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The Virtual World of Verbal Learning: Simulating the Classic Memory Drum Experiment

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Abstract

One paradigm for the study of human verbal learning and recall comes from the German psychologist Hermann Ebbinghaus from the last quarter of the 19th century. His most influential contribution to Psychology is his 1885 text, Ueber das Gedaechtnis, or Memory: A Contribution to Experimental Psychology (Ebbinghaus 1885/1964). It is a masterful examination of the course of acquiring and recalling lists of nonsense syllables with himself as the single subject. The so-called rote method was the repetition of hundreds of consonant-vowel-consonant nonsense lists presented in serial order until a list was perfectly reproduced. The crude technology of his day was a weight-driven time devise not unlike a clock. The 2oth century equivalent was the popular electro-mechanical memory drum like the one manufactured by the Ralph Gebrands Company of Arlington MA. This paradigm produced literally thousands of published papers and textbooks in support of Associationism to explain the learning and recall (e.g., Underwood and Schulz, 1960). This paper presents a comparison between the standard electro-mechanical apparatus and a more modern computer-based methodology. The voracity of the rote learning paradigm was demonstrated in a comparison of 2 groups of subjects. Mean learning and recall results for the two groups by either method produced no significant differences. The results are interpreted as support for the view that the serial rote paradigm from Ebbinghaus is a robust characterization of the basic mechanisms of human verbal behavior.

Keywords: acquistion, recall, Ebbinghaus, nonsense syllables, rote learning, memory drum

1. Introduction

Technology to support psychological research originated from about the second half of the 19th century (Garvey, 1929; Sanford, 1893). It was in these years as psychology strove to be taken as a quantitative science that notable figures such as Wilhelm Wundt and F. C. Donders, among others, introduced “modern” measurement devices in the form of mechanical and electro-mechanical equipment into their research “methodology.” Equipment that largely originated in the physiological laboratories of the day was borrowed to present stimulus parameters and to quantify responses in the new psychological laboratories (Boring, 1952). The guiding proposition was that the fundamental laws governing action and even thinking could be uncovered by way of specific scientific procedures in conjunction with the latest instrumentation. The goal was, of course, to establish cause-effect relations for human thinking, problem-solving, sensation, and perception.

In his classic text, *Experimental Psychology*, Benton Underwood identified 7 early foundational areas of measurement for investigations of human behavior: time perception, illusions, thresholds, reaction time, perceptual-motor behavior and performance, verbal behavior, and problem-solving (Underwood, 1966).

Each of these areas benefited from the evolving technology to present, measure, and record responses – the fundamental "stuff" of the "new" psychology. In fact, as in the case of other sciences dependent upon measurement, the progress of psychological knowledge was from the beginning inextricably linked to advances in machine technology based on electricity. The use of modern brain imaging techniques, for example, such as the f-MRI, are the 21st century equivalents of the revolving smoked cylinder of the late 19th century to provide data for the understanding and interpretation of human behavior.

2. Associationism and Human Memory

The field of understanding verbal learning and recall began in earnest and flourished with the laboratory work of two German psychologists in their respective university spaces. Born in the same year, Hermann Ebbinghaus (1850-1909) at Berlin and Georg Elias Mueller (1850-1934) at Goettingen defined the experimental paradigm for verbal learning and recall. Of the two, Ebbinghaus has more notoriety today, primarily because of his remarkable 1885 text, *Ueber das Gedaechtnis* (*On Memory),* the very first carefully documented study of memory with himself as the sole subject. Mueller is less well known, but also deserves mention for his use of the mechanical memory drum and standardization of the methods for learning and recall of verbal material (Behrens, 1997; Mueller & Schumann, 1894).

Ebbinghaus and Mueller based their work on Associationism, the philosophical view which originated in the British school of Empiricism, that *any* learning or recall occurs as a result of repetition of stimulus-response connections. Associationism proposes that there is a precise indubitable connection between the repetition of events and their recall – the more repetitions the stronger the memory "trace" between the stimulus-response events. Furthermore, the connection is intractable without interference from a source of disruption. For Wilhelm Wundt, association was one of the fundamental laws for human action and mental processes (Boring, 1950). A contemporary example of this would be the continuing trauma that we know as PTSD.

