The generation effect: Software demonstrating the phenomenon

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The generation effect occurs when people demonstrate better memory for material that they have generated than for material that they have merely read. The software described here allows students to participate in replications of generation effect experiments. The program can be used with its default settings to present simple experiments. I have used this feature in research methods courses to provide data for writing research reports. The program can also be modified to allow students to design and conduct their own variations of generation effect experiments.

Slamecka and Graf (1978) presented five experiments demonstrating that memory for self-generated material is better than memory for material that is merely read. They dubbed this phenomenon the generation effect. This effect has since received a lot of attention (Begg & Snider, 1987; Begg, Vinski, Frankovich, & Holgate, 1991; Burns, 1990, 1992; Gardiner, Smith, Richardson, Burrows, & Williams, 1985; Glisky & Rabinowitz, 1985; Greenwald & Johnson, 1989; Hirshman & Bjork, 1988; Johns & Swanson, 1988; McDaniel, Waddill, & Einstein, 1988; McElroy & Slamecka, 1982; Nairne, Puse, & Widner, 1985; Payne, Neely, & Burns, 1986; Schmidt & Cherry, 1989; Slamecka & Fevreski, 1983; Slamecka & Katsaiti, 1987; Watkins & Sechler, 1988). This report describes software that allows students to participate in generation effect experiments.

Slamecka and Graf (1978) presented lists of word pairs to their participants. Each pair was produced using some rule (e.g., a rhyming pair would be *rave-cave*). For the *read* condition, participants read this list of word pairs. They were also told the rule that related the words in each pair. For the *generate* condition, participants were told the rule, and then they saw the stimulus word and the first letter of the response (*rave-c*). The participant's task was to complete the response. After the list was presented, participants were given a memory test.

Slamecka and Graf (1978) found the generation effect to be a robust phenomenon. They found significant effects with recognition, free recall, and cued recall memory tests. They found the effect when the read and generate tasks were presented within participants and when the tasks were presented between participants. They found the effect for intentional and incidental memory conditions. The only limitations were on the effect reported by

Slamecka and Graf for recognition memory and cued recall for the stimuli.

Since Slamecka and Graf, the robustness of the effect has been qualified by a number of observations. McElroy and Slamecka (1982) found that there was no generation effect for nonwords (see also Nairne et al., 1985; Payne et al., 1986; but see Johns & Swanson, 1988, for a generation effect with nonwords). Nairne et al. (1985) found no generation effect with low-frequency words. Slamecka and Katsaiti (1987) found no generation effect for bilingual (Greek-English) word pairs. They also found no generation effect for lists presented between participants (see also Begg & Snider, 1987). Schmidt and Cherry (1989) found that reading is superior to generating when participants recall both members of the pair. Begg et al. (1991) found a reduced or reversed effect when participants were instructed to imagine the referent of the response. Burns (1992) found that reading is superior to generating with slow presentation rates and a free recall task.

Much of the research on the generation effect has been conducted to distinguish between various theoretical accounts of the effect. The main three competing explanations of the generation effect are as follows: (1) Generating enhances information about the relation between the stimulus term and the response, (2) generating enhances information about the generated word itself, and (3) generating produces a combination of both types of enhancement (a multifactor account) (Burns, 1990; Hirshman & Bjork, 1988; see also Slamecka & Katsaiti, 1987, for other possible explanations). McDaniel et al. (1988) added a third component to the multifactor account: Generating enhances encoding of the list structure. Testing between these accounts involves manipulating some variable that should cause the generation effect to obtain or not obtain and looking for the effect.

In Table 1, I present a list of experiments investigating the generation effect. For each experiment, I outline the basic design and present a simplified version of the results. Inclusion in the table was generally restricted to experiments using list-learning paradigms, since these are

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Table 1
Representative Experiments, Basic Design, and Direction of the Generation Effect

