Recall of Simple Words

Nicholas Elich, Calahan Lackovic, Edy Reynolds, and Joshua Rowe

ABSTRACT. *College students spend countless hours studying and finding optimal study conditions can be a major boon to productivity and success. Specifically, organizational patterns and sound can play a large role in how a student studies; for example, some students prefer complete silence while others prefer listening to some sort of audial stimulation. To examine this, a repeated measures study was designed and executed to test a participant's ability to recall words based on sound conditions and the type of word grid presented. Findings showed that some treatments, such as ordered words with white noise, resulted in more words memorized than other treatments, like random words with music. Overall, a participant's ability to remember words is largely dependent on inherent individual characteristics, but the treatment applied does have a significant effect on the number of words recalled.*

1. INTRODUCTION

As undergraduate college students in S.T.E.M. majors working though upper-division courses, we were curious to examine the effectiveness of our current studying techniques and whether or not we could improve our methodology to reach higher academic success. As such, when we were given the opportunity to design and conduct an experiment, we were intrigued with the idea of analyzing the impact of sound and organization on recall/memory. Of course, being at Cal Poly, we have an accessible population of peers who also ascertain to the university wide goal of "Learn by Doing" and were able to carry out the experiment with relative ease.

Instinctually, we believed that grids of grouped words would be easier to memorize than randomized ones. It's reasonable to say that the human brain recognizes and focuses on patterns, which formed much of the basis behind our hypothesis in the previous statement. As for sound conditions, we believed that silence and/or white noise would represent the optimal condition to memorize words. Of course, this prediction carries a somewhat large margin for error. Sound preference when studying can be a difficult proposition to extend to a large population as some might prefer sound/music, while others might prefer pure silence.

2. MATERIALS AND METHODS

Treatments:

	Silence	White Noise	Music
Random Grid	Random/ Silence	Random/ White Noise	Random/ Music
Ordered Grid	Ordered/ Silence	Ordered/ White Noise	Ordered/ Music

A 3 (silence, white noise, music) x 2 (ordered words, random words) repeated measures design was carried out to test our hypothesis. We randomly selected fourteen 18 to 23 year old current Cal Poly students to participate in the experiment. Each participant received all six treatments in one sitting and the order in which each participant received the treatments was completely randomized.

Each of the six word sheets consisted of a 5x5 printed word grid with 25 two syllable words. The random word grids contained words with no association to each other and the ordered word grids were constructed using five rows of words, of which each row contained words from a similar category. The five categories were Thanksgiving, beach, travel, school, and animals. The category order was randomly assigned for each ordered sheet, and the words within each category were randomly assigned. It is important to note that random words were randomly assigned to a grid and no words were repeated across grids.

Each participant was informed that they would be given 30 seconds to view the word grid under the noise condition and one minute of silence to hand write as many words as they could recall from the grid. After each treatment they would be given a new, blank sheet of paper to recall words. All timing was done using the Clock app on an Apple iPhone.

The participant was then informed as to what noise condition they would be receiving, but not what word grid they would be receiving. The silent noise condition was conducted in a controlled environment with no added noise. The white noise condition was implemented by playing "White Noise 3 Hour Long" by Erik Eriksson, White Noise Therapy [1] and the distracting music condition was "Who Let The Dogs Out" by Baha Men [2] played from 0:30 to 1:00. All noise conditions were played through headphones at 75% volume level. After each treatment was conducted, the total number of words recalled was recorded; in order for the word to be counted as recalled, it had to be spelled correctly, but did not have to be in the same order as the given grid.

Once all data was collected, we used the SAS Institute Inc. JMP Pro, Version 17. SAS Institute Inc., Cary, NC, 1989-2023. to run our analyses. We carried out a Fit Model to analyze normality and variance and a Fit Y By X to view our ANOVA results and further investigate the data.

3. RESULTS AND DISCUSSION

A one-way ANOVA was carried out with 5 numerator degrees of freedom and 65 denominator degrees of freedom which had a corresponding F-statistic of 3.22 and p-value of 0.0116. One point to note is that we chose to block on the individuals themselves to reduce person-to-person variation. The corresponding ANOVA reports 13 numerator degrees of freedom, 65 denominator degrees of freedom, an F-statistic of 7.71, and a p-value of less than 0.0001. Finally, means and standard deviations for factors and treatments are shown in Table 1 and Table 2.

