 58.07\%$ , $SD = 23.56\%$ ), 20s ( $M = 58.51\%$ , $SD = 21.56\%$ ), and 40s delay ( $M = 56.70\%$ , $SD = 22.34\%$ ).				
age*delay	3	219	3.03	<b>0.0302</b>
Older adults ( $M = 63.29\%$ , $SD = 28.92\%$ ) were marginally more confident after study than younger adults ( $M = 54.15\%$ , $SD = 30.22\%$ ).				
diff*delay	6	438	2.13	<b>0.0487</b>
Delay does not impact JOLs for easy items (overall, $M = 64.59\%$ , $SD = 20.87\%$ ). For medium items, 40s ( $M = 53.60\%$ , $SD = 26.32\%$ ) and 60s ( $M = 60.97\%$ , $SD = 19.22\%$ ) are marginally different neither differed from 0s ( $M = 55.79\%$ , $SD = 24.07\%$ ) or 20s ( $M = 57.14\%$ , $SD = 24.68\%$ ). For hard items, 20s ( $M = 51.94\%$ , $SD = 25.37\%$ ) and 40s ( $M = 53.31\%$ , $SD = 23.73\%$ ) are marginally different from 60s ( $M = 59.47\%$ , $SD = 23.12\%$ ), and are not different from 0s ( $M = 54.05\%$ , $SD = 25.29\%$ ).				
age*diff*delay	6	438	1.51	0.1743

## Judgements of Learning Fluency (Reaction Times)

Effect	Num DF	Den DF	F Value	p-value
age	1	73	5.38	<b>0.0232</b>
Younger adults ( $M = 2.79$ s, $SD = 1.29$ s) are faster than older adults ( $M = 3.57$ s, $SD = 2.59$ s).				
diff	2	146	0.54	0.5817
age*diff	2	146	2.48	0.0871
delay	3	219	7.76	<.0001
JOLs were made more quickly at 20s ( $M = 2.79$ s, $SD = 0.95$ s) and 40s ( $M = 2.91$ s, $SD = 1.13$ s) than at 60s ( $M = 3.27$ s, $SD = 1.29$ s) and 0s ( $M = 3.74$ s, $SD = 3.64$ s), indicating more careful consideration of confidence for immediate and 60s JOLs.				
age*delay	3	219	1.04	0.3775
diff*delay	6	438	2.94	<b>0.0080</b>
Delay did not matter for easy or medium items. For hard items, 20s delay JOLs ( $M = 2.67$ s, $SD = 0.95$ s) were made more quickly than 60s delay JOLs ( $M = 3.22$ s, $SD = 1.55$ s). Immediate JOLs ( $M = 3.62$ s, $SD = 5.02$ s) and 40s JOLs ( $M = 3.00$ s, $SD = 1.55$ s) did not differ from the rest.				
age*diff*delay	6	438	0.67	0.6702

## DISCUSSION

Our first hypothesis was unsupported by our finding that JOLs were actually higher after the 60s delay compared to the 0s delay. As expected, however, JOLs decreased along with increasing difficulty. This was complicated by an Difficulty x Age interaction such that length of delay did not matter for easy items, but offered marginal differences for moderately difficult and hard items, with higher JOLs paired with longer delays.

Stimulus difficulty impacted cued recall accuracy as expected, with harder items associated with lower recall accuracy. Accuracy was also a bit higher following a 60s delay, perhaps benefitting from distributed retrieval practice.

## REFERENCES

- Cohen, M. S., Yan, V. X., Halamish, V., & Bjork, R. A. (2013, April 8). Do Students Think That Difficult or Valuable Materials Should Be Restudied Sooner Rather Than Later? *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 39(6), 1682-1696. doi: 10.1037/a0032425
- Hayward, W. G., Zhou G., Gauthier, I., & Harris, I. M. (2006) Dissociating viewpoint costs in mental rotation and object recognition. *Psychonomic Bulletin & Review* 13(5), 820-825. doi:10.1167/6.6.812
- Hines, J. C., Hertzog, C., & Tournon, D. R. (2015). Younger and older adults weigh multiple cues in a similar manner to generate judgments of learning. *Aging, Neuropsychology, and Cognition*, 22, 693-711. doi: 10.1080/13825585.2015.1028884
- Nelson, D. L., McEvoy, C. L., & Schreiber, T. A. (2004). The University of South Florida word association, rhyme, and word fragment norms. *Behavior Research Methods, Instruments, & Computers*, 36, 402-407. doi:10.3758/BF03195588