Representative Experiments	Basic Design	Effect
Slamecka & Graf (1978)		
1	Generate versus read between participants; five rules (associate, category, opposite, synonym, rhyme); recognition memory test.	
	Self-paced presentation and experimenter-paced presentation (4 sec per item).	Generate > Read
2	Generate versus read within participants.	
	Intentional and incidental learners.	Generate > Read
3	Recognition test for stimuli.	No effect
	Recognition test for responses.	Generate > Read
4	Three rules (synonym, opposite, rhyme); free recall.	Generate > Read
5	Cued recall for stimuli.	No effect
	Cued recall for responses.	Generate > Read
Extensions of the Effect		
Slamecka & Fevreiski (1983)	Likelihood of generation on the effect; low information generation (trivial-v) versus high information (trivial-vi-l); free recall.	
1	Successful and unsuccessful generation.	Generate > Read
Glisky & Rabinowitz (1985)	Single word task.	
1	Read a word or complete a fragment; incidental learning; recognition memory.	Generate > Read
Gardiner et al. (1985)	Effect of generation difficulty on recall; manipulate difficulty by removing zero through four letters from five letter words.	Generate > Read (more letters removed leads to better recall)
Johns & Swanson (1988)	Generation effect for nonwords; reveal entire nonword at the end of generation.	
1	Words and nonwords; recall and recognition tests.	Generate > Read
Watkins & Sechler (1988)	Incidental memory task.	
1	Participants instructed to memorize pictures; generate and read stimuli presented as distractor material.	Generate > Read
2	Incidental and intentional learners.	Generate > Read (bigger for incidental)
Greenwald & Johnson (1989)	Antonym task, test memory for stimuli.	
1	Cued recall for stimuli and free recall for stimuli.	Generate > Read
	Recognition for stimuli.	No effect
Limitations of the Effect		
McElroy & Slamecka (1982)	Generation effect for nonwords; recognition memory.	
1	Timed and self-paced presentation for words.	Generate > Read
	Timed and self-paced presentation for nonwords.	No effect
Nairne et al. (1985)	Generation effect for nonwords; frequency manipulation.	
1	Participants told nonwords are obscure words or nonwords; free recall.	No effect
3	Nonwords and low-frequency words (≤ 1 /million); recognition.	No effect
	Medium-frequency (25–40/million) and high-frequency (> 100 /million) words; recognition.	Generate > Read
Payne et al. (1986)	Relationship between stimulus and response.	
1	Word stimulus–word response and nonword stimulus–word response.	Generate > Read
	Word stimulus–nonword response and nonword stimulus–nonword response.	No effect
Slamecka & Katsaiti (1987)	Effect of bilingual word pairs; between- versus within-participants designs.	
1	Generate versus read within participants; English–English word pairs.	Generate > Read
	Generate versus read within participants; Greek–English word pairs.	No effect
3	Generate versus read within participants; English–English word pairs.	Generate > Read
	Generate versus read between participants; English–English word pairs.	No effect
Reversals of the Effect		
Schmidt & Cherry (1989)	Recall of both members of a word pair; generation task is easy (1.3 letters omitted) versus hard (2.6 letters omitted).	
1	Easy and hard generation, free recall and cued recall.	Read > Generate
Begg et al. (1991)	Manipulate strategy used during reading and generating.	
1	Pronounce response (generated or read).	Generate > Read (not always reliable)
	Imagine referent of response (generated or read).	Read > Generate or No effect
Burns (1992)	Slow (7 sec/item) versus fast (14 sec/item) presentation.	
1A	Recognition memory (5 AFC, 2-week delay); fast and slow rates.	Generate > Read
1B	Cued recall; fast and slow rates.	Generate > Read
1C	Free recall; slow rate.	Read > Generate
	Free recall; fast rate.	No effect

the sorts of experiments that the software was designed to present. The summaries presented in the table are not intended to be exhaustive summaries of the articles described. The focus is on manipulations that affect the presence of the effect. The implications for theoretical accounts of the generation effect have not been included.

THE SOFTWARE

My goal in developing the software was to provide a first experiment to use in my Research Methods courses. I have used the experiment as the foundation for the first lab report several times, and I have found that the exercise of writing a generation effect paper transfers well to the writing of future papers in the class. This experiment is ideal for research methods applications for a number of reasons. First, the effect is robust. It is useful for the first experiment to come out as expected. Second, it is simple to conduct. Third, the motivation for the research is accessible to undergraduates with limited knowledge of psychology.

The software can be used in its default mode, or it can be modified to present a wide range of experiments (replication of most of the experiments in Table 1 is possible). The default experiment is a simple demonstration of the generation effect. Participants may read or generate a response list with 24 word pairs: 8 pairs in each of three rules. In the default mode, the reading and generating tasks are presented between participants. The rules are the opposite (e.g., *up-down*), category (e.g., *pen-pencil*), and rhyme (e.g., *grape-ape*) rules from Slamecka and Graf (1978). There are also three practice trials for each rule. In the default mode, generating is self-paced, and reading is at a rate of 4 sec per item. The default memory task is free recall. After an experimental session, participants may save their data as a text file. If the program's folder is on the Desktop, the default experiment will run automatically when the program is launched. This version of the experiment is the one that I have used in my methods classes.

The software may also be modified by using a set of parameters to implement variations on the basic experiment. These parameter settings can be saved, and the program can be launched by double-clicking on the parameter file. When launched from a file, the parameter settings replace the default settings. The word lists can also be modified, further increasing the program's flexibility. Template word files for between-participants and within-participants lists are included with the experiment. These files contain detailed instructions on list construction. The path to a word list can be stored with a parameter set, automating the process of carrying out novel experiments.