Table 1. Means and Standard Deviations of Levels for Both Factors

	Words Remembered (WR)		
Grid	**Mean**	**Std Dev**	**Letters**
Ordered	8.05	2.56	A
Random	7.14	2.39	B
Sound			
Music	7.04	2.08	
Silent	7.71	2.54	
White Noise	8.04	2.82	

Levels not connected by the same letter are significantly different

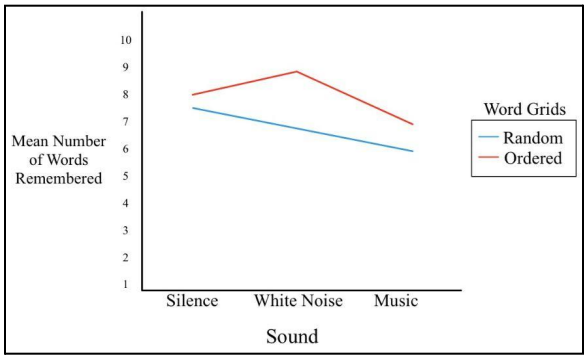
Table 2. Treatment Means and Standard Deviations

	Words Remembered (WR)	
Treatment	**Mean**	**Std Dev**
Random/ Silent	7.50	2.56
Random/ White Noise	7.00	2.54
Random/ Music	6.93	2.20
Ordered/ Silent	7.93	2.59
Ordered/ White Noise	9.07	2.79
Ordered/ Music	7.14	2.03

For the purposes of our study, we will consider a larger mean number of words as being better. The study examines the number of words a participant can memorize and as such, a higher

word recall count represents better performance. From Table 1, the grid pattern that resulted in the higher mean was Ordered at 8.05 words compared to Random at 7.14 words. As for the sound condition, White Noise performed best with a mean of 8.04 words, Silent performed second best with a mean of 7.71 words, and Music performed the worst with a mean of 7.04 words. Looking at the experiment's factors/levels separately, the optimal combination would be an ordered grid with white noise.

Figure 1. Interaction Plot Between Word Grid and Sound Condition on Mean Number of Words Remembered



From Figure 1, interaction is evident between sound and word grid on the mean number of words remembered (WR) as the means for random and ordered word grids change under different sound conditions. For example, a random grid with silence has a mean of 7.50 words while a random grid with music has a mean of 6.93 words. However, although there is interaction, JMP output does not denote said interaction as being statistically significant given that Sound*Grid has an F-statistic of 2.52 and a corresponding p-value of 0.0883.

From Table 2, the Grid/Sound treatment that resulted in the highest mean number of words remembered was Ordered/White Noise with a mean of 9.07 words, while the treatment that resulted in the lowest number of words remembered was Random/Music with a mean of 6.93 words. We note, like above, that the treatment with the highest mean number of words remembered was an ordered grid paired with white noise.

Given that interaction is not significant, our analysis will not include pairwise comparisons.

4. CONCLUSIONS

The results of this study suggest a person's ability to recall simple words is largely based on individual proficiency, but the conditions that they experience play a role in their WR scores. Our data leads us to believe that a combination of order and white noise might optimize a person's recall, while a mix of randomness and distracting music might hinder a participant's recall. We would expect that these findings might be similarly observed in other 18-23 year old Cal Poly students who might participate in the study, under similar conditions to those in the study.

While conducting our study, we made observations that felt notable to include. In particular, participants appeared to construct similar methods for writing words they were able to remember. Common strategies included jotting down words in pairs, as they appeared on the grid, and in columns. It was also interesting to note that an overwhelming majority of participants remembered and wrote down "Carrots" and "Onions" off of a random word grid. It should be noted that these two words are related and given that the rest of the words were unrelated, participants might have been drawn to the connection.

We'd be curious to examine how results might change with more participants or a different population of interest. Some disparities to consider might be geographic and/or demographic discrepancies.