3. Laboratory Technology and the Study of Memory

The modern laboratory methodology used for the study of associative learning and recall has been somewhat detached from the philosophical and psychological history of the subject. This is remarkable, considering the unbroken use of stimulus-response methodology used to present "syllable-like" verbal material used to arrive at a scientific understanding of the underlying constructs and support for theory. Ebbinghaus as the "inventor" of nonsense syllables (2-3 consonants separated by a vowel that more or less resembled actual German words) was not concerned so much with the system of presentation of the syllables that he combined into lists of 10 to 15 he called "series" (Ebbinghaus, 1885/1964). It was enough for him to repeat presentations of a series until a perfect recitation occurred. At that point, for him, learning had occurred by the "serial anticipation method," whereby he could anticipate each syllable in the list *before* it came into view.

Over many years Ebbinghaus studied the number and positions of errors in the series; the number of repetitions of series needed for learning (one perfect anticipation of all the syllables in the list); and the number of repetitions of series needed for perfect recall. In fact, the creation of the so-called nonsense syllable is the contribution most identified with Ebbinghaus, even though he also uncovered basic principles for the role of practice, forward and backward associations within series, and most interesting of all, the savings score, an elegant measure of memory for a series. This was defined as the difference between the numbers of repetitions needed to learn a series to one perfect anticipation minus the number of repetitions needed to relearn the series to the same criterion. His classic text *(Ueber das Gedaechtnis)* seemed to finally fix an experimental methodology for the study of "higher mental processes." It was considered epoch-making by the scientific community of the time and earned Ebbinghaus a prestigious promotion at Berlin University in 1886 (Boring, 1950). Some years later, Mueller, known particularly for his meticulous experiments on vision and psychophysics, established standards and rules for the study of both serial and paired-associate lists (Mueller & Pilzecker, 1900).

The second part of the equation for the study of verbal learning and recall from the perspective of Associationism in the nineteenth-century was the presentation "technology." Unlike the extant devices for the study of sensation, perception, and reaction time based on physiological processing of the stimulus, such as the chronoscope (Gundlach, 1997), electro- mechanical devices were not available initially to Ebbinghaus for his studies. He merely wrote out his series of syllables on slips of paper. In all, he created about 2,300 syllables from the 11 vowel and 19 consonant sounds of the German language (Ebbinghaus, 1885/1964).

Each syllable would be presented for a few seconds to learn and to be recalled. To control for each syllable receiving the same length of time to be viewed, he first used a metronome set at 150 strokes/minute. Eventually he moved to a clock for this timing.

Such was Ebbinghaus' initial "technology" until the invention of a true apparatus (*Gedaechtnisapparat*) designed by Wilhelm Wirth that could independently present the syllables by a mechanical device (Zimmermann, 1903). The device rotated a paper disc with radially arranged stimulus material. The disc was attached to a central wheel with a hanging weight, similar to a pendulum clock. Spots for the stimulus unit depended on the number of cogs on the wheel. A second device, also designed by Wirth, used a paper belt instead of a disc (Voboril, Kventon, & Jelinek, 2013).

Much later a "memory drum" was designed to present nonsense syllable trigrams driven by an electric motor. The most popular one found in college and university laboratories during the 20th century was manufactured by the Ralph Gebrands Company of Arlington, Massachusetts (see Figure 1). The apparatus could present a list of syllables, say 10-15, on a paper roll attached

Figure 1
Ralph Gebrands Co. Electro-mechanical Memory Drum

to a revolving drum with gears that made contact with cogs on an adjacent wheel to control the rotation. The subject viewed the syllable or any other visual stimulus for that matter through an aperture for a specified length of time (*e.g.*, 3 sec or 5 sec) set by cogs on the drum.

The same list could be viewed over and over again until an arbitrary criterion of learning was reached, typically that each syllable would be correctly spelled out as a response *before* it appeared in the window. This methodology, along with the thousands of 3-letter consonant-vowel-consonant tri-grams allowed for a myriad of topics to be studied, such as length of lists, inter-stimulus interval, and recall interval (c.f. Underwood and Schulz, 1960; Battig and Spera, 1962). Further, with the work of E.J. Archer and others to identify the *relative differences in syllable association value to normal* English, variables related to the difficulty in acquisition and recall of syllables could be investigated (Archer, 1960). Indeed, electrical devices such as the Gebrands memory drum became the standard apparatus for literally thousands of experimental reports from psychological laboratories in the second half of the 20th century and supported the academic careers of hundreds of American researchers, such as Benton Underwood, William McGeoch, James Deese, Kenneth Spence, William Estes, and Norman Spear to name just a few of the major contributors to the human verbal behavior literature.