In Table 2, I present a list of the program parameters that users may set. Some of these parameters were included in the program for practical purposes (e.g., to hide instructions). Others have implications for theoretical accounts of the effect (e.g., presenting the read and gener-

ate tasks between or within participants). For parameters with theoretical implications, citations have been provided that demonstrate the use of the parameter. A description of the possible settings of each parameter has also been included. The parameters are arranged according to their location in the program.

USING THE SOFTWARE

Students should be assigned a participant number and a condition (read or generate) before carrying out the experiment. It is possible to hide all of the files from the students. All they need to see is a parameter file called "Double-click me." Launching this starts the program. Students can then enter their participant number and choose read or generate. Help is available in the software for the basic experiment set-up.

A little more instruction is required in order to get students to save the data. The program offers the *save* option immediately after the experiment. I usually instruct students to save their data in a special folder for the class. Non-Macintosh users sometimes have trouble with this.

The data file is a text file which contains the memory results. It also contains all of the parameter settings and the word lists. Lists are shown in the order presented and categorized by rule. The program will not automatically compute serial position curves or other sophisticated memory measures. However, all of the information required for these computations is available in the data file.

Parameter sets that replicate the experiments in Slamecka and Graf (1978) have been included with the software (with the exception that only three rules are used). The program's flexibility also allows instructors to demonstrate other list-learning memory experiments. As an example, parameter sets that allow partial replication of the experiments in Glanzer and Cunitz (1966) (investigating transfer from short-term memory to long-term memory) and Bjork and Whitten's (1974) Experiment 1 (investigating long-term recency) have been included.

CONCLUSION

I have found that the generation effect makes a nice first experiment for use in Research Methods courses. The effect is robust (in four semesters of using the experiment, generate participants have demonstrated better memory than read participants every time). The number of potential variations is enormous, and the literature is accessible to undergraduates.

Availability. I developed the software using Think Pascal (1991). The software will run on any Macintosh with System 7 or higher as its operating system. The software has been tested on various Power Macintoshes (one running System 8), and some earlier models. The software is available on my web site, www.mtsv.edu/~wlangsto. The software can also be obtained by sending a disk to the author.

Table 2
Program Parameters, Representative Experiments, and Possible Settings

Program Parameter	Representative Experiments	Possible Settings
Presentation Parameters		
Self- versus experimenter-paced presentation.	Slamecka & Graf (1978)	Generate and read tasks can be either self- or experimenter-paced.
Hide cues (stimuli).		Allows presentation of word lists for additional types of memory experiments.
Generate from first letter versus fragment.	Slamecka & Fevreiski (1983)	First letter presents pairs in the format "grape-a." Fragment presents pairs in the format "grape-a-e"; the number of letters removed can be set from zero to <i>N</i> .
Rules are blocked or in random order.	Slamecka & Graf (1978)	Blocking rules presents all words within a rule in adjacent list positions. Random presents them in random order. A third setting allows presentation in the same order as the word list file.
Repeat the entire list <i>N</i> times.	Slamecka & Graf (1978)	The list can be repeated up to five times.
Repeat each item <i>N</i> times.		Each item can be repeated up to five times in a row.
Delay <i>N</i> seconds after each item.		A filled (counting backward) or unfilled delay can be presented after each item for <i>N</i> seconds.
Delay <i>N</i> seconds after list presentation.	Slamecka & Graf (1978)	A filled (counting backward) delay can be presented for <i>N</i> seconds after the list.
Test Parameters		
Memory task is free recall, cued recall, or recognition.	Burns (1992)	One of the three memory tasks can be used.
Remember stimuli versus responses.	Greenwald & Johnson (1989)	The memory task can be based on the stimulus list or the response list.
General Parameters		
Present read/generate tasks within participants.	Slamecka & Katsaiti (1987)	The read/generate tasks can be within participants or between participants.
Hide instructions.		The automatic instructions can be suppressed if experimenters want to substitute custom instructions.
Hide practice.	Watkins & Sechler (1988)	Hiding practice allows the use of custom practice trials.
Intentional versus incidental instructions.		Intentional memory instructions describe the memory task and present a practice memory test. Incidental instructions do not mention memory and suppress the practice memory test.
Loose scoring (whatever is generated is "correct") versus strict scoring.		For loose scoring, the participant's generated list will be used to score memory. For strict scoring, only responses consistent with the word list file will be scored as correct.
Enable mouse-click escapes.		Typing "quit" at any point where a typed response is expected will always escape from the program. Enabling mouse clicks will cause an escape if the mouse button is depressed when the program is presenting timed information (such as the read task).
Attach word file to parameter set.		Attaching a custom word file to a parameter set allows experimenters to change the default word file.

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