5. REFERENCES

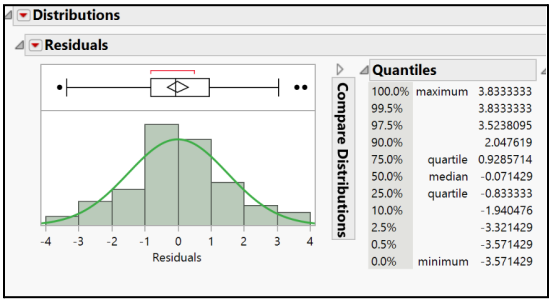
[1] Eriksson, Erik. "White Noise 3 Hour Long." *White Noise Therapy.* White Noise, 2016.

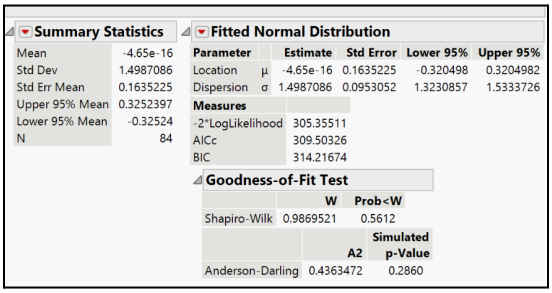
[2] Baha Men. "Who Let the Dogs Out." *Who Let the Dogs Out*, S-Curve Records, 2000, track 1.

6. APPENDIX

Appendix A: Model Assumptions

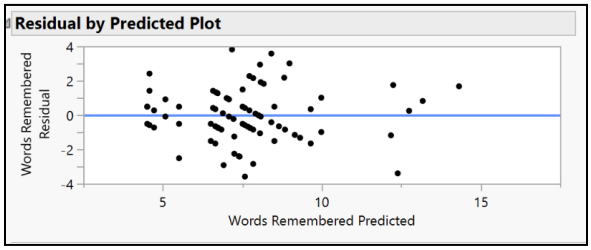
Normality of Residuals





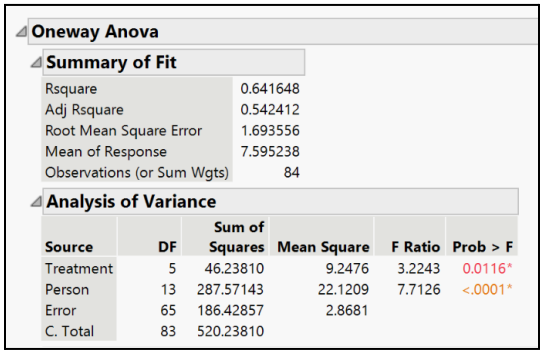
Based on the histogram, we see that there is a roughly normal distribution. In addition, the Normal Quantile Plot also suggests that the residuals are normally distributed. The notion of normal residuals is further reinforced by the Shapiro Wilk Test. Based on the test's p-value of 0.5612, we do not have sufficient evidence to reject the null hypothesis that the data comes from a normal distribution, and thus conclude that the assumption of "Normality" is supported.

Equal Variance



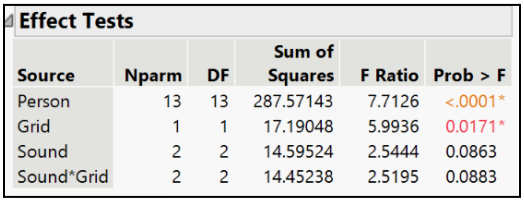
Based on the Residuals Plot, we see that the residuals (data points) are all approximately equally distributed from zero. This suggests that the data have roughly equal variance and that the model assumption of equal variance is supported.

Appendix B: ANOVA Analysis



Based on the Treatment F-statistic of 3.22 and p-value of 0.0116, we have sufficient evidence to say that Treatment has a statistically significant effect on the number of words remembered. This conclusion can be generalized to similar 18 to 23 year old Cal Poly students who participated in the study, under similar conditions to those in the study.

Appendix C: Effects Test



We ran a Fit Model with person, grid, sound, and the interaction between sound and grid to check if grid and sound had a main effect on the mean number of words remembered. Based on the F-statistic of 5.99 and p-value of 0.0171, we have sufficient evidence to say that grid has a main effect on mean WR. In addition, based on the F-statistic of 2.54 and p-value of 0.0863, we do not have sufficient evidence to say that sound has a main effect on mean WR. These conclusions can be generalized to similar 18 to 23 year old Cal Poly students who participated in the study, under similar conditions to those in the study.