Using Postfeedback Delays to Reduce Racing in Online Learning

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USING POSTFEEDBACK DELAYS TO REDUCE RACING IN ONLINE LEARNING

by

Anna L. Conard

A dissertation submitted to the Graduate College
in partial fulfillment of the requirements
for the degree of Doctor of Philosophy
Psychology
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Computer-based instruction (CBI) has become an increasingly popular tool in both business and education throughout the last decade. Despite the various benefits of using CBI, there are several challenges that accompany this mode of instruction, such as computer-based racing. Computer-based racing occurs when learners respond so quickly that frequent mistakes are made. The purpose of the current study was to investigate the impact of postfeedback delays on racing through online lessons conducted in uncontrolled settings. Six different computer-based instructional formats were assessed in terms of learner performance and satisfaction using a between-group pretest-posttest design. Statistically significant differences were observed in regards to the presence of feedback, but not the delay variable in general. Marginally significant results were obtained for postfeedback delays specifically. The results of the current study may extend the literature on postfeedback delays by suggesting that an overt form of self-evaluation during a delay may not be necessary for postfeedback delays, and that postfeedback delays may potentially be effective, even in uncontrolled environments.
I’d like to begin by thanking my graduate advisor, Dr. Douglas A. Johnson, for his continuous support and encouragement throughout this project. This study could have not happened without his intellectual contributions and sustained assistance. I’d also like to thank my research assistants: Megan Ireland, Taylor Longacre, and Thomas Ferragut for their hard work and dedication to this research project. Additionally, I would like to thank my graduate thesis committee: Dr. Alyce Dickinson, Dr. Douglas Johnson, Dr. Heather McGee, and Dr. Kevin Munson, for their valuable expertise and knowledge. Lastly, I would like to thank the Continuous Learning Group for their generous financial assistance.

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INTRODUCTION

Computer-based instruction has become an increasingly common tool for instruction in both education and industry (Marroletti & Johnson, 2014). Throughout the past ten years, there has been a significant shift from traditional in-class interactions to computer-based and computer-assisted instruction (i.e., both standalone and supplemental models) in higher education (Allen & Seaman, 2013). Likely due to its high flexibility in location, time and resources, there has been an increasing enrollment in online courses over the past decade (Allen & Seaman, 2013). According to Allen and Seaman, the proportion of students taking at least one online course is at an all-time high of 32 percent. Further, it was reported that the number of students taking at least one online course increased by over 570,000 to a new total of 6.7 million in the fall 2011 semester (Allen & Seaman, 2013).

It was the seminal work on self-instruction done by Edward Lee Thorndike, and later Fredrick Burk and Mary Ward, in the 1920’s that set the theoretical foundations for modern-day computer-based instruction (CBI) (Khosrow-Pour, 2006). Beginning his work in education in the early 1910’s, Edward Lee Thorndike was an early advocate of behavioral approaches to learning and helped to found the field of educational psychology. Thorndike's theoretical perspective was based on an association theory, similar to many others during that time. Furthermore, Thorndike’s law of effect introduced the relation between reinforcers and punishers on behavior. Specifically, the law of effect held that when a response to a stimulus led to pleasure, the stimulus-response connection was strengthened, and when a response led to painful punishment, the connection was weakened. His application of behavioral theory prompted his
suggestion that traditional classroom teaching methods be based on the law of effect (Thorndike, 1932). Around this same time, Frederick Burk established possibly the first individualized system of instruction, labeled Individualized Instruction, while President at San Francisco State Normal School. Burk became interested in the individualized system of instruction when one of Mary Ward’s students began to develop a similar system at this same university. Starting in 1912, Burk, Ward, and a few of their colleagues began developing self-instructional materials for most of the curriculum at San Francisco State Normal School (Rao, 2008). As the name suggests, each student was able to proceed through the material at his or her own pace. Specifically, these innovators were the first to introduce instruction that could be completed at an individualized pace and required minimal direction from the teacher. This development, in addition to Thorndike’s law of effect, set the groundwork for future work in the area of teaching and education.

Heavily influenced by the work of Thorndike, Burk, and Ward, Sydney Pressey invented the testing machine, using the foundations set by these pioneers to teach rudimentary skills. Pressey’s testing machine was developed for the automatic testing of information by requiring the student to respond to a set of multiple-choice questions. While using the device, the student reads the question and presses the button that corresponds with his or her first choice answer. If the student selects the correct answer, the device proceeds to the next question; however, if the student does not select the correct answer, the error is tallied and he or she must continue to make choices until the correct response has been selected (Pressey, 1926). Unfortunately, the development of Pressey’s testing machines failed to transform education like he had predicted and testing
machines were not adopted in education. In addition to Pressey’s invention of the testing machine in 1924, B. F. Skinner introduced a similar technology he called a teaching machine in the 1950’s (Hartley, 1974). Although Skinner’s teaching machines were also not successful as a whole, the program within the machine proved to be a valuable product itself.

It’s important to note that it is not the teaching machine that imparts knowledge to the student, but the program within the machine that teaches the student. As such, the development of the teaching machine gave birth to the use of Programmed Instruction (PI). “The Science of Learning and the Art of Teaching” by B. F. Skinner (1954) was probably the first introduction of PI in the field of learning. In that paper, which was presented at a conference of *Current Trends in Psychology and the Behavioral Sciences*, Skinner reacted to the inadequacies he observed in the classroom (e.g., infrequency of reinforcement, aversive control of behavior, and no provision for successive approximations). Skinner’s presentation and article prompted various subsequent articles on the educational system and ways to improve current practices.

Skinner not only produced influential and important examination in the area of education, but he also mentored and collaborated with many scholars who continued to make further advances in the field. While Skinner likely introduced the concept of PI to the field, it was the practitioners and instructional designers who developed the ways in which such technologies were applied. One such practitioner was Dr. Susan Markle, a graduate student who worked under B. F. Skinner at Harvard. One of Dr. Markle’s chief contributions for improving educational practices was in training others to program effective instruction, including the development of instructional frames. In her book,
Good Frames and Bad, Markle (1964) outlines the ways in which we develop units of instruction (i.e., written clearly, logical ordering of frames, and eliminate irrelevant material). The material presented in this book and other works by Dr. Markle have influenced the way in which instructional programs have been developed.

Originating from Fred Keller’s work in Brazil, the Personalized System of Instruction (PSI) made its place in educational practices during the 1960’s (Keller, 1968). Adopted by many psychologists and those outside of the field, PSI encompasses five basic components: (1) mastery of course material, (2) the use of proctors, (3) self-pacing, (4) stress upon the written word, and (5) use of lectures and demonstrations primarily for motivational purposes (Eyre, 2007). As mentioned, one key element of Keller’s PSI is that the course material is broken down into small units of study, such as a book chapter or course unit. In order for the student to progress to the next unit of material, he or she must demonstrate mastery by passing a test. If the student does not meet the criterion performance on the initial test, he or she must restudy the unit material and take the test again. This process continues until the student passes the test, after which he or she may move on to the subsequent material. This process is much like the process of self-pacing in computer-based instruction in that the learner must demonstrate mastery before continuing through a lesson. The common elements between PSI and computer-based instruction are not surprising when one considers that the original impetus for PSI came from Fred Keller’s favorable impressions of the teaching machine movement (Keller & Sherman, 1974). However, the element of self-pacing becomes difficult when dealing with an entire class of students in a traditional classroom setting.
As mentioned above, one frequently cited limitation of PSI has been the issue of how to efficiently manage all of the testing necessary for a successful PSI course within a traditional classroom setting. Nevertheless, technological advancements have dramatically increased the feasibility and flexibility of implementing such courses. One such example is the development of computer-aided personalized system of instruction (CAPSI) (Pear & Novak, 1996). This technology utilizes the methodology and philosophy of PSI, but allows for much more flexibility in permitting each student to progress through the instructional material and testing at his or her own pace. This flexibility is achieved through the use of computers to deliver the instruction. Again, this methodological practice of self-pacing is a key element of computer-based instruction.

Around the same time that Keller’s PSI started gaining recognition, Ogden Lindsley founded Precision Teaching, a method of instruction that bases “educational decisions on changes in continuous self-monitored performance frequencies displayed on ‘standard celeration charts’” (Lindsley, 1992, p. 51). One key element of this method is the focus on directly observable behavior. In other words, precision teachers translate learning tasks into behaviors that can be easily counted and recorded. In addition, those utilizing this method of instruction use frequency as a measure of student performance, which provides a more complete account, than accuracy alone, of the effectiveness of the instructional program. With Precision Teaching came the “Standard Celeration Chart,” a graph for charting behavior frequency across time (Lindsley, 1992). This chart allows for teachers and students to easily count behaviors and accomplishments in the classroom. Daily measurement of performance is a key component of Precision Teaching, and such measures allow for self-recording by students and the sharing of results among teachers.
and students. Given this, the standard celeration chart became a tool for communicating individual student performance among teachers of Precision Teaching. Student performance data is also frequently used to design individualized interventions for students. Ogden Linsdley’s celeration chart remains widely used today in Precision Teaching and has been extended to areas such as business management and macroeconomic applications. While there is not a direct connection between CBI and Precision Teaching, the original teaching machine movement also placed a strong emphasis on repetition until mastery, although not to the degree as demanded by fluency standards (Skinner, 1958).