Necessity is the mother of invention, or at least the mother of application, and it was inevitable that, either because of the need for more reliable and sensitive instrumentation or because newer research hypotheses and experimental designs were not able to be studied through the standard methodologies, computer technology and digital programming could come to the rescue. In a word, electro-mechanical equipment became too burdensome. In the case of the serial rote (or anticipation) paradigm, some problems encountered were: individual lists were typed onto paper; lists had to be changed and aligned on the drums; teeth on the drum and cogs on the motor jammed; motors quit or varied in speed; and the cumbersome equipment had to be stored, maintained, repaired, or replaced! In the case of the first author, a driving force for on-line programming was the small number of machines available for an increasing number of students enrolled in a research methods course.

4. Design of Digital Serial Rote Learning and Recall

Modern computer programs, such as Adobe Captivate or PowerPoint, therefore, proved to be a viable answer. To create an online replication of the classic serial learning experiment, the second author constructed a simple video display program for lists of nonsense syllables on a plain white background. Each syllable in a list appeared for exactly 2 seconds with a 1 second blank screen between syllables. Syllables were randomly selected from high association value syllables (Archer, 1960) to create 16 original lists of 10 syllables each in a no-frills Myriad Pro font. For the presentation of any one list to the subject, an initial 2-sec screen with 3 asterisks preceded the first syllable to signal the subject that the list was about to begin. A series of 3 dashes were presented after the 10th syllable to signal the end of the list. The interval between presentations of a list was arbitrarily set for 10 sec. The design was easily accomplished using basic video editing software.

Once the videos were completed, a few additional display requirements needed to be considered. To closely mimic the standard electro-mechanical methodology, the videos had to display with no distractions on the screen. This eliminated some common video display options like YouTube. In addition, the experiment could only be visible to students during the class sessions so that eager subjects could not access the syllables between sessions. Lastly, the experimenters needed to easily access all of the test variations.

The university's streaming video server provided the solution to these issues. With the videos uploaded to the server, the instructor could set the permissions to allow only course members to view the videos during class and then set the videos to" private" between classes. The nonsense syllables displayed with a minimum of distraction on a white screen, with only the controls to stop and start the video visible below the text. A webpage with links to the 16 memory drum videos gave students easy access to the various lists, in which students were assigned in pairs, one serving as subject and one as the "experimenter." Refer to Appendix for the digital design that presented lists of nonsense syllable trigrams to the subjects.

5. Comparisons of Learning and Recall

Changing the experimental methodology from an electro-mechanical to an on-line format provided an opportunity to compare student performance in the undergraduate research methods course. The last semester for the electro-mechanical apparatus was Spring 2011 and a subsequent semester using the on-line method was Spring 2013. From the above discussion of the reliability of the serial rote method, it was hypothesized that regardless of the display methodology the mean number of trials to criterion and the number of syllables correctly recalled after a 7-day recall interval would *not differ significantly* between the 2 groups of students.

In Spring semester 2011 the class consisted of 8 students and in Spring 2013 the class consisted of 13 students (hence the desire to use the on-line method of presentation of syllables!). The mean number of trials for the Acquisition criterion (one perfect anticipation of a 10-syllable list) were 13.12 and 13.08, respectively. The number of syllables correctly recalled for the 2 groups were 4.0 and 4.39, respectively. Needless to say, an independent groups t-test for the difference between the group means was not conducted. These results stand on their own merit and suggest that the method of presentation of the syllables – electro-mechanical or on-line – was inconsequential for both learning and recall of the lists.

6. Enter the Digital Age in Verbal Learning and Recall Experiments

Logistical necessities for changes to replace the traditional rote learning paradigm using electro-mechanical equipment came with the growing numbers of students enrolled in an undergraduate psychological research course and the complexity of research designs emerging from the verbal behavior literature. This is over and above the considerations of reliability of the machinery that required cogs and gears and lists of syllables taped around drums. Computer technology and digital programming came to the rescue just at the right time.

Nevertheless, the significant consideration of the changes in laboratory methodology speaks of the fundamental nature of human brain functioning; namely the way the visual stimulus, brain processing, and verbal response are "wired" to produce dependable outcomes. The serial rote paradigm based on associationistic processes has been supported to understand at least this aspect of human brain functioning. It makes no difference, essentially, to the conscious subject *how* verbal symbols are presented in a rote learning task. As long as there are consistent elements in the *way* the stimuli are presented, such as inter-stimulus interval, length of material, familiarity of the material, and the like, successful association of the stimulus-response components will occur during learning and recall. Just as the verbal learning studies of the 19th century evolved from the presentation of verbal material on slips of paper (from Ebbinghaus) to weight-driven machines to electro-mechanical devices to virtual memory drums presented on-line, the serial rote paradigm in the Ebbinghaus model of Associationism provides an elegant explanation of human brain functioning.