## RESULTS

### Accuracy

Effect	Num DF	Den DF	F Value	p-value
age	1	73	3.37	0.0707
diff	2	146	97.17	<.0001
Accuracy was greatest for easy ( $M = 71.41\%$ , $SD = 15.50\%$ ), moderate for medium ( $M = 55.39\%$ , $SD = 18.36\%$ ), and lowest for hard ( $M = 47.30\%$ , $SD = 20.44\%$ ).				
age*diff	2	146	1.29	0.2786
delay	3	219	3.25	<b>0.0228</b>
Accuracy was greatest for 60s JOLs ( $M = 60.32\%$ , $SD = 18.09\%$ ) compared to 0s JOLs ( $M = 54.12\%$ , $SD = 21.91\%$ ), with 20s JOLs ( $M = 59.79\%$ , $SD = 18.53\%$ ) and 40s JOLs ( $M = 57.90\%$ , $SD = 18.71\%$ ) not being statistically different from either.				
age*delay	3	219	1.20	0.3108
diff*delay	6	438	1.69	0.1211
age*diff*delay	6	438	1.68	0.1254

### Gamma - Judgements of Learning x Accuracy

Effect	Num DF	Den DF	F Value	p-value
age	1	72	5.25	<b>0.0248</b>
Young adult JOLs correlated with their accuracy ( $M = 50.28\%$ , $SD = 39.40\%$ ) better than those of older adults ( $M = 33.76\%$ , $SD = 53.17\%$ ).				
diff	2	134	1.63	0.2003
age*diff	2	134	2.15	0.1200
delay	3	202	1.79	0.1507
age*delay	3	202	0.42	0.7370
diff*delay	6	202	1.37	0.2301
age*diff*delay	6	202	0.69	0.6554

### Confidence Judgements

Effect	Num DF	Den DF	F Value	p-value
age	1	73	0.30	0.5849
diff	2	146	48.37	<.0001
CJs were highest for easy ( $M = 63.91\%$ , $SD = 17.75\%$ ), moderate for medium ( $M = 54.02\%$ , $SD = 17.32\%$ ), and lowest for hard ( $M = 47.98\%$ , $SD = 18.36\%$ ).				
age*diff	2	146	0.85	0.4307
delay	3	219	3.21	<b>0.0239</b>
CJs were significantly lower following 0s JOLs ( $M = 51.80\%$ , $SD = 20.35\%$ ) compared to 60s ( $M = 57.86\%$ , $SD = 18.18\%$ ), with 20s ( $M = 56.83\%$ , $SD = 18.09\%$ ) and 40s ( $M = 54.71\%$ , $SD = 19.49\%$ ) conditions not differing from either.				
age*delay	3	219	0.15	0.9275
diff*delay	6	438	1.88	0.0825
age*diff*delay	6	438	1.32	0.2468

Contrary to predictions, younger adults' JOLs were more predictive of cued recall performance than were those of older adults. This may have resulted from overall better memory performance on the part of older adults coupled with a bit of underconfidence on their part during study. No age-related difference was found for CJs, however, indicating intact monitoring of retrieval processes.

## FUTURE DIRECTIONS

In future studies, we plan to examine further variations in delay and also tighten the timing of the delays. Qualtrics limitations created some degree of imprecision in the implementation of delays in this initial study, but a more advanced approach will solve this issue. We also intend to collect data in the context of a multirial learning experience to determine how specific JOL delays in trial 1 might relate to subsequent JOLs in trial 2 (similar to Hines, et al., 2015).

- Rhodes, M.G. & Tauber, S. K. (2011) The influence of delaying judgements of learning on metacognitive accuracy: A meta-analytic review. *Psychological Bulletin*, 137(1), 131-148. doi: 10.1037/a0021705
- Sikström, S., & Jönsson, F. (2005) A model for stochastic drift in memory strength to account for judgements of learning. *Psychological Review* 112(4), 932-950. doi: 10.1037/0033-295X.112.4.932

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