Developed by Siegfried Engelmann in the 1960’s, Direct Instruction was designed to maximize efficiency of instruction, while also acknowledging the differing skill levels of students (Engelmann, Becker, Carnine, & Gersten, 1988). This method of instruction was originally developed as a response to the demand for better educational practices among at-risk students. One of Engelmann’s primary beliefs was that students must be able to establish mastery of a skill before moving on in their studies and learning other skills. Given this, Engelmann proposed that students be sorted in small groups based on current skill level. This strategy aligns with that of computer-based instruction in that the material and pace may be individualized to each learner. Furthermore, a primary feature of Direct Instruction is the scripting of instructional material to decrease variability in presentation, a feature that is inherently present in the pre-made lessons of CBI. One of the longest and most expensive educational research projects in history, Project Follow Through, investigated the efficacy of Direct Instruction (Watkins, 1997). The findings were marked in that Direct Instruction produced the most significant outcomes for basic
scholastic skills, cognitive skills, and affective outcomes. While a majority of public schools typically neglect the use of this empirically validated educational method, various charter and private schools have retained the Direct Instruction approach (Moran & Malott, 2004). The many behavioral approaches outlined above were trying the capture the envisioned benefits promised by computer-based instruction and overlap in techniques are commonly witnessed, perhaps due to shared philosophical assumptions and similar educational goals.

Again, early behaviorists such as B. F. Skinner were proponents of automated forms of instruction (Johnson, 2014). Although he pioneered mechanized instruction that may appear unsophisticated by today’s standards (e.g., the need to clumsily rotate knobs and turn levers), many of Skinner’s recommended best practices remain relevant for modern forms of computerized instruction. Through the use of advancing technology, Skinner (1958) advocated that a learner should be able to progress through the material at his or her own pace. Further, Skinner advised that question construction is an important piece of the learning process and a student must compose a response, rather than select one. One reason for this is that multiple-choice questions must include plausible incorrect answers to be effective, which Skinner argued was disruptive to the learning process in that they are not part of the delicate process of shaping behavior. Another reason is that the student should be able recall rather than recognize the correct response, as well as see that it is right. Skinner also stated that in order to maximize the effectiveness of instruction, the student must go through a designated sequence of steps. Skinner explained that each step must be small enough that the reader is capable of progressing through it, yet with each step the student moves closer to the desired behavior.
Additionally, according to Skinner, effective instruction will enforce active engagement by requiring the learner to demonstrate mastery of the material before progressing to the subsequent material. By requiring a demonstration of mastery before continuing through the material, the instruction becomes learner-paced. That is, the learner is required to respond correctly in order to continue through the lesson.

A typical classroom setting is instructor-paced in that the students will complete the coursework on a set schedule determined by the instructor. In even a small classroom, the instructor will move too quickly for some, while moving too slowly for others. Those who move too quickly through the material may be penalized for doing so, and those who move too slowly may simply be left behind (Skinner, 1958). Besides instructor pacing, Skinner argues that another serious criticism of traditional classroom teaching is the infrequency of reinforcement. In a typical classroom setting, many minutes, hours, and even days intervene between the student’s response and consequence from the instructor. Given this, Skinner proposed timely and contingent reinforcement as a way to minimize and possibly eliminate the aversiveness of traditional education. Immediate reinforcement is much more feasible with online instruction since feedback on the correct answer can immediately follow the student’s response (Skinner, 1958). Much like the teaching machines of the 1950’s, computer-based instruction has the potential to provide immediate and individualized feedback for responding, regardless of class size or the time at which an assignment is completed. Additionally, computers can tirelessly provide unbiased and accurate feedback that is unrelated to student characteristics or the nature of the student response (Mandernach, 2005). A study conducted by Mandernach found that students prefer feedback that is direct and clearly addresses the correctness of their
response. It is important to note that an automated device, such as CBI, does not necessarily need to replace the instructor’s interactions with his or her students. Rather, this instrumental assistance would merely improve these relations by allowing the instructor to provide supplemental reinforcement and feedback, rather than merely using instructional time to grade student responses as right or wrong. Thus, effective instruction may still require supplemental reinforcement from the teacher or trainer (Skinner, 1958).

Overall, there are many potential advantages to employing CBI. In a meta-analysis conducted by Kulik (1994), investigators collected data on both CBI and conventional classes. According to the authors, the most significant finding was related to instructional time; Kulik found that CBI produced a substantial reduction in the time associated with the delivery of instruction. Specifically, Kulik reported that the average reduction in time was 34 percent in college instruction, however, this is limited by the amount of time it takes to develop the material, as discussed later. Further, the authors reported that, on average, CBI raised examination scores by about 3 percentage points over conventional classes. A later review by Johnson and Rubin (2011) summarized 12 years of comparative research on CBI between 1995 and 2007. Specifically, the reviewers looked at research on interactive CBI relevant to employee training techniques. Interactive CBI means the learner’s response is demonstrative, requiring the student to show he or she understands a given point before proceeding to new material. The authors reported results consistent with Kulik in that interactive CBI was found to be comparable, or even superior to, instructional alternatives (e.g., classroom instruction, textbook/manuals, etc.) 95.2 percent of the time. Specifically, the authors found that 64.3 percent of instructional comparisons demonstrated improvements through the use of
interactive CBI, while 31 percent reported no difference or mixed results. Furthermore, the authors reported that interactive CBI is a recommended method for delivery of training materials, as it will likely produce greater learning outcomes over other approaches by enforcing such interactions. In addition, Johnson and Rubin suggested that even if the training approach is not dependent on CBI alone, supplementing instructional methods with interactive CBI may also improve learner performance. That is, given the potentially high costs associated with programming for such interactions, it may be worthwhile to program CBI as a supplement to other instructional methods.

There are a number of CBI applications common in both business and education, one such application being eLearning. eLearning is an online tool for delivering instruction using numerous types of media (text, audio, images, etc.). This type of CBI application may be used as standalone instruction, or may supplement other forms of instruction. As mentioned earlier, CBI and other eLearning solutions (which include standalone CBI, hybrid approaches, and computer-aided forms of instruction) continue to impact the manner in which students and employees receive instruction. Despite the tremendous potential for eLearning, there is also considerable reason for concern. According to Angelino, Williams, and Natvig (2007), attrition rates for courses taught online are 10-20 percent higher than classes taught in a traditional face-to-face setting. Consistent with these findings, a study conducted over a five-year time span found that students were more likely to fail or withdraw from online courses than from traditional courses (Xu & Jaggars, 2011). While it is difficult to identify the specific cause for higher attrition rates in CBI, Brown (1996) reported that a lack of support from instructors and troubles in contacting them played an important role in the students’ decision to dropout.
Similar to these findings, Willging and Johnson (2004) found that lack of social interaction, lack of interest, lack of technical support, assignment level, learning style conflict, and the learning environment were the most cited reasons for students dropping out of an online course.

The cost and time required to develop an online course presents another concern for online learning. For instance, Chapman (2010) administered surveys to 249 organizations, all of which have developed online learning content for almost 20 million learners. Those responsible for developing the material were asked how much it costs to develop just one hour of instructional materials across various modalities. Respondents reported an average cost of $5,934 for traditional instructor-led learning, $10,054 for basic eLearning (simple text graphics, test questions, etc.), $18,583 for interactive eLearning (use of multimedia, animations, etc.), and $50,371 for advanced eLearning (simulations, games, etc.). These same respondents were also asked how much time it takes to develop just one hour of instructional material across these same modalities. On average, respondents reported that it takes 43 hours for face-to-face instruction, 79 hours for basic eLearning, 184 hours for intermediate eLearning, and 490 hours for advanced eLearning. Given these findings, one argued drawback of CBI is that it will likely require a greater up-front investment for the development of educational materials.

Another potential problem with eLearning is a sense of learner isolation. Though eLearning offers ease, flexibility, and the ability to access a classroom in the learner’s own time, students may also feel a sense of social seclusion. The "distance" aspect of distance learning removes much of the social interactions that would be present in traditional learning environments. Woods (2002) reported that student satisfaction with
the overall learning experience depends, quite substantially, on faculty interaction and involvement in the course.