Open Practice Statement: All data and materials are available from the first author.

References

Archer, E. J. (1960). Re-evaluation of the meaningfulness of all possible CVC trigrams. *Psychological Monographs, 70, No. 10.*

Battig, W. F. & Spera, A. J. (1962). Rated association values of numbers from 1-100. *Journal of Verbal Learning and Verbal Behavior, 1,* 200-202.

Behrens, P. J. (1997). G. E. Mueller: The third pillar of experimental psychology. In Bringmann, W. G., Lueck, H. E., Miller, R., & Early, C. E. (Eds.). *A pictorial history of psychology* (171-176). Carol Stream IL: Quintessence.

Boring, E. G. (1942). *Sensation and perception in the history of experimental psychology.* New York: Appleton-Century-Crofts.

Boring, E. G. (1950). *A history of experimental psychology, 2nd Ed*. New York: Appleton-Century-Crofts.

Ebbinghaus, H. (1885/1964). *Memory: A contribution to experimental psychology.* Trans. A Ruga & C. E. Bussanius. New York: Dover.

Garvey, C. R. (1929). List of American psychological laboratories. *Psychological Bulletin, 26, 652-660.*

Gundlach, H. U. K. (1997). Time-measuring apparatus in psychology. In Bringmann, W. G., Lueck, H. E., Miller, R. & Early, C. E. (Eds.). *A pictorial history of psychology* (111-117). Carol Stream IL: Quintessence.

Mueller, G. E. & Pilzecker, A. (1900). Experimentelle beitraege zur lehre von gedaechtniss [Ex-perimental contributions to theory of memory]. *Zeitschrift fuer Psychology. I. Supplement.*

Mueller, G. E. & Schumann, F. (1893). Experimentelle beitraege zur unterzuchungen des Gedaechnisses [Experimental contributions to the investigation of memory]. *Zeitschrift fuer Psychologie und Physiologie der Sinnesorgane, 6,* 81-190, 257-339.

Sanford, E. (1893). Some practical suggestions on the equipment of a psychological laboratory. *American Journal of Psychology, 5,* 421-438.

Underwood, B. J. (1957). *Psychological research.* New York: Appleton-Century-Crofts.

Underwood, B. J. & Schulz, R. W. (1960). *Meaningfulness and verbal learning.* Philadelphia: Lippincott.

Underwood, B. J. (1966). *Experimental psychology, 2nd Ed.* New York: Appleton-Century-Crofts.

Underwood, B. J. (1982). *Studies in learning and memory: Selected papers.* New York: Praeger.

Voboril, D., Kventon, P., & Jelinek, M. (2013). Psychological machinery: Experimental devices in early psychological laboratories. Frankfurt-am-Main: Peter Lang.

Zimmermann, E. (1903). *Preis-Liste ueber psychologische und physiologische Apparta.* Leipzig: Edvard Zimmermann.

Appendix

Online Nonsense Syllable Lists for Undergraduate Experiments

To create an online replication of the classic memory drum experiment, we designed a simple video to display each nonsense syllable on a plain white background for exactly 2 seconds with one second of blank screen between syllables. Syllables randomly selected from high association value syllables were used from Archer (1960) for 16 original lists of 10 syllables each. For the presentation of any one list to the subject, an initial 2-sec screen with 3 asterisks preceded the first nonsense syllable to signal the subject that the list was about to begin. A series of 3 dashes were presented after the 10th syllable to signal the end of the list. The interval between presentations of a list was for 10 sec. In all, 16 different memory drum videos were produced so that their visual presentations were identical to the paper lists .

The design was easily accomplished using basic video editing software. Each nonsense syllable was added in a no-frills font, Myriad Pro, on a blank white screen, and the syllable was set to appear after one second and display for two seconds. Once the videos were completed, a few additional display requirements needed to be met. To closely mimic the original experiment, the videos had to display with no distractions on the screen. This eliminated some common video display options like YouTube. In addition, the experiment could only be visible to students during the class sessions so that eager subjects could not access the syllables between sessions. Lastly, the student experimenters needed to easily access all of the test variations.

The university's streaming video server provided the solution to these issues. With the videos uploaded to the server, the instructor could set the permissions to allow only course members to view the videos during class and then set the videos to private between classes. The nonsense syllables displayed with a minimum of distraction on the white screen, with only the controls to stop and start the video visible below the text. A webpage with links to the 16 memory drum videos gave students easy access to the various lists.