Computer-Based Fluency Training with the Terminology of Behavior Analysis

Guillermo E. Yaber-Oltra

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COMPUTER-BASED FLUENCY TRAINING WITH THE TERMINOLOGY OF BEHAVIOR ANALYSIS

by

Guillermo E. Yaber-Oltra

A Dissertation
Submitted to the
Faculty of The Graduate College
in partial fulfillment of the
requirements for the
Degree of Doctor of Philosophy
Department of Psychology

Western Michigan University
Kalamazoo, Michigan
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This study examined the effects of computer-based fluency training on the learning of behavior-analysis terminology. Sixty-nine undergraduates studied the definitions of half a set of behavior-analysis terms using a computer program Think Fast (Parsons, 1989), and half using their regular methods. Think Fast training items consisted of typing the words missing from definitions. On seven out of nine post-training quizzes, students were better able to define terms previously studied with the computer program. In a related experiment, volunteers studied half a new set of terms using the computer, either typing or saying the answers. Students mastered the definitions better when they typed the answers. There were no differences in the presentation order of the concepts so neither a primacy nor a recency effect was supported. Even though the amount of time allowed to study the definitions was the same for both methods, Think Fast training with the typing mode was still superior. This suggests that in both experiments, the superiority of typing the answers using Think Fast was a result of the training method used and not the amount of time devoted to practice with the definitions. Fluency training using Think Fast with the typing mode helps students achieve competency with behavior-analysis terminology.
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Computer-based fluency training with the terminology of behavior analysis

Yaber-Oltra, Guillermo Enrique, Ph.D.

Western Michigan University, 1993

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them my dream came true. I dedicate this dissertation to my father and my moth­
er. You deserve all the applause.

Guillermo E. Yaber-Oltra
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CHAPTER I

INTRODUCTION

A goal of higher education is that students acquire, maintain, and transfer verbal (intellectual) repertoires. Students should become competent with concepts and skills of a given content domain; and in turn, graduates with these competencies can then contribute to the physical and social well-being of their community (Malott, 1984).

Behavioral systems analysis might help to achieve these goals through the design and implementation of effective instructional systems. Behavioral systems analysis consists of the use of behavior-analysis and systems-analysis to help behavioral systems achieve their goals (Malott, 1974; Malott & Garcia, 1987). In this approach the first step consists of using tools of systems-analysis, particularly goal-directed systems design to analyze the system and subsystems' goals and determine how their components contribute to the accomplishment of the system's goals. The second step is to use behavior-analysis to help individuals and groups acquire, maintain, or improve skills so that each of the system's components will contribute to the attainment of the organization's goals. In practice, both researchers and practitioners in applied behavior analysis have attempted to improve instructional systems through the application of the principles of behavior (Geller, 1992; Skinner, 1968).

An example of an instructional system is a psychology course. Boneau (1990) specified the goal of such a course by using the term psychological literacy to designate a list of terms and concepts that "psychologists and their students
might be expected to know (p. 891). He determined this set of concepts through the statistical analysis of results from a survey sent to psychology textbooks' authors that served as expert judges. Through this procedure he established the top 100 psychological terms, and the top 100 terms in each of the 10 subfields that he used to cover the field of general psychology. In a variation of Boneau's approach, behavior-analysis literacy can mean mastery of questions or problems regarding behavior-analytic terms, definitions, and examples. A behavioral term is a word that has a technical meaning for behavior-analysis (e.g., behavior). A definition is a description of a behavioral term by its properties (e.g., muscular movement or glandular secretion). A behavioral example is an instance or model of a behavioral term (e.g., lever-press) (see Figure 1).

Behavior-Analysis Literacy

Learners acquire an intellectual (verbal) repertoire of behavioral terminology

Term  "Behavior"

Definition  "A muscular movement or glandular secretion"

Example  "Lever-press"

Figure 1. Behavior-Analysis Literacy Model.
The arrows linking the three components of the model suggest the wide variety of training and testing possibilities within the instructional system. Performance mastery in a content domain such as behavior-analysis requires the steps of repertoire acquisition, fluent use of the concepts, their maintenance over time, and their application to new situations or more complex skills as pointed out by Johnson and Layng (1992). These authors referred to those steps as: accuracy training, fluency building, endurance building, and applying.

The first step, accuracy training, consists of the acquisition of a repertoire of terms, definitions, and examples of the content domain of behavior-analysis. For example, given a behavioral term, "behavior," provide its corresponding technical definition and or example: "a muscular movement or glandular secretion," "level-press." The second step, fluency building, consists of using that repertoire with accuracy and speed. For example, given a set of behavioral terms provide as many definitions or examples as possible in one minute or other short duration timings. The third step, endurance building, consists of performing rapidly and accurately with progressively longer time-periods until the learner performs the skill over an appropriate time frame. An example of this step might be: Given a set of 12 behavioral terms, be able to provide all of the corresponding definitions or examples with at least 92% accuracy and in 5 minutes. The final step, applying, implies the application of the acquired repertoire to answering new questions or solving new problems, those not included in the original training. One instance of this final step could be: Given a new set of 20 problem situations, name and diagram the appropriate behavioral contingency in 20 minutes; or give an original example of a punishment contingency in 2 minutes. In summary, competent individuals with behavior-analysis will show an accurate, fluent, enduring, and generalized (extended) performance in this subject matter (Johnson & Chase, 1981).
Fluency building is the second step toward performance mastery, and a requisite for endurance. Fluency, the combination of accuracy and speed, is a performance rate that generates useful skills that are still performed after long periods without practice (Johnson & Layng, 1992). Fluency will make it more likely that students can perform despite distractions, will retain the skill for longer periods of time, and will be competent to apply what they already have in their repertoire to acquire new skills (Binder, 1988). A cost-effective way to achieve fluency is to use a system of measurement that includes the dimensions of time and frequency.

"Say All Fast a Minute Each Day Shuffled" (SAFMEDS, McDade, Austin, & Olander, 1985, p. 49) is an example of a training strategy oriented toward building fluency. A deck of cards is prepared with questions and answers on opposite sides of the cards. The student works with the deck, providing oral answers as quickly as possible while another person (a peer, instructor, or coach) keeps track of the answer and the recording interval. McDade and Olander (1990) compared three types of SAFMEDS with 17 students enrolled in a course on theories of personality. This course was taught using a personalized system of instruction format (Keller, 1968). They compared questions and answers SAFMEDS, student-generated SAFMEDS, and instructor generated SAFMEDS. In the first protocol (Q & A), the instructor gave students questions and answers that students wrote on cards (questions and answers on opposite sides). In the second protocol (student generated), students were provided with a list of terms and they had to develop a question for each with the help from the textbook. The students wrote the questions and answers on cards. In the third protocol, students were evaluated on SAFMEDS previously developed by the instructor which students never saw before their initial testing on the unit. Questions and answers were on each side of
the card. No differences were found among the protocols in terms of the highest average frequency of correct responses for each of the 13 units of the course (M:Q&A = 33.82; M:S = 32.78; M:I = 32.77). So, according to the authors, similar results may be obtained with different ways of designing SAFMEDS.

Another approach to designing SAFMEDS consists of using them in computer-based instruction. Computer-based instruction (CBI) can be delivered in an individualized, interactive, and guided way (Steinberg, 1991). Kulik and Kulik (1987) combined the results of four separate meta-analyses of computer-based instruction in elementary, high school, colleges and universities, and adult education. Their analyses covered 199 comparative studies. Two of their major findings were: The average effect (measured by the effect size) of computer-based instruction was to increase exam scores by .31 standard deviations, or from the 50th up to the 61st percentile (based on 199 studies), and reduced the average of instructional time by 32% (based on 28 investigations).

One critical element of CBI is the software used for instruction. Courseware is the term used to label software specifically developed for instructional applications of the computer (Baker, 1990). There are four kinds of courseware: tutorials, simulations, games, and drill, as well as practice programs.

The goal of tutorials is to incorporate new skills in the student's repertoire. Tutorials present information, provide feedback, and adapt the instruction according to the student's response. Behavior Analysis: A Computer-Based Tutorial (Hardy, 1989) is courseware designed to teach behavioral principles and concepts using the tutorial format.

Computer games are courseware that teach new skills or allow drills in the context of a game. The World of Sidney Slug and His Friends (Acker & Goldwater, 1991) contains tutorials and simulations with elements of a computer game.
for instruction in behavior modification.

Simulations represent real events that help students learn new skills and strategies in a controlled environment. Behavior on a Disk (Catania, Matthews, & Shimoff, 1990) consists of a set of simulations that serve as supplemental activities in a behavior-analysis course.

Drill CBI programs are more suitable for helping students to maintain and improve skills already learned. Drill programs are appropriate for fluency building when they can function as computerized SAFMEDS. The Precision Learning System (Precision Learning Systems, 1993) and Think Fast (Parsons, 1989) are computer programs that allow the instructor to design computerized flashcards or SAFMEDS. Think Fast is a computer-based instructional system that helps students become fluent with concepts and facts. This drill-type instructional software uses the analogy of the flashcard where the "term," the "definition," or the "example" part of the behavior literacy model can be used to enhance instruction.

In a series of pilot studies designed to optimize the fluency-laboratory subsystem of a behavior-analysis course (Appendix C), several computer-based testing and training modalities were evaluated. Think Fast was the courseware used for fluency training. The training procedures involved the students typing the missing key words or small phrases from definitions. General results from those experiments were as follows:

1. In comparison with the student's standard study methods, training with Think Fast produced superior performance on post-training quizzes, when the quiz questions involved filling in keywords missing from definitions or writing the correct term given a definition.

2. Training with Think Fast was not better than standard training when evaluated with quizzes where the student wrote the whole definition given the term.
or with matching quizzes.

The purpose of the present research was twofold: First, it was to further analyze the effects of computer-based fluency training on the academic performance of undergraduate psychology students. And second, it was to redesign, evaluate, and revise the fluency-laboratory subsystem of an undergraduate course in behavior-analysis.
CHAPTER II

EXPERIMENT 1: THE VALUE OF COMPUTER-BASED FLUENCY TRAINING

The desired terminal performance is that students be able to correctly write definitions of behavioral terms. However, pilot work with Think Fast (Parsons, 1989) showed no differential impact on writing definitions when the training had involved filling in key words or brief missing phrases from those definitions. Therefore, the present study involved Think Fast training where the student was required to write the whole definitions.

Subjects

Sixty-nine junior and senior students enrolled in a behavior-analysis course participated in the Think Fast laboratory, as part of their regular course requirements. The psychology department at a Midwestern university offered the course in the winter semester of 1992. Using a consent form, students had the opportunity to give or deny permission to use their data in public presentations or publications (see Appendix B).

Setting

The course included three types of activities: (1) classroom discussions and homework related to the course textbook (Malott, Whaley, & Malott, 1993), (2) a Skinner-box laboratory, and (3) a Think Fast fluency laboratory where students received computer-based fluency training with the terminology of behavior analysis. Every fluency-laboratory included 30 minutes of training with half the terms
contained in the day's chapter. This training was followed immediately by a paper-and-pencil quiz over all the terms introduced in that chapter; in other words, the quiz included both those terms used in the Think Fast training and those not used. The point system used in the course consisted of: (a) 20 points for the conceptual homework exercises for each chapter (b) 50 points for each of the five laboratory reports, (c) 10 points for participation in each fluency laboratory, (d) 20 points for each quiz, and (e) 100 points for the final paper. Students needed 92% of the points in each of the above categories to receive an A for this course. The training facility contained 25 MS-DOS XT computers.

Apparatus and Program

Each computer had 640K of random memory, one 3.5-inch disk drive, a keyboard, and a color monitor. One 3.5-inch floppy disk for each participant included the Think Fast program and the files with the behavioral terms and definitions from eight chapters of the book. The Think Fast "card" gave a term and a partial definition and the student had to complete the definition. A "deck" is a collection of cards (see Figure 2).

Procedure

Think Fast training consisted of nine 30-minute sessions, twice a week. The ninth session was a review session covering 20 terms from previous chapters--10 previously studied with Think Fast and 10 studied without it. Each Think Fast deck included approximately half the terms from the day's chapter (a total of 77 terms across eight chapters, 40 with Think Fast and 37 without Think Fast). Students knew in advance which terms of the total set would be in the Think Fast program. Prior to the Think Fast laboratory they studied the remaining
non-Think Fast terms of the day's chapter using their regular study techniques (e.g., making and using flashcards, writing the definitions on paper, or memorizing the definitions directly from the textbook). Of course, they also could and typically did study the Think Fast terms using their regular study techniques, before the Think Fast laboratory.

During the first 5 minutes of each Think Fast session, students used a browse mode to review the day's deck of terms. In the browse mode, Think Fast presented the term and the complete definition on the same screen, and the student merely paged from screen to screen.

During the next 25 minutes, students studied the day's terms using a type mode. In the type mode, Think Fast randomly selected and presented a term and part of the definition. The student typed the missing words. Think Fast beeped each time the student typed a wrong key. The student had to type the correct key before proceeding with the answer. If the student typed more than three wrong keys, Think Fast counted the answer as wrong and beeped accordingly when the answer was complete. It gave a different beep if the answer was correct. Then it
went on to the next randomly selected term and partial definition, sampling without replacement. Fluency criteria were set for each chapter according to the number of cards and the number of words per card (e.g., four times with Chapter 4, one correct/minute at least in one deck, and 85% accuracy). The number of decks students had to practice varied from 4 up to 10 and the number of correct/minute from 1 up to 8 correct/minute according to the length of the chapter.

This version of Think Fast allowed answers up to 70 characters in length. But most of the definitions were longer than 70 characters; so the definitions were divided into major phrases, and multiple cards were prepared with the same definition. Then a different major phrase was omitted from each card. The number of missing phrases (and, therefore, the number of cards) for each definition varied from one to five.

Dependent Variable

The score on the quiz at the end of each training session was the measure of performance. Each quiz included items in this form: given the term, write the complete definition. The author graded all quizzes and computed a separate percentage score for definitions studied with and without Think Fast for each session and for all students. The definition had to be perfect though not word for word to be correct. Nine correlated-sample t tests were computed to analyze quiz performance. A questionnaire administered after the last session collected students' opinions as a measure of the social validity of the intervention.

To obtain a reliability measure, a second instructor graded 20% of the quizzes. He did not know which definitions were in the Think Fast program. Interobserver agreement was calculated for each session, using the number of
agreements divided by the sum of agreements and disagreements and multiplied by 100. Overall agreement across the nine sessions was 94.44%.

Results and Discussion

Quiz performance with terms studied using Think Fast was significantly better than performance with terms studied without the program in six of nine t-test comparisons for the nine quizzes (see Table 1). In Session 7, this situation reversed, performance with terms not studied with Think Fast was significantly better than performance with terms studied with the program. Quiz scores with terms studied using the computer program was above the 92% course requirement for an A in seven out of nine comparisons. This contrasts with two of nine for terms studied without the program (see Figure 3).

The highest scoring 10% of the students (n = 7) got 100% on all the terms for all nine quizzes whether or not the terms were in the Think Fast decks. The lowest scoring 10% of the students had a mean of 69.11% overall for terms studied with Think Fast and 52.95% for terms studied without the program, a 16% difference in performance (t(6) = 2.84, p < .05).

Students' opinions favored Think Fast training. They said that practice with the program helped them with the quizzes (Figure 4), and that it helped them gain competence with the use of behavioral terminology (Figure 5).

Three students expressed problems with poor typing skills or preferred not to work with computers. And a few students said the fluency training was boring or said it added little to their current study strategies. The addition of computer-based fluency training with Think Fast increased quiz performance. The average group performance was equal to or above the 92% criterion for an A in seven of nine sessions using Think Fast. The atypical results in Session 7 could have come
Table 1
Mean Percentage of Correct Answers With and Without Think Fast, t-Test Values, and Sample Size Across Sessions

<table>
<thead>
<tr>
<th>Session</th>
<th>MTF</th>
<th>MnTF</th>
<th>t value</th>
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<tr>
<td>1</td>
<td>96.40</td>
<td>89.09</td>
<td>2.78*</td>
<td>67</td>
</tr>
<tr>
<td>2</td>
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</tr>
<tr>
<td>3</td>
<td>80.80</td>
<td>66.62</td>
<td>4.93*</td>
<td>69</td>
</tr>
<tr>
<td>4</td>
<td>93.56</td>
<td>85.61</td>
<td>2.68*</td>
<td>66</td>
</tr>
<tr>
<td>5</td>
<td>99.04</td>
<td>93.48</td>
<td>2.01*</td>
<td>69</td>
</tr>
<tr>
<td>6</td>
<td>97.06</td>
<td>83.48</td>
<td>4.71*</td>
<td>68</td>
</tr>
<tr>
<td>7</td>
<td>78.36</td>
<td>83.36</td>
<td>-2.31*</td>
<td>61</td>
</tr>
<tr>
<td>8</td>
<td>93.79</td>
<td>93.41</td>
<td>0.24</td>
<td>66</td>
</tr>
<tr>
<td>9</td>
<td>93.93</td>
<td>88.39</td>
<td>2.48*</td>
<td>56</td>
</tr>
</tbody>
</table>

Note. MTF = with Think Fast. MnTF = without Think Fast.

*Significant at the .05 level.

from two factors: In this session for the first time, students worked with eight instead of four terms using the Think Fast. So students spent less practice time with each term. Also, one "control" card was erroneously programmed as an experimental card, provoking confusion, anger, and complaints that may have adversely affected the training session. Lack of differences in Session 8 was more a result of a performance increase with non-Think Fast related terms than a performance decrease with the Think Fast terms. The data of top and bottom performers suggest that adding Think Fast helps bottom performers. Scores from this subgroup increased 16% with the program. However, there was still room for
Figure 3. Mean Percentage of Correct Answers With and Without Think Fast.

Figure 4. Social Validity of Impact of Think Fast Helped on the Quizzes.
Figure 5. Social Validity of Impact of Think Fast on Fluency.

improvement for this subgroup because the average score was only 69% even with Think Fast.

A typical fluency-training session lasted 50 minutes: 30 minutes for training and 20 minutes for the quiz. Students sometimes arrived later than the start of the hour or had to go to the next class before the hour was over; so the actual practice time was generally less than the practice time available. Increasing the length or number of training sessions might improve the performance of students who failed to reach the 92% criterion.
CHAPTER III

EXPERIMENT 2: CONTROLLING FOR RECENCY AND AMOUNT OF STUDY

Two confounding variables might have accounted for the results of Think Fast (Parsons, 1989) fluency training in the previous experiment: (1) recency of training--students did their study of non-Think Fast terms before the Think Fast session but much of their study with the Think Fast terms occurred just before the quizzes, and (2) amount of training--Think Fast training was added to the prior studying the students had already done on their own with those same Think Fast terms (in other words, students typically studied the Think Fast terms, as well as the non-Think Fast terms, before the Think Fast session, so many of them may well have spent more combined time studying the Think Fast terms). The present study dealt with these confoundings.

Subjects and Setting

The instructor announced the present study as an optional activity lasting one hour to the students who had participated in the previous experiment. Participants could add up to 10 bonus points to the quiz component of this second randomly assigned to one of two experimental conditions. Thirty students out of 45 completed the training sequence satisfactorily. Fifteen students did not follow all the instructions so their data were eliminated. The experimental room and computers were the same as in the first study. These students had an average of twenty 40-minute sessions of previous work with Think Fast.
Materials

Two sets of terms were selected from an advanced chapter of the course textbook. Terms were matched and then randomly assigned to one of the two sets. Selection criteria were: length, difficulty, and content similarity. The number of definitions were the same \((n = 5)\); the number of cards were equal \((n = 16)\); and the mean number of words in each answer was almost the same \((M_1 = 18; M_2 = 19)\). In addition, three independent judges evaluated the matching strategy. All agreed in keeping the two decks of five definitions without any modification.

Procedure

Casual observation suggested that when studying on their own, students usually wrote the definitions on index cards, notebooks, or sheets of paper and then reviewed them. This was the informal control condition against which Think Fast had been compared in the previous experiment. The present experiment involved a more specific and uniform control condition—an analog to the typical paper-based home study. Think Fast also provided this analog—the "electronic flashcard" with the say mode. Students could say the answers aloud or silently to themselves, press the space-bar to see the correct answer, and then score their answer as correct or incorrect by pressing either the "c" or the "i" key. The Think Fast type mode was the same as in the previous experiment. Thus, this experimental condition (the type mode) differed from the control condition (the say mode) in two major ways: The student had to type rather than say the phrase missing from the definition; and the computer, rather than the student, decided whether to count the answer as right or wrong.

Fifteen students studied a set of five terms with the say mode; then they
studied a set of five terms with the type mode. A second group of 15 students studied with the type mode and then with the say mode. Immediately after the study-period, all participants were asked to write the 10 definitions on a quiz. The order of presentation (first-second) and the mode of training (type-say) were the variables under study.

**Dependent Variable**

The dependent variable was the percentage of correct definitions on a written quiz given immediately after the training session. If all elements of the definitions and the relationship among them were included in the answer, the answer was scored right. A second instructor, unaware of the experimental conditions graded 30% of the quizzes. The inter-observer agreement was 90%.

**Results and Discussion**

Training involving typing the definitions produced significantly better performance on the test of handwritten definitions than did training involving saying the definitions ($M = 3.03$ vs. $M = 1.86$), $t_{(29)} = 3.34$, $p < .05$. (See Figure 6.)

This suggests that in Experiment 1, the superiority of performance on the Think Fast terms resulted from studying them with Think Fast and not from one of the confounding variables. In other words, the results were not due to the students having spent more time studying the Think Fast terms or having studied them more recently. A more detailed analysis adds strength to that interpretation. The amount of time allowed for training was the same for the two methods, and yet typing with Think Fast was still superior. This suggests that the superiority of Think Fast in Experiment 1 might not be due to the amount of time used to study.
Furthermore, the number of times through the deck of terms when typing the answers was less than half obtained when merely saying the answers ($M = 1.7$ vs. $M = 4$).

This suggests that in both studies, the superiority of typing the answers with Think Fast was due to the training method and not the number of times practicing the definitions. There were no differences in terms of the presentation order ($M = 2.8$ vs. $M = 2.1$), $t(29) = 1.8$, $p < .05$, so neither a primacy nor a recency effect was supported. This suggests that neither primacy nor recency was responsible for the obtained results in the first experiment.

In this second experiment, the superiority of the type mode could be due to either of two factors: (1) The automatic feedback feature of the type mode was not present in the say mode, so this could account for the difference, or (2) there might have been more transfer from the type mode used in training to write mode used in testing.

![Figure 6. Group Performance Average According to Training Mode and Presentation Order.](image-url)
CHAPTER IV

GENERAL DISCUSSION

Computer-based fluency training with Think Fast (Parsons, 1989) helps students improve their performance on questions over terminology. This favors the trend observed in meta-analyses of computer-based fluency training which recommend the use of computers for instruction (Kulik & Kulik, 1987). Both experiments supported the superiority of a fluency-training strategy using the Think Fast program that involves typing the definition, given the term.

Student opinion is that Think Fast helps them on quizzes. Students also rated the program as somewhat helpful in achieving general fluency with behavioral terminology. Student complaints about their poor performance with the program due to their lack of typing skills, might be solved by allowing them to use the say mode of the program along with collaboration of peers for testing purposes; however, few students have availed themselves of that option in follow-up applications.

Following the steps of behavioral systems analysis (Malott, 1974) brought improvements to the behavioral instructional system in each phase of this research. For example, the procedure of testing behavioral terminology was improved within the system from initially using matching questions (Experiment 1 in Appendix C), to filling in the keywords missing from the definition, up to the terminal objective of requesting students to write the complete definition of all the concepts included in each assignment. Training requirements were also improved from asking students to fill in missing keywords up to requiring them to type fluently the whole
definition for each term. The Think Fast program also improved; feedback from the experimenter and instructors helped the author of Think Fast to modify the program in ways that improve the training capabilities of this courseware.

Two additional issues deserve discussion: Was the instructional design appropriate for building fluency? Is a computer-based fluency-laboratory a cost effective way to build fluency?

One way to achieve fluency is to use a system of measurement that includes the dimension of time and frequency (Binder, 1988). Think Fast has built-in features that make possible this sort of fluency training. The program provides immediate feedback for each response and measures of accuracy and speed for each time through a deck. Cumulative information across decks and days in which practice is done are provided through tables and graphs. Logarithmic and arithmetic graphs are possible. Browsing, typing, and saying are modalities that can be used for instructional purposes. The program may well include the features needed for fluency training.

On the other hand, the instructional system applied in this case allowed students to work with only one deck for one session of 20 to 30 minutes and a different deck for each session. This feature of the instructional system hardly meets the definition of fluency building that specifies frequent practice sessions of short duration on the same deck. Some decks of the program fit this requirement but others do not. The size of a given deck typically depends on the number of terms for each chapter and the number of words for each question. With six cards in a deck and typing just the missing keywords as the performance requirement, 51 students improved their mean percentage of correct responses from 65% up to 85% in 10 trials. Also their average of number of correct a minute increased from 1.5 a minute up to 3.5 a minute in a single session of 20 minutes (Malott, Yaber,
& Price, 1992). Since the number of cards and the number of words for each card varied from chapter to chapter but the practice time was fixed, differential performance with the decks may be expected from chapter to chapter. One way to overcome this problem would be to provide students more opportunities for practice using the university computer network system. In this way, students would have practice time outside the fluency-laboratory hours. Alternatively, they could be given the computer disk to use when and where they wished, though past experience suggests special contingencies would be needed to ensure adequate usage.

Is a computer-based fluency-laboratory a cost-effective way to build fluency? The instructional subsystem required students to attend the fluency-laboratory twice a week for one-hour sessions in which they practiced 20 to 30 minutes and then took the quiz for the corresponding chapter. If alternative strategies were found, some instructional time might be saved. Malott, Yaber, and Bocian (1992) compared the performance of 37 students with concepts previously studied only with preprinted flashcards, versus concepts studied with flashcards and Think Fast. Nine chapters were studied with each of the experimental conditions in an alternate fashion. Mean average performance with concepts studied with flashcards and Think Fast was slightly but statistically superior to performance with preprinted flashcards alone ($M = 97.7$ vs. $M = 95.52$; $t_{(36)} = 2.29; p < .05$). The major contribution to this difference came from the lowest 15% of the scores. Students with less than 92% in the flashcard condition ($n = 5$) improved their scores between 8% and 17% in the computer training plus flashcard condition. These results suggest that flashcards are a cost-effective alternative to help most students achieve fluency with behavioral terminology, but that bottom performers benefit from the added Think Fast training. However, further research comparing Think Fast alone and flashcards alone will help clarify this issue. Terms and definitions

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are just two of the components of the model of behavior-analysis literacy. Think Fast could also be used to help students achieve fluency with examples of behavioral terminology, the third element of the model.

Overall computer-based training using Think Fast is a useful adjunct to help students achieve fluency with behavior-analysis terminology.
APPENDICES
Appendix A

Human Subjects Institutional Review Board Approval
Date: August 18, 1991
To: Guillermo Yaber
From: Mary Anne Bunda, Chair
Re: HSIRB Project Number: 91-08-09

This letter will serve as confirmation that your research protocol, "Effects of Computer-based Training Program on Academic Achievement of Behavior Analysis Students" has been approved under the exempt category of review by the HSIRB. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the approval application.

You must seek reapproval for any changes in this design. You must also seek reapproval if the project extends beyond the termination date.

The Board wishes you success in the pursuit of your research goals.

xc: R. Malott, Psychology

Approval Termination: August 18, 1992
Appendix B

Informed Consent
As part of Dr. Malott's ongoing efforts to improve Psychology 360, he has introduced an academic activity—computer-based instruction (the Think Fast program). The purpose of this instruction is to help students improve their fluency in the use of behavior analysis concepts. As a regular part of these efforts at instructional improvement, I will evaluate these innovations as part of my doctoral dissertation. I will evaluate scores on quizzes that are normally administered throughout this course. I will compare the quiz scores between concepts studied previously with and without Think Fast.

In addition, I will evaluate the weekly performance of the students in terms of accuracy and speed of use of the concepts within the computer-based instruction. All that I have described thus far is Dr. Malott's standard course procedure. However, I would now like to ask your permission to use your individual data in any public presentation of these results, either talk or articles. I will present only group means, with groups of at least 10 students each. Furthermore, you will not be personally identified as having participated in this evaluation. Thus, you will receive neither benefit nor harm from having your data included in such a public presentation. On the other hand, the field of behavior analysis and instructional methods, as well as future students, may receive some small benefit from knowing the results of this ongoing effort to help students improve their academic performance.

If you have any questions about this, please feel free to call me at 375-7359. You can withdraw your permission for the future use of your own data in the public presentation of these group means at anytime.

If you would like to allow your data to be included in public presentations of this evaluation, please sign this form in the space provided and keep the copy of the form that is attached. Then fold and place this sheet in the class envelope, whether you sign it or not. I will not open the envelope until after Dr. Malott has taken your grades to the registrar. That way there can be no question of the influence of your decision on your course grade.

Thank you for your consideration.

Guillermo Yaber
Graduate Psychology Student
YOUR SIGNATURE BELOW INDICATES THAT YOU UNDERSTAND THE ABOVE INFORMATION AND HAVE DECIDED TO VOLUNTARILY PARTICIPATE

(Please print your name)

_________________________  _______________________
Your signature                    Date
Experiment 1

Testing Formats, Subjects, and Setting

Twenty-nine junior and senior students enrolled in a behavior-analysis course volunteered to participate in this study for optional points toward their course grade. Using a consent form, students could give or deny permission for the use of their data in public presentations or publications. The course included three types of activities: (1) classroom discussions and homework related to the textbook used (Malott, Whaley, & Malott, 1993), (2) a Skinner-box laboratory, and (3) an optional fluency laboratory where students received computer-based fluency training with the terminology of behavior-analysis. Students could exchange their participation in the fluency laboratory for optional activity points, valid toward their course grade. Each fluency laboratory involved working with half the terms of the textbook's chapter. After the fluency-laboratory and during the seminar scheduled later, students took post-training quizzes. These quizzes included terms previously trained with or without Think Fast (Parsons, 1989). The point system in the course consisted of: (a) 15 points for each homework discussion session, (b) 20 points for conceptual homework exercises for each chapter, (c) 50 points for each of five laboratory reports, (d) 20 points for each quiz, and (e) 100 points for the final term-paper. Students needed 92% of the points in each of the above categories to receive an "A" for this course.

Apparatus, Programs, and Materials

The training facility contained 25 MS-DOS XT computers. Each computer had at least 640K of random memory, one 3.5-inch disk drive, a keyboard, and a color monitor. One 3.5-inch floppy disk for each participant included the Think
Fast program and the files with the behavioral terms and definitions from the textbook. Each file in the program is called a deck. A deck is a collection of cards. Each card consisted of a term and a definition. The program presented the term or the definition and the student said or typed what should be on the other side of the card. Think Fast allowed the student three response modes: type, say, or browse. In the type mode, a student read one side of the card on the computer screen and typed the definition or part of the definition. Think Fast evaluated and scored each answer as right or wrong. In the say mode the student said the answers aloud or silently, pressed the space-bar to see the correct answer and then scored the answer as correct or incorrect by typing either "c" or "i." Also, using the browse mode, the students could review all the terms and definitions before working with these other modes.

Dependent Variable

The performance measure was the percentage-correct score for terms studied with and without the Think Fast program for each chapter. The three types of criterion performance items were: (a) matching definitions and terms (evaluated for six chapters); (b) fill-in the missing words, given the term and part of the definition (evaluated for 18 chapters); and (c) write the term, given the definition. This last quiz was administered at the end of the semester covering 20 terms, 10 previously studied with Think Fast and 10 studied without the program.

Independent Variable

Computer-based fluency training was: (a) given the definition, type the term, and (b) given the term and part of the definition, type the missing words. Students needed to meet the following response requirements to earn the optional
points: Practice one deck of cards three times with five correct/minute and 100% accuracy in two modes, type the term and type the keywords.

Design and Procedure

A within-subject design was used. Students went to the fluency-laboratory twice a week, and worked with both training modes until they met the fluency requirements or until the 50-minute session ended. The students did not know which half the terms would be on Think Fast; so they studied all the terms before coming to the fluency-laboratory. Then they went to the seminar and took the quizzes, which included terms previously studied with and without the program. At the end of the semester they took a quiz covering 20 randomly selected terms from the book, 10 of which were studied previously with the program and 10 without. This quiz was not announced and did not count toward their final grade. A questionnaire administered after the last session collected students' opinions as a measure of social validity of the intervention.

Results

Thirteen students out of 29 completed the study. This attrition occurred during the first 2 weeks of the study. Performance with terms studied with Think Fast was superior to terms not studied with the program on two out of the three types of quizzes. Performance on the matching quiz was similar for both groups ($M = 93.06$ and $M = 89.38$). Results favored Think Fast training for quizzes where the students filled in the blanks (missing words from the definition), ($M = 73.15$ and $M = 62.74$), $t(12) = 2.29$, $p < .05$ and where they wrote the term, given the definition ($M = 63.38$ and $M = 51.54$), $t(12) = 1.94$, $p < .05$, (one-tailed test). (See Figure 7.)
Students rated Think Fast favorably. They reported it helped them become more fluent with the behavioral terminology. They also said the training helped them improve their quiz scores. They considered this type of training a useful option. The main concern of the students was the typographical errors on some cards. Despite Think Fast, the average quiz scores were still below the 92% required to obtain an "A" in the course.

Experiment 2

Size of the Response Requirements During Training

In recycling the instructional system, the next step was to answer the following question: Will a higher response requirement during training improve quiz performance?

Subjects and Setting

Between 13 and 21 freshmen and sophomore students volunteered for this study. They were enrolled in a general psychology course during the summer.
semester of 1991. They could earn optional points and exchange those for a regular homework. They could use Think Fast outside and/or inside the computer laboratory. Apparatus, materials, and training facilities were the same as in the first study.

**Design and Procedure**

Students worked with the terms using Think Fast in a reserved computer laboratory just before the regular class or at their convenience. But they had to turn in the Think Fast disk before class to obtain the optional points. Training involved practicing each deck 10 times with both the type-the-term and the type-keywords modes. The response requirement increased from five correct/minute to eight correct/minute in both modes. The students studied seven sessions (chapters) under this condition. Criterion test items were: (a) fill-in the blanks as used in the previous experiment and (b) given the term, write the whole definition (the form used in the review quiz of the previous experiment).

**Results**

Performance with Think Fast was significantly superior to performance without it for six out of seven comparisons. Overall quiz performance following Think Fast was superior (M = 81.91 and M = 64.42) to the section of the previous experiment where the quiz format was the same (M = 73.15 and M = 62.74).

This improvement in performance probably resulted from the increased mastery criterion in the present experiment (see Figure 8).

There were no performance differences on the review chapter. This lack of difference on the review quiz may have resulted from two causes: The first was a change in the quiz format (from fill-in the missing words to write the complete
Figure 8: Mean Percentage of Correct Answers According to Session With and Without Think Fast (Fill-in Keyword Quiz).

definition). The second was the students' failure to meet the fluency criteria for that quiz (only half the students met the criteria for the review quiz). Response requirement increments produced increased superiority for Think Fast training.

Experiment 3

Fill-in the Missing Words During Training

To recycle the Think Fast component of the instructional system, the following questions were addressed: (a) Could Think Fast training be better for the quiz-type "given a term, write the complete definition," and (b) is the fill-in the missing word mode the only mode needed for training?

Subjects and Setting

Nineteen to 21 students from the same introductory psychology course as the previous experiment participated in the same settings.
Design and Procedure

Training consisted in working with the fill-in the missing word option for each chapter. The student went through each deck 20 times with the same response criteria as before (eight correct responses/minute in three decks and 100% accuracy). This experiment lasted for the next four chapters and had a review test over those chapters.

Results

Performance was similar between the Think Fast and traditional study conditions across the four chapters (M = 87.55 and M = 85.04). Training by filling in the missing words alone was not better than the students' own strategies for the quiz type "given the term, write the complete definition." Perhaps the change in the quiz format from fill-in the missing words to write the complete definition given the term was responsible for this lack of differences. This result was obtained in the review quiz of the previous experiment, where the change of quiz format occurred for the first time. Only in Chapter 11, students in both groups of concepts performed 100%; thus, there was still room for improvement.

Experiment 4

Type Small Phrases and Terms During Training and Write the Term During Quizzes

In this study, the research returned to two training modes. The type-answer mode was reinstalled and the number of missing blanks for each card increased. These changes were made to find if students' performance could be improved beyond that of the previous experiments.
Subjects and Setting

Eight to 10 subjects participated in this experiment for four sessions. The setting was the same as before.

Design and Procedure

Training consisted in working with the type-the-term and fill-in the missing word option with four chapters. Response requirements were:

1. Practice with each deck at least 5 times using the type-the-term option. The response requirements were three out of five decks with at least eight correct/minute and 100% accuracy.

2. Practice at least 20 times with the fill-in the blanks option with four correct/minute and at least three consecutive and 100% accuracy. The student was required to type small phrases instead of a few keywords for the fill-in-the-blank mode. Whole answers instead of partial answers was a requisite during training. (In the partial answers option, students just typed part of the answer and the program completed the small phrase. Whole answers required students to type the small phrase completely in order for the answer to be counted correct.)

Results

Performance during the first session favored Think Fast (MTF = 85.19 and MnTF = 66.67), t(7) = 3.42, p < .05. However, in the remaining sessions there were no significant differences between training conditions. The overall quiz performance for four chapters was M = 89.47 with Think Fast training and M = 83.19 for traditional training.
General Discussion

General results from the four experiments suggest that computer-training with Think Fast was better than regular study methods for two out of three types of post-training quizzes. Think Fast was superior to other study methods with the fill-in the missing words type of quiz (Experiments 1 and 2). Also, Think Fast was superior to the students' own study strategies when the performance requirement was to write the correct term, given the definition (Experiment 1). However, training with this program wasn't better than regular study strategies on quizzes where the student wrote the whole definition, given the term (Experiments 3 and 4). One possible explanation for these results is that the types of training used (typing the missing keywords or typing small phrases) were not better than their regular study methods to help students master the behavioral terminology. A third type of training may be tested, where the student is required to type all parts of the definition, rather than just the keywords, or small phrases.

When the difficulty level of the quizzes was higher, Think Fast fluency training was more effective than students using their own study techniques (Experiment 1). Performance differences between computer-training and control conditions are larger when the test required students to construct the answer (fill-in, or write the term) in comparison with a choice test (matching). This finding favors the use of Think Fast, for fluency training, since constructed responses are the most frequent forms used for academic evaluations in our instructional system.

Future research will focus on issues of component analysis and cost/benefit comparisons. One study will test which component (typing the answers or the built-in feedback element of the program) makes this instructional strategy effective. Another study will evaluate the cost/effectiveness of devoting a computer
laboratory to such training compared to training with preprinted flashcards. Previous research has shown that flashcard-based fluency training may be as useful as computer-based fluency training (McDade, Austin, & Olander, 1985), so a comparison of this sort may bring new possibilities for the present instructional system.

The behavioral-system analysis approach to instruction (Malott, 1974) was useful to optimize a computer-based fluency training component of a behavior-analysis course. The model served as a guide for the evaluation and improvement of the instructional system through this study. It may be used for the evaluation and improvement of other instructional systems.

This research focused on the relationship of the term and the definition elements of the behavioral terminology. However, it is necessary to develop computer instructional materials to train other relationships (e.g., terms and examples). This training may further help learners to achieve literacy with behavior-analysis terminology.
BIBLIOGRAPHY