These reported disadvantages call for a refined understanding of the disconnect between the potential of CBI and the shortcomings in its actual implementation. One potential challenge in addressing these issues is the large variation in the implementation of online instruction currently being used. A possible explanation for this large variation is the lack of training received by those developing the instructional material. Based on 2011 survey results, approximately 20 percent of higher education institutions offer no training to instructors on teaching courses online (Allen & Seaman, 2011). Between the lack of training and considerable up-front development time that goes into crafting CBI, many online modules and eLearning classes may be more comparable to the first draft of a textbook than they are to the third or fourth edition of a popular text (Bodner, 1997).

Unfortunately, the current use of CBI is often a replication of traditional teaching techniques and the required responding is largely passive in nature (Johnson, 2014; Markle, 1990). According to Johnson and Rubin (2011), while many current computer-based programs claim to be interactive, this level of interaction may be no more advanced than simply progressing through a textbook. An interactive CBI program should allow the student to not only progress at his or her own pace, but also allow the student to demonstrate his or her knowledge and understanding of the material. Thus, these interactions should be demonstrative in that the learner must demonstrate his or her understanding before progressing in the material. The nature of these interactions may be the key consideration in developing successful CBI.
Given the increasing trend in usage and potential drawbacks when done poorly, CBI is a research topic that warrants further investigation to discover best practices. One consideration regarding computer-based interactions is how the learner paces his or her responding. While self-pacing is a frequently cited advantage of CBI, it may also have detrimental effects on learning. Specifically, there is a challenge resulting from within unit self-pacing in CBI. There are two types of self-pacing in CBI: within unit pacing and overall course pacing (Johnson & Dickinson, 2012). Overall course pacing refers to the deadlines in which learners are expected to complete the assigned material. Within unit self-pacing refers to the time spent studying within a specific instructional unit. From a behavioral perspective, previous research suggests that self-pacing should not be used for overall course pacing, as learners are typically poor managers of their own time and more likely to procrastinate (Johnson & Dickinson, 2012). Conversely, self-pacing within instructional units remains a primary benefit of CBI.

When CBI is poorly designed, there is a high likelihood that the learner will try to avoid or escape the instructional environment. As such, it is important to try to make CBI more palatable to learners to promote approaching and orienting behaviors (Marroletti & Johnson, 2014). However, a problem remains even if the aversive elements of instruction have been minimized: CBI is typically still competing against an array of activities with more reinforcing value. When learners are allowed to self-pace in a CBI environment (one of the promoted benefits of CBI), these learners are also likely to respond quickly in order to move on to a more reinforcing set of conditions (i.e., a non-instructional environment). Unfortunately, the learner’s responding may become too rapid for learning to take place, a phenomenon termed computer-based racing (Johnson & Dickinson,
When such racing occurs, students are not attending to the instructional material and move through the lesson at a detrimentally fast pace. As previously mentioned, one of the most significant contributions of CBI is the ability to engage the learner in meaningful responding. By hurrying through the unit without attending to the instructional material, learners are no longer able to engage in such responses.

At this point, only two methods for reducing computer-based racing have been investigated. The first method involves the use of monetary incentives/disincentives for accurate and inaccurate responding, though this research has produced mixed results. Johnson and Dickinson (2012) found that incentives and disincentives did not have a significant impact on performance and also reduced satisfaction. Conversely, Munson and Crosbie (1998) reported a 10% increase in performance after implementing incentives/disincentives, with no changes in satisfaction following the introduction of the incentive system. It should be noted that enforced mastery criteria - previously discussed as an advantage of CBI - is another possible method for countering the issue of racing in online instruction. However, there is currently a lack of research directly comparing the potential solution of such enforced mastery criteria to other methods.

The second investigated method for reducing computer-based racing is the use of postfeedback delays (Crosbie & Kelly, 1994; Dubuque, 2012; Johnson & Dickinson, 2012). When using CBI with postfeedback delays, the learner is presented with some form of feedback following a correct or incorrect response. After presenting this feedback, the computer will enforce a delay for a predetermined amount of time before the learner can continue through the material. Only after the time period has elapsed may
the learner resume the lesson. Postfeedback delays appear to be effective in that they foster additional exposure time to the material.

Bilodeau and Bilodeau (1958) were among the first to examine postfeedback delays on performance. Specifically, they were interested in finding the most effective length of postfeedback delay. The authors found that using exceptionally long postfeedback delays (24 hours or seven days) actually had adverse effects on performance, as the long delays produced detrimental learner frustration. On the other hand, it is possible for postfeedback delays to become so short that they lose their effectiveness by not allowing for remediation or rehearsal (Johnson & Dickinson, 2012). Bourne, Guy, Dodd, and Justesen (1965) found that moderate postfeedback delays (10-15 seconds) produced better performance compared to both longer and shorter delays.

Crosbie and Kelly (1994) investigated the effects of postfeedback delays for both correct and incorrect responding with the use of programmed instruction. Specifically, they investigated the possibility of postfeedback delays functioning as punishers for incorrect responding. The authors compared performance under three conditions: 10-second delay following all answers (correct and incorrect), 10-second delay following incorrect answers only, and no delay. The authors found no substantial difference in responding between the no delay condition and the 10-second delay following only incorrect answers. They did, however, report that the 10-second delay following all answers improved performance over the no delay condition. These findings suggest that punishment was not the mechanism of action for the effectiveness of postfeedback delays (Crosbie & Kelly, 1994). In a second experiment, Crosbie and Kelly compared a blank-screen delay, in which no material was presented throughout the delay, to a postfeedback
delay and no delay condition. The authors found no significant difference between the no
delay condition and the 10-second blank-screen delay condition. They did, however, find
that the 10-second postfeedback delay condition resulted in higher performance than the
other two conditions. These findings suggest that extra time spent looking at the content
during the 10-second delay may have resulted in the increased performance.

A later study by Kelly and Crosbie (1997) confirmed their previous finding that
an opportunity to review instructional content during a forced postfeedback delay results
in better performance. The authors modified their previous studies by shortening the
length of experimental sessions and adding pretest, posttest, and follow-up tests to assess
the impact of their interventions over time. For this experiment, subjects were exposed to
either a 10-second postfeedback delay for each question or no postfeedback delay.
Similar to their previous findings, the authors found that the postfeedback delay
improved performance, and these improvements were maintained and even increased
throughout the remainder of the experiment. Additionally, following the completion of
each instructional set, the program asked subjects how satisfied they were with the
experimental condition used during the session. Using a nine-point scale, the authors
reported that the subjects were satisfied with the delay, however, training took
approximately 20 percent longer, and subjects sometimes complained that their progress
was unduly delayed.

A later study by Johnson and Dickinson (2012) evaluated performance and
satisfaction for three different formats: postfeedback delay, incentives/disincentives, and
control. Unlike similar studies investigating the use of postfeedback delays to reduce
racing, Johnson and Dickinson applied a shorter delay of just five seconds. For the
postfeedback delay condition, participants were paid 5 cents for each question they completed, regardless of accuracy, and encountered a 5-second delay in which the question, feedback, and the participants’ responses were displayed on the screen. For the incentives/disincentives condition, participants were paid 5 cents for each question they answered correctly, and lost 5 cents for each incorrect response. Unlike the postfeedback delay condition, there was no delay in this condition. For the control condition, participants were paid 5 cents for each response regardless of accuracy, and again, did not encounter a delay. The authors found that posttest scores increased with the use of postfeedback delays. The authors also found that postfeedback delays negatively affected satisfaction when compared to the control condition, as participants disliked being artificially slowed by the delay. There was no reported difference in satisfaction between incentives/disincentives and postfeedback delays. Overall, participants preferred the control condition to the other two formats.

Dubuque (2012) also investigated the use of postfeedback delays on reducing racing in three separate experiments. For the first experiment, participants were exposed to three conditions: control, contingent delay, and contingent interactive delay. Problems answered correctly for all three formats produced immediate feedback, no enforced delay, and access to the next problem. Incorrect answers in the control condition produced the same consequence as correct answers (immediate feedback, no delay, and the next problem). Problems answered incorrectly for the contingent delay condition resulted in immediate feedback and an enforced 60-second delay following the response. Incorrect answers under the contingent interactive delay condition required subjects to click a button every 5 seconds throughout the 60-second delay in order to continue.
through the material. The experimenter randomly assigned participants 20 order of operations math questions for all three experiments. Results from the first study suggest a ceiling effect, as the authors reported high levels of responding under all three conditions. In order to address this limitation, Dubuque completed a second experiment in which the questions were made more difficult by including more integers. In the second experiment, the author found a significant increase in performance for the contingent delay condition when compared to the other two conditions. Additionally, increasing the number of integers per problem had the intended effect of increasing the problem difficulty. However, the delay period was quite lengthy (60 seconds) and therefore increased the time substantially for low performers. Also, the author did not investigate whether the contingent interactive delay actually prevented subjects from engaging in outside activities while progressing through the lesson. These limitations were addressed in a third and final experiment by decreasing the delay to 30 seconds for the contingent delay condition and requiring the participant to click a button (within 3-seconds) at a random time throughout the delay for the contingent interactive delay condition. Specifically, participants in the contingent interactive delay condition were shown a button on the screen that changed from “Look for the button to appear here” to “Click here to go to the next problem” at a random time within 20-40 seconds into the delay countdown. Each subject had only a short window of 3-seconds to click the button, and were able to advance to the next question if he or she pressed the button when the label changed. However, if the participant did not click the button before it disappeared, they were forced to restart the same delay from the beginning. Once the countdown finished, subjects were given access to another button labeled, “Click here to restart the
countdown” that started the delay over again if clicked. Results from all three experiments suggest that simply withholding progress in the lesson is enough to prevent racing behavior and that while longer postfeedback delays are effective in reducing racing, the time it takes to complete the lesson is substantially longer. Further, a satisfaction survey revealed that a majority of subjects preferred the control condition to the other two conditions. The contingent interactive delay condition also produced slightly lower satisfaction ratings than both the control and contingent delay conditions.

While previous research on postfeedback delays has provided valuable contributions in reducing racing during CBI, there are several limitations that warrant attention. Firstly, the majority of previous studies have been conducted in highly controlled laboratory settings (Crosbie & Kelly, 1994; Johnson & Dickinson, 2012; Kelly & Crosbie, 1997), thus removing most real-life competing activities that could have an impact on performance. For example, in Crosbie and Kelly’s study, the noncontingent delay produced higher performance than no delay, but there was no difference in performance between no delay and noncontingent delay with blank screen. The authors speculate that the noncontingent delay improved performance because learners used the delay periods to study. However, the subjects in this experiment completed the unit lessons in a controlled lab setting. When a lesson is taken online, it is typically completed in a location of the learner’s choosing, as is the case when students take an online course. Given this, students have the opportunity to browse the Internet, interact with friends, watch television, or engage in a number of competing activities while completing the lesson. As previously mentioned, the students in Crosbie and Kelly’s study did not have the opportunity to engage in these competing behaviors. Thus, it is likely that the subjects
in the noncontingent delay had nothing better to do than to study the material presented on the screen during the delay. It is possible that if completed in a location of their choosing, learners may engage in competing behaviors rather than study the material. Given this, CBI research conducted in a controlled lab setting may prevent findings from generalizing to an actual online lesson. To address this issue, this study was conducted in a location of the participant’s choosing to determine the impact on performance.

Another limitation in previous research is the length of the postfeedback delay. Longer postfeedback delays (30 and 60-second) greatly increase instructional time and make a potentially aversive situation even more aversive (going against the intent of Skinner’s automated instruction). Kelly and Crosbie (1997) found that while a longer postfeedback delay (10 seconds) significantly improved performance, training took 20 percent longer and some subjects complained that, regardless of the correctness of their answer, their progress was unfairly delayed. Further, while Dubuque (2012) found that the use of much longer delays (30 and 60 seconds) significantly improved performance, such lengthy delays will greatly increase instructional time and potentially add aversive properties to the instruction, thus creating a considerable barrier for adoption in training and education.

A majority of previous research on the use of postfeedback delays to reduce racing have been conducted in a highly controlled laboratory setting. In order to more closely simulate the use of CBI, the lesson used in this study was completed online in a location of the participant’s choosing. Another limitation that was addressed in this study was the length of the postfeedback delay. Up to this point, most research has investigated longer postfeedback delays, limiting adoptability for most educational and business
settings. Given this, the purpose of the current study was to investigate the use of postfeedback delays to reduce racing in CBI and address some limitations of previous postfeedback delay research.
METHOD

Participants and Setting

127 undergraduate students were recruited using recruitment flyers (see Appendix A) and in-class recruitment (see Appendix B) from a large university. Two sessions (pretest and posttest) were conducted in a university laboratory containing four workstations. Cubicle walls separated each workstation from one another in order to prevent participants from viewing the work of other participants. Instructional modules were completed online in a location of the participant’s choosing (home, coffee shop, computer lab, etc.). Regardless of test scores, participants earned $15 cash following the completion of all modules and tests within a three-week period. Participants also earned an additional $5 for scoring higher than 65% on the posttest.

Instructional Material

A computer program, using instructional material from *The Analysis of Behavior* (Holland & Skinner, 1961), was used for the instructional modules. The pretest and posttest was paper-based and also developed using Holland and Skinner’s (1961) text. Sets 1-16 and 18-22 (21 total) were used for the instructional modules, while sets 17 and 29 were used for the pretest and posttest. Questions from sets 17 and 29 were combined to construct the pretest and posttest, as these sets are cumulative reviews of all previous units. For 16 of the instructional modules, additional “exhibit” printouts (based on the exhibits used in the Holland and Skinner (1961) textbook) supplemented each of the instructional sets (see Appendix C). Instructional material from *The Analysis of Behavior* was used in order to avoid ceiling effects, as 50% correct responding was a typical outcome for posttest measures in a previous study (Johnson & Dickinson, 2012).
Additionally, previous research has successfully applied this text for investigating computer-based racing (Crosbie & Kelly, 1994; Johnson & Dickinson, 2012; Kelly & Crosbie, 1997).

All instructional sets and a tutorial were emailed to participants within 24 hours of the introductory/pretest session. The program tutorial allowed the participant to become familiar with the CBI format before beginning the instructional sets. The tutorial did not include any of the material from Holland and Skinner’s (1961) text, but was simply used as a tool to familiarize participants with the navigation and format of the computer-based modules.

Upon opening the program and selecting a specific unit, participants clicked on the “Begin Unit” button to begin the lesson (see Appendix D). The program was presented on the computer screen, displaying the unit number and total number of questions for the unit. The slides used for each instructional module included short, incomplete statements that required participants to type a response. After typing a response into the appropriate field, participants clicked the “Submit Your Answer” button immediately below or next to the response field (see Appendix E). At the end of each instructional set, participants were required to click on the “End Unit” button displayed on the screen to complete the lesson.

Pretest and Posttest Measures

Again, pretest and posttest measures were based on sets 17 and 29 from The Analysis of Behavior (Holland & Skinner, 1961). The pretest measure consisted of a 51-question paper-based test (see Appendix F) and the subject’s score on the pretest was used as a covariate measure of performance. Additionally, the pretest was used to filter
out any subjects who were especially fluent with the material. Prior to completing the pretest, subjects were told that they would earn $5 cash by scoring higher than 65% on the test. Any subject that met this criterion was immediately excluded from further participation in the study; however, participants were not informed of this prior to completing the pretest. The same set of 51 questions was used as the posttest measure, and again, subjects were told that they would earn $5 cash by scoring higher than 65% on the test. Further, regardless of test scores, participants earned $15 for simply completing all 21 modules and the posttest within a three-week period. The incentives were used to ensure that participants made genuine attempts to do well on the tests, and do so within this time interval.

Dependent and Independent Variables

Posttest scores were used to assess differences between six CBI groups. Following completion of the posttest, the experimenter immediately evaluated and recorded the participant’s score on his or her personal record sheet. Participant record sheets were filed in a secure location and only accessible to the experimenter and research assistants. In addition, post-participation surveys were administered to all subjects following their participation in this study. In order to confirm the participant’s completion of all 21 modules within a three-week period, the lead experimenter had exclusive access to a webpage with the participant number and the time stamp associated with each unit.

The independent variables investigated in this study were the delay length (5-second or no delay) and feedback type (self-evaluative feedback, feedback only, or no
feedback). Participants were randomly assigned to one of the six experimental groups. See Appendix G and H for a step-by-step comparison of the different groups.

**Feedback Only with 5-second Delay.** At the start of each instructional unit, participants clicked the “Begin Unit” button to begin the instructional set. After clicking the “Begin Unit” button, the screen displayed a question, a response box, and a “Submit Your Answer” button. After reading the question, participants responded by typing their answer into the appropriate response field and clicking the “Submit Your Answer” button. Participants in this condition were then presented with a screen in which the correct answer was displayed directly next to the participant’s typed response (see Appendix I). In addition to the question, participant response, and correct answer, a horizontal countdown bar that gradually decreases in size remained visible on the screen throughout the 5-second delay. After the countdown bar disappeared, participants were able to click the “Proceed to Next Question” button and continue through the lesson. Participants were able to view this screen for as long as they would like until clicking the “Proceed to Next Question” button.

**Feedback Only with No Delay.** This condition was identical to the previous condition, except participants were not exposed to the enforced delay of 5-seconds. Rather, participants assigned to this condition had immediate access to the “Proceed to Next Question” button following the presentation of the question, correct answer, and participant response. Again, participants were able to view this screen for as long as they preferred until clicking the “Proceed to Next Question” button.

**Self-Evaluative Feedback with 5-second Delay.** This condition was identical to the previous 5-second delay condition, except participants were exposed to a self-
evaluative feedback component. Similar to the previous conditions, the question, participant response, and correct answer were displayed immediately after submitting a response. However, following the presentation of this material, subjects were required to score the correctness of their response by typing either “C” (correct) or “I” (incorrect) into the appropriate field (see Appendix J). After reviewing the correct answer and scoring their response, participants clicked on the “Submit Scoring” button. After submitting a score, a 5-second countdown immediately began in which the participant was unable to continue until after the countdown bar disappeared. Participants were able to review the content for as long as they preferred, until clicking the “Proceed to Next Question” button and moving on to the next question.

Self-Evaluative Feedback with No Delay. This condition was identical to the previous condition, except participants were not exposed to the 5-second enforced delay. Rather, the “Proceed to Next Question” button became immediately available after the participant scored his or her response. Again, participants were able to review the content for as long as they preferred, until clicking the “Proceed to Next Question” button and moving on to the next question.

No Feedback with 5-second Delay. After the participant typed a response and clicked the “Submit Your Answer” button, a screen appeared with only the question and countdown bar in view. Unlike the previous conditions, participants did not have access to the correct answer, nor were they able to view their response after submitting an answer (see Appendix K). When the countdown bar disappeared, a “Proceed To Next Question” button immediately appeared and clicking the button allowed the participant to advance to the next question.
No Feedback with No Delay. This condition was identical to the previous condition, except the “Proceed to Next Question” button became immediately available after the participant submitted a response. Again, the participant did not have access to his or her response after clicking the “Submit Your Response” button.

Experimental Design

A between-group pretest-posttest design was used and participants were randomly assigned to one of six experimental groups: a) Self-evaluative feedback with a 5-second delay (19 participants), b) Feedback only with a 5-second delay (21 participants), c) No feedback with a 5-second delay (20 participants), d) Self-evaluative feedback with no delay (29 participants), e) Feedback only with no delay, (19 participants), f) No feedback with no delay (19 participants).

Experimental Procedures

Pretest session. As indicated by the recruitment flyer and script, potential participants emailed the lead researcher to schedule an introductory/pretest session (see Appendix L). The researcher then sent a follow-up e-mail with additional details (length of participation, brief purpose, and what will be required of them to participate), as well as scheduled the participant’s pretest/introductory session. An example of this e-mail can be found in Appendix M. During the pretest/introductory session, the experimenter briefly explained the study and allowed the potential participant to read over the informed consent document (see Appendix N and O). The introductory session was hosted in a separate university laboratory room with a single desk and computer. If consent was obtained, the experimenter randomly assigned the participant to one of six experimental conditions and assigned a participant number. As indicated by the initial e-mail with the
experimenter, the participant immediately began the pretest following the conclusion of the introductory session.

For the pretest session, participants were placed at an unoccupied workstation. The experimenter read the following script prior to beginning the pretest: “Using a pencil or pen, please answer all questions on this test. Please silence your phone and place your belongings in an inaccessible location for the duration of this session. I will be available on the other side of the cubicle wall, so if you need anything during the test, just come get me. After you have completed the test, please let me know. Also, you will earn $5 by scoring higher than 65% on the test. Do you have any questions?” After the experimenter finished reading the script aloud and answered all questions, the participant began the pretest. The participant’s identification number was written at the top right corner of the test to ensure confidentiality.

After the participant completed the pretest, the experimenter immediately scored the test while the participant waited in a seated area directly outside of the laboratory room. If the participant scored lower than 65%, the experimenter and participant returned to the other laboratory room to schedule the posttest/debriefing session. For those same participants, the posttest/debriefing session was scheduled approximately three weeks following the introductory session. The experimenter informed the participant that he or she would receive an e-mail with the instructional sets and program tutorial within 24 hours. The participant was also told that the modules could be completed at a location of their choosing and all instructional sets had to be completed before taking the posttest. The experimenter provided the participant with a folder composed of 16 instructional “exhibits” and read the following script: “The exhibits presented in this folder will
supplement 16 of the 21 instructional units. Please read the appropriate exhibit prior to beginning the unit and refer to the exhibit throughout the lesson as needed. The exhibits are numbered accordingly with the units. Please return the exhibit folder when you return to the lab for your posttest and debriefing session. Do you have any questions regarding the exhibits?"

If participants had scored higher than 65% on the pretest, the experimenter and participant would have returned to the other laboratory room for a debriefing session. The researcher would have read the following: “We would like to thank you for your interest in participating in this study. Unfortunately, due to your high performance on the pretest, we have determined that you are too familiar with the material used in this study and we will not be able to include you as a participant. As indicated earlier, you will receive $5 for scoring higher than 65% on the test. We would like to thank you for your time and please do not discuss details of this study with other individuals. Do you have any questions?” The experimenter then would have answered any questions and provided the participant with his or her $5. However, this procedure was never utilized in the present study due to the fact that no participants scored 65% or higher on the pretest.

For those continuing participation in the study, three reminder e-mails were sent to participants prior to their scheduled posttest: four days before the posttest, two days before the posttest, and the day immediately before the posttest (see Appendix P). The e-mails included the day and time of the scheduled session, as well as the total number of sets the participant had completed thus far. It was expected that reminder e-mails would prompt the participant to complete all of the modules prior to their scheduled posttest/debriefing session.
Posttest session. As previously mentioned, the same test was used for both the pretest and posttest. The administration of the posttest was also identical to the pretest in that it was paper-based, completed in the university laboratory, and immediately scored by the experimenter. As indicated earlier, participants earned an additional $5 for scoring higher than 65% on the test. Similar to the pretest, the posttest was immediately graded by the researcher and the participant was told his or her performance on the test.

Debriefing session. Following the completion of the posttest, the experimenter debriefed the participant on details of the study (Appendix Q) and asked the participant to complete a brief survey regarding the study (Appendix R). Once the participant had completed the participation survey, the experimenter read the debriefing script and, if requested, provided the participant with an extra credit slip. As previously mentioned, the participant received $15 cash immediately following the debriefing session. If the participant scored 65% or higher on the posttest, he or she received an additional $5 at this time. The debriefing session was held in the small laboratory room, away from all other participants.

Experimental Analysis

A two-factor ANCOVA was used to analyze posttest scores for all participants in the six experimental groups. The covariate measure was the pretest score from the introductory session.

Interobserver Agreement

Interobserver agreement (IOA) was collected for both pretest and posttest scoring. Two experimenters scored each test independently, marking each response as correct or incorrect. For both the pretest and posttest, the primary experimenter scored the test
immediately after the participant finished. A second experimenter then independently scored the accuracy of responses at a later time. The lead researcher reviewed any scoring discrepancies and made the final decision. In order to calculate IOA, the number of agreements was divided by the number of agreements plus disagreements, and then multiplied by 100.
RESULTS

Table 1 displays the raw means for the number of correctly answered questions for both the pretest and posttest. A two-factor ANCOVA was used to analyze posttest gains for all six groups. The covariate was the score on the pretest. A total of nine participants scored more than 65% on the posttest: four in the self-evaluative feedback with 5-second delay condition, two in the no feedback with no delay condition, two in the feedback only with 5-second delay condition, one in the no feedback with 5-second delay condition, one in the self-evaluative feedback with no delay condition, and one in the feedback only with no delay condition. No participant scored above 65% on the pretest. Thus, all participants had the opportunity to complete the study in its entirety. Table 2 displays the raw means for the pretest and posttest data as percentages.

Table 1

Raw Means for Pretest and Posttest Scores

<table>
<thead>
<tr>
<th>Condition</th>
<th>n</th>
<th>Pretest</th>
<th>Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feedback Only with 5-second Delay</td>
<td>21</td>
<td>5.76</td>
<td>18.23</td>
</tr>
<tr>
<td>Feedback Only with No Delay</td>
<td>19</td>
<td>5.00</td>
<td>15.42</td>
</tr>
<tr>
<td>Self-Evaluative Feedback with 5-second Delay</td>
<td>19</td>
<td>5.73</td>
<td>18.79</td>
</tr>
<tr>
<td>Self-Evaluative Feedback with No Delay</td>
<td>29</td>
<td>4.51</td>
<td>12.55</td>
</tr>
<tr>
<td>No Feedback with 5-second Delay</td>
<td>20</td>
<td>5.60</td>
<td>13.55</td>
</tr>
<tr>
<td>No Feedback with No Delay</td>
<td>19</td>
<td>5.52</td>
<td>13.10</td>
</tr>
</tbody>
</table>

As depicted in Table 3, the obtained differences between groups on the delay variable were not statistically significant \((F(1, 120) = 2.35, p = 0.128)\). However, there was a statistically significant main effect on the feedback variable \((F(2, 120) = 3.335, p <\)
Fisher’s protected LSD pairwise comparisons were calculated and discovered statistically significant differences between the feedback only and no feedback condition \((p<.05)\), as well as the self-evaluative feedback and the no feedback condition \((p<.05)\).

Table 2

*Raw Means as Percentage Correct: Pretest and Posttest*

<table>
<thead>
<tr>
<th>Condition</th>
<th>n</th>
<th>Pretest</th>
<th>Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feedback Only with 5-second Delay</td>
<td>21</td>
<td>11.3%</td>
<td>35.7%</td>
</tr>
<tr>
<td>Feedback Only with No Delay</td>
<td>19</td>
<td>9.8%</td>
<td>30.2%</td>
</tr>
<tr>
<td>Self-Evaluative Feedback with 5-second Delay</td>
<td>19</td>
<td>11.2%</td>
<td>36.8%</td>
</tr>
<tr>
<td>Self-Evaluative Feedback with No Delay</td>
<td>29</td>
<td>8.8%</td>
<td>24.6%</td>
</tr>
<tr>
<td>No Feedback with 5-second Delay</td>
<td>20</td>
<td>11.0%</td>
<td>26.6%</td>
</tr>
<tr>
<td>No Feedback with No Delay</td>
<td>19</td>
<td>10.8%</td>
<td>25.7%</td>
</tr>
</tbody>
</table>

Table 3

*Source Table for Analysis of Covariance*

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>(F)</th>
<th>(p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feedback (A)</td>
<td>2</td>
<td>329</td>
<td>164</td>
<td>3.335</td>
<td>0.039*</td>
</tr>
<tr>
<td>Delay (B)</td>
<td>1</td>
<td>116</td>
<td>116</td>
<td>2.35</td>
<td>0.128</td>
</tr>
<tr>
<td>A X B</td>
<td>2</td>
<td>79</td>
<td>39</td>
<td>.799</td>
<td>0.452</td>
</tr>
<tr>
<td>Pretest</td>
<td>1</td>
<td>7026</td>
<td>7026</td>
<td>142.24</td>
<td>0.000</td>
</tr>
<tr>
<td>Error</td>
<td>120</td>
<td>5928</td>
<td>49</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted Total</td>
<td>126</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note: * denotes \(p<.05\)
The results in Table 1 and 2 were suggestive of a clear and strong trend for the delay variable, except for the no feedback delay condition. As such, an additional ANCOVA was calculated without the inclusion of the no feedback conditions (see Table 4). With this analysis, the feedback variable becomes non-significant but the delay variable becomes marginally significant ($p = 0.095$).

Table 4

*Source Table for Analysis of Covariance: Restricted to Feedback Conditions*

<table>
<thead>
<tr>
<th>Source</th>
<th>$df$</th>
<th>SS</th>
<th>MS</th>
<th>$F$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feedback (A)</td>
<td>1</td>
<td>10.634</td>
<td>10.634</td>
<td>.189</td>
<td>0.665</td>
</tr>
<tr>
<td>Delay (B)</td>
<td>1</td>
<td>160.406</td>
<td>160.406</td>
<td>2.847</td>
<td>0.095</td>
</tr>
<tr>
<td>A X B</td>
<td>1</td>
<td>36.173</td>
<td>36.173</td>
<td>.642</td>
<td>0.425</td>
</tr>
<tr>
<td>Pretest</td>
<td>1</td>
<td>4742.323</td>
<td>4742.323</td>
<td>84.169</td>
<td>0.000</td>
</tr>
<tr>
<td>Error</td>
<td>83</td>
<td>4676.449</td>
<td>56.343</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted Total</td>
<td>87</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5

*Adjusted Means for Percentage Correct: Posttest Scores*

<table>
<thead>
<tr>
<th>Condition</th>
<th>$n$</th>
<th>Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feedback Only with 5-second Delay</td>
<td>21</td>
<td>34.1%</td>
</tr>
<tr>
<td>Feedback Only with No Delay</td>
<td>19</td>
<td>31.3%</td>
</tr>
<tr>
<td>Self-Evaluative Feedback with 5-second Delay</td>
<td>19</td>
<td>35.3%</td>
</tr>
<tr>
<td>Self-Evaluative Feedback with No Delay</td>
<td>29</td>
<td>27.3%</td>
</tr>
<tr>
<td>No Feedback with 5-second Delay</td>
<td>20</td>
<td>25.5%</td>
</tr>
<tr>
<td>No Feedback with No Delay</td>
<td>19</td>
<td>24.9%</td>
</tr>
</tbody>
</table>
As illustrated by Table 5, the two conditions with the postfeedback delays (feedback only with 5-second delay and self-evaluative feedback with 5-second delay) produced the highest gains in posttest performance. Based on the results of the original ANCOVA analysis (Table 3), there were no statistically significant interaction effects detected ($F(1, 120) = 0.799, p= 0.452$).

A total of 25 participants concluded their participation in the study prior to taking the posttest: seven participants from the no feedback with 5-second delay group, six participants from the feedback only and no delay group, five participants from the self-evaluative feedback with no delay group, three participants from the no feedback and no delay group, two participants from the feedback only with 5-second delay group, and two participants from the self-evaluative feedback with 5-second delay group. The researchers did not follow up with these participants to determine the basis for their withdrawal.

Again, participants completed a post-participation survey following the completion of the posttest. As can be seen in Table 6, the results of the ANOVA analysis illustrate a statistically significant difference between conditions on the feedback variable when participants were asked to rate the following statement, “I feel like I learned a lot from the instructional modules.” (1= strongly disagree and 5= strongly agree) ($F(5, 119) = 2.931, p < .05$). Fisher’s protected LSD pairwise comparisons revealed statistically significant differences between the no feedback conditions and both the self-evaluative feedback conditions and feedback only conditions (p<.05). However, there were no statistically significant differences between the self-evaluative feedback conditions and
feedback only conditions \((p = 0.647)\), nor were there any differential differences between the delay variables \((p = 0.745)\).

Table 6

*Source Table for Analysis of Variance: “I feel like I learned a lot from the instructional modules.”*

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>(F)</th>
<th>(p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between</td>
<td>5</td>
<td>18.771</td>
<td>3.754</td>
<td>2.931</td>
<td>0.016*</td>
</tr>
<tr>
<td>Within</td>
<td>119</td>
<td>152.429</td>
<td>1.281</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>125</td>
<td>1208.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted Total</td>
<td>124</td>
<td>171.20</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note: * denotes \(p < 0.05\)

Table 7

*Average Group Responses to the Statement “I feel like I learned a lot from the instructional modules.”*

<table>
<thead>
<tr>
<th>Condition</th>
<th>(n)</th>
<th>“I feel like I learned a lot from the instructional modules.” (1 = Strongly Disagree 5 = Strongly Agree)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feedback Only with 5-second Delay</td>
<td>21</td>
<td>2.68</td>
</tr>
<tr>
<td>Feedback Only with No Delay</td>
<td>19</td>
<td>2.32</td>
</tr>
<tr>
<td>Self-Evaluative Feedback with 5-second Delay</td>
<td>19</td>
<td>2.84</td>
</tr>
<tr>
<td>Self-Evaluative Feedback with No Delay</td>
<td>29</td>
<td>1.96</td>
</tr>
<tr>
<td>No Feedback with 5-second Delay</td>
<td>20</td>
<td>2.25</td>
</tr>
<tr>
<td>No Feedback with No Delay</td>
<td>19</td>
<td>2.41</td>
</tr>
</tbody>
</table>
As can be seen in Table 7, the self-evaluative feedback with a 5-second delay group reported the highest score when asked to rate this statement, with an average score of 2.84 on a 5-point rating scale. Conversely, the self-evaluative feedback with no delay condition reported the lowest score when asked this same question, with an average score of 1.96 on a 5-point rating scale.

Based on the ANOVA analysis, there were no statistically significant differences between groups on the overall satisfaction rating \((F(5, 119) = .457, p=.807)\). Table 8 displays the average rating for each group when asked to rate the following statement, “In general, I was satisfied with the format of the instructional program.” (1= strongly disagree and 5= strongly agree).

Table 8

*Average Group Responses to the Statement “In general, I was satisfied with the format of the instructional program.”*

<table>
<thead>
<tr>
<th>Condition</th>
<th>n</th>
<th>“In general, I was satisfied with the format of the instructional program.” (1 = Strongly Disagree 5 = Strongly Agree)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feedback Only with 5-second Delay</td>
<td>21</td>
<td>2.55</td>
</tr>
<tr>
<td>Feedback Only with No Delay</td>
<td>19</td>
<td>2.53</td>
</tr>
<tr>
<td>Self-Evaluative Feedback with 5-second Delay</td>
<td>19</td>
<td>2.26</td>
</tr>
<tr>
<td>Self-Evaluative Feedback with No Delay</td>
<td>29</td>
<td>2.18</td>
</tr>
<tr>
<td>No Feedback with 5-second delay</td>
<td>20</td>
<td>2.20</td>
</tr>
<tr>
<td>No Feedback with No Delay</td>
<td>19</td>
<td>2.41</td>
</tr>
</tbody>
</table>

The three most frequently reported alternative activities while completing the modules were talking/texting on the phone (78%), checking social media (58%), and
socializing with friends (53%), with talking/texting on the phone being the most popular choice across all six groups. When asked where the participants completed a majority of the instructional modules, the most common response across all six groups was at their home or dorm room (72%).

Interobserver agreement for both pretest and posttest scoring averaged 98.1% and never fell below 94.2% for either test. Specifically, there was a 97.3% agreement for the pretest scoring and 98.9% agreement for posttest scoring.
DISCUSSION

While previous research on the use of postfeedback delays has demonstrated their effectiveness for increasing the retention of instructional material, a majority of studies have been conducted in highly controlled laboratory settings. Further, some of the previous research has investigated longer postfeedback delays (i.e., 60 seconds), possibly limiting adoptability for most educational and business settings. Given these limitations, the purpose of the current study was to investigate the use of postfeedback delays of a fairly brief duration to improve the retention of CBI within realistic environments. As indicated by Table 3, the present study did not find any differential effects between groups for delays in general. However, the differences between groups were statistically significant for the feedback variable \((p=0.039)\). More specifically, all four of the feedback conditions produced statistically greater gains on the posttest as compared with the two conditions without feedback. These findings are not surprising considering the extensive amount of literature on the usefulness of feedback in increasing performance (Alvero, Bucklin, & Austin, 2001).

Although delays in general were not significant, this does not necessarily mean that the postfeedback delays were ineffective. It is possible that the no feedback with a delay condition masked the effectiveness of the delay variable for the original analysis expressed in Table 3. It is worth noting that this is the only delay condition that does not involve postfeedback delays, since such postfeedback delays are impossible in the absence of feedback. To test for this possibility, an ANCOVA without the no feedback groups was conducted, as shown in Table 4. Unlike the previous analysis, the delay variable appears to be marginally significant \((p < 0.10)\) when restricted to delays that are
postfeedback in nature. This restricted analysis also results in the feedback variable becoming non-significant ($p = 0.665$). The implication of these analyses is that postfeedback delays are effective at improving performance, even when used in uncontrolled environments, but delays in general are not effective. That is, delays only have functional value in the presence of feedback. However, requiring learners to overtly self-evaluate the accuracy of their responding appears to be irrelevant in the context of postfeedback delays. In other words, feedback matters, but self-assessment of that feedback does not. These findings are largely in alignment with previous studies examining the efficacy of postfeedback delays in reducing computer-based racing and retaining instructional material in CBI (Crosbie & Kelly, 1994; Dubuque, 2012; Johnson & Dickinson, 2012).

There are several possible reasons for why the postfeedback delays were only marginally significant, rather than demonstrating a stronger result. One possible explanation relates to the relatively small sample size of the current study. Given that unusually low course enrollments negatively impacted participant recruitment, there was only an average of 21 participants randomly assigned to each group. Larger groups may have further increased the power of the study and the likelihood of obtaining more powerful $p$-values. Furthermore, the participants in the current experiment completed the modules at a location of their choosing, introducing a lot of potential confounds in these uncontrolled environments. Despite this, the investigation of postfeedback delays in uncontrolled environments was a key component of the current study and one that distinguishes it from other research in this area. Investigating the effectiveness of postfeedback delays in real-world settings offers insight to the practical worth of such
delays in CBI. As such, obtaining marginally significant differences for postfeedback delays may be quite noteworthy given all of the unknown and potential competing variables introduced by the natural environment. Overall, these results are suggestive that at-home CBI can be made more effective by the inclusion of both feedback and enforced delays.

The nature of potential competing variables is important for understanding the practical value of postfeedback delays and designing future research. For example, the most commonly reported alternative activity was talking and texting on the phone. It is possible that some participants exposed to feedback throughout the delay simply attended to other stimuli throughout the duration of the delay. While a delay of five seconds does not provide a large interval for engaging in many types of alternative activities, simple tasks such as texting can easily be completed in less than five seconds and this activity is readily available at all times for someone who carries a cell phone. In other words, the home environment may allow for fast and relatively simple competing contingencies to occur, unlike many controlled lab settings. Participants engaging with such fast alternatives may discount feedback entirely during the delay intervals. Again, this is why marginally significant results may still be important for postfeedback delays. The findings also suggest ways to increase the ecological and external validity of future lab research. For example, laboratory studies may consider allowing participants the opportunity to use cell phones for texting purposes during sessions. This would introduce a realistic and probable competing contingency, but would do so in a relatively controlled fashion, unlike the home environment that potentially introduces many competing contingencies simultaneously.
Unlike many of the original studies on postfeedback delays (Crosbie & Kelly, 1994; Dubuque, 2012; Kelly & Crosbie, 1997; Munson & Crosbie, 1998), the current study used a between-group design rather than a single-subject design. This is important with the settings and tasks involved in the present study, as single-subject research designs may result in potentially unrepresentative samples. That is, when you compare the effectiveness of a treatment by examining the performance of only a few subjects, you are introducing the problem of variability between these individual subjects. Ideally, single-subject research would control for this by identifying and controlling for the source of that variability. However, since each individual has a different and extensive learning history, researchers have no way of controlling for preexisting differences between individuals with this type of research. In the case of feedback, the delivery of feedback may generate some very emotional responding for some individuals, perhaps from a history of being heavily criticized by others, while others may have a history of feedback being very beneficial to their performance. These preexisting differences may account for differences, and no matter how precisely these variables are delivered, researchers simply cannot control for these different learning histories. Again, implementing a feedback intervention is likely going to generate large variability in responding across participants. Therefore, it is important to use adequate sample sizes and care when interpreting studies utilizing small samples.

Although there were no statistically significant differences between groups with regard to satisfaction, the feedback only with a 5-second delay group reported the highest rating of overall satisfaction. This finding is inconsistent with those reported by Johnson and Dickinson (2012) in that they discovered that the control group (no feedback and no
delay) was the most preferred condition. Conversely, the satisfaction findings in the current study are consistent with those reported by Crosbie and Kelly (1994) in that the delay did not produce lower rates of satisfaction. In other words, the delay had no detectable impact on satisfaction ratings. It is important to note that participants rated none of the six formats favorably. That is, all group averages for the rating of overall satisfaction fell within the range of 2.1 and 2.6 on the 5-point rating scale. One possible explanation for this finding is the lack of entertaining aspects of the material. Another possible explanation is the absence of a clear and direct connection to other personal or academic objectives.

There were statistically significant differences between feedback groups when asked to rate the statement, “I feel like I learned a lot from the instructional modules.” Specifically, there were statistically significant differences between the self-evaluative feedback conditions and the no feedback conditions, as well as statistically significant differences between the feedback only conditions and no feedback conditions. As such, it appears that the provision of feedback not only enhances the retention of material, but also affects the perception of learners so that they also feel like they learned more.

When examining postfeedback delays only (Table 4), it appears that the different types of feedback conditions were irrelevant. Given this, an overt evaluation of response accuracy might not be a key characteristic of the success of a postfeedback delay. One important practical implication of this finding is that it might make the programming of instructional materials easier. If it is true that there are no performance differences between feedback only and self-evaluative feedback, programmers can avoid the extra work involved with requiring overt self-evaluation following the provision of feedback.
However, it appears that it would still be important to both provide feedback and enforce a delay when that feedback appears. Covert self-evaluation seems plausible and likely when an opportunity to remediate is enforced, which may account for why no differences were obtained during self-evaluative feedback and feedback only conditions. That is, participants may always self-evaluate, even within feedback only conditions, when presented with an enforced postfeedback delay.

Further, the current findings suggest a way of improving learning outcomes without the need for additional human evaluators. Again, the findings suggest that performance may improve in the absence of any evaluation, human or machine. That is, no one or no thing stated, “that’s correct” or “that’s incorrect.” Instead, the program simply stated the correct answer and in the self-evaluate feedback conditions, asked the participant to self-evaluate. If it is the case that simply presenting feedback during a delay increases performance without external evaluation, it may be argued that there is not a need for human observers to evaluate the accuracy of a response. Rather, the instructional material may simply provide the learner with information on how they should have responded. With simple responses, such as a single word or sentence, machines may provide the evaluation by simply displaying the correct response. However, it is likely that human evaluators will be needed for evaluating more complex responses, such as lengthy essays or papers.

Although the current study provides some evidence in support of previous findings in that postfeedback delays increase performance, this does not mean that postfeedback delays will always be equally effective. It is important that researchers continue to pursue such investigations to determine the formats under which
postfeedback delays can perform most effectively. In addition to measures of test performance, future researchers should collect data on the differences in total training time across groups. When some form of online training is used, either in a business or academic setting, it is likely going to be important that the program is completed within a specified length of time. That is, a measure of training duration is another key variable for determining the effectiveness and adoptability of CBI.

Future researchers should also collect self-report measures of covert responding for those in the feedback only groups. If it is the case that the delay is effective because of covert responding, future research should consider collecting information on the type of responding that is occurring during the delay with the use of participant self-reports. Ideally, this information will be collected in real-time, immediately following the delay. Inquiries such as, “what were you doing throughout the delay?” or “were you asking yourself clarifying questions throughout the delay?” may provide some valuable information on the use of postfeedback delays without an overt self-evaluative component.

Besides measures of training time and covert responding, future researchers may be interested in looking at differences in duration of test taking as a measure of fluency. For example, while there appear to be only small differences on the test performance between the feedback only and self-evaluative feedback groups, it is possible that the self-evaluative feedback groups took less time responding on the posttest than did the feedback only group, thus demonstrating greater fluency of the material. If this is the case, it may be beneficial to incorporate an active feedback component to training in a real-world setting where fluency of material is essential.
The current study found results to suggest that postfeedback delays can be effective at improving retention in real-world environments. However, delays in general were not supported as being effective. As such, one cannot blindly throw in delays to improve performance, but rather one must utilize postfeedback delays in particular. The use of delays in CBI must allow for learner remediation of the material and such remediation cannot take place without some form of confirmation or correction. It is hoped that the present study contributes to a better understanding of the use of postfeedback delays in CBI, and that future studies will continue to pursue such investigations.
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Organizational Behavior Management, 31, 55-94.
doi:10.1080/01608061.2010.541821


doi:10.1207/s15328023top2302_14


doi:10.1126/science.128.3330.969


Appendix A

Recruitment Flyer
Research Participants Needed

I am currently seeking individuals to participate in a study designed to test computer-based instruction under various conditions. The material used for this study focuses on the experimental analysis of behavior and will likely benefit you in your future psychology courses.

Participants will earn between $15-$20 if they complete the study in its entirety.

**Time Commitment:** Two, 30-minute meetings (on campus) and 21, 20-30 minute sessions over the course of three weeks (location of your choice). The total time commitment for the study is approximately 8 hours.

If you are interested in learning more about this study, please contact the email listed below. Be sure to provide your name, e-mail and/or telephone number, and the times you can be reached. All information is confidential.

Thank you!

E-mail: anna.l.conard@wmich.edu
Appendix B

In-class Recruitment Script
Recruitment Script

Hello, my name is ______________ and I am working with Anna Conard in the Instructional Design and Management Lab here at Western. We are currently looking for individuals to participate in a study designed to test computer-based instruction under various conditions. The material used for this study focuses on the experimental analysis of behavior and, therefore, will likely benefit you in your future psychology courses. Interested individuals will have the opportunity to earn between $15-$20 if they complete this study in its entirety.

Two sessions, approximately 30 minutes each, will be held in a university laboratory here in Wood hall. Following the first on-campus session, you will be asked to complete 21 sessions over a 3-week period at a location of your choice.

Your participation is completely voluntary and you may withdraw at any time. Your willingness to participate in this study or your withdrawal from this study at a later time will not hurt your grade in this class or any other class.

If you would like to learn more about this study, please contact Anna Conard by emailing her at anna.l.conard@wmich.edu. The e-mail for Ms. Conard is also printed on the board behind me.

Thank you for your time!
Appendix C

Sample of Unit Exhibit
Exhibit for Unit 4

Read exhibit now and refer to it as needed.

Experiment 1.

Pavlov placed a dog in a standard experimental situation. On repeated *conditioning* trials a tone was sounded for 5 seconds, and approximately 2 seconds later the dog was given powdered food. This pairing of tone and food powder was repeated, with trials spaced from 5 to 35 minutes apart at random intervals, for fifty trials. Trials 1, 10, 20, 30, 40, and 50 were *test* trials, that is, the tone was sounded for 30 seconds and *no* food powder was given.

<table>
<thead>
<tr>
<th>Trial Number (tone alone)</th>
<th>I</th>
<th>Drops of Saliva</th>
<th>II</th>
<th>Time Between Onset of Tone and Salivation (in seconds)</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td></td>
<td>---</td>
<td></td>
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<tr>
<td>10</td>
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<td>50</td>
<td>59</td>
<td></td>
<td>2</td>
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<td></td>
</tr>
</tbody>
</table>

Experiment 2. (Do not read Experiment 2 until instructed to do so.)

A dog had been conditioned to salivate to a metronome beating at 104 ticks per minute. Several interspersed test trials (metronome ticking for 30 seconds but not followed by food powder) provided approximately 10 drops of saliva on each trial. The ticking metronome was then presented on every trial for 30 seconds without being paired with food powder. (Sufficient time was allowed between trials to avoid appreciable fatigue.) The results for this series of consecutive trials without food are presented on the following table.

<table>
<thead>
<tr>
<th>Trial Number</th>
<th>I</th>
<th>Drops of Saliva</th>
<th>II</th>
<th>Time Between Onset of Metronome and Salivation (in seconds)</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
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<td>9</td>
<td>0</td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix D

Begin Unit Screenshot
Unit 12

30 questions total

When you're ready to begin, click the button below:

Begin Unit
Appendix E

Submit Your Answer Screenshot
Q 3: In (D), "neutral stimulus" means a tone which *** effect on salivation before conditioning.

Type your answer(s) in the space(s) below.
Appendix F

Pretest/Posttest
Test

- The number of words needed to complete an item is indicated by the number of blanks. Thus “_____” indicates a one-word response, whereas “_____ _____” indicates a two-word response. When asterisks (***) are used in place of blanks, fill in as many words as you think necessary to respond to the item.
- The abbreviation TT calls for a technical term. When it is used, a nontechnical word is incorrect.

Q1: On a cumulative record, the slope of the line indicates (1) ** *, and the hatch marks or pips usually indicate (2) * **.

Q2: (1) _____ behavior is strongly influenced by the consequences of previous similar responses, whereas (2) _____ behavior depends upon a preceding stimulus.

Q3: In a conditioned reflex, when a conditioned stimulus is repeatedly presented alone, the magnitude of the conditioned response (1) _____ and the latency of the conditioned reflex (2) _____, until (3) _____ is complete.

Q4: When a pigeon is reinforced for pecking a key, the reinforcing stimulus occurs (1) _____ a peck, and the (2) _____ at which this response is (3) _____ (TT) increases.

Q5: Turning off a television commercial is reinforced by termination of a(n) (1) _____ reinforcer; turning on a very funny program is reinforced by the presentation of a(n) (2) _____ reinforcer.

Q6: Name the response systems involved in the following: walking to the table, putting food in the mouth and chewing it, (1) * * * muscle; moistening food with saliva, (2) * **; passing food into stomach, (3) * * *; and providing stomach with digestive juices, (4) * * *.

Q7: Many so-called traits ascribed to individuals (aggressiveness, persistence, friendliness, etc.) are simply alternate ways of indicating an individual’s _____ of emitting certain types of behavior.

Q8: In differential reinforcement, one form or magnitude of behavior is (1) * * * and other, possibly rather similar forms or magnitudes, are (2) * **.
Q9: The experimenter deliberately arranges reinforcement for key pecking, but superstitious behavior is conditioned by _____ reinforcement.

Q10: In a reflex, the (1) _____ of a stimulus is the intensity which is barely sufficient to (2) _____ a(n) (3) _____.

Q11: An important aspect of respondent conditioning is the _____ relation between presentations of the initially neutral stimulus and of the unconditioned stimulus.

Q12: After a chimpanzee has exchanged tokens for food, water, a mate, etc., the tokens * * * effective as reinforcers if the chimpanzee is well-fed but deprived of water.

Q13: Conditioned operants are eliminated in two contrasting ways: the response is emitted without reinforcement in the process called (1) _____, but is not emitted in the process called (2) _____.

Q14: In conditioning a reflex, as the number of pairings of the conditioned and unconditioned stimuli increases, the latency of the conditioned reflex (1) _____ and the magnitude of the conditioned response (2) _____, until both reach a limit.

Q15: A psychologist fed a baby when he emitted "coos," but not when he cried. We would expect that crying when hungry would be (1) _____ (TT) because of the withholding of (2) _____. (TT)

Q16: Certain groups of responses, such as those elicited by a sudden loud noise, are characteristic of a state of _____.

Q17: When we differentially reinforce successive approximations to a final form of behavior, we are _____ behavior.

Q18: Persistent head scratching, pencil chewing, table tapping, etc., while studying are frequently conditioned (1) _____ operants resulting from (2) _____ contingencies of reinforcement.

Q19: Two ways of effectively preventing unwanted conditioned behavior are: (a) to (1) _____ it by withholding reinforcement, or (b) to condition some (2) _____ behavior.
Q20: A stimulus which elicits a response without previous conditioning is called a(n) (1) _____ _____; a stimulus which elicits a response only after conditioning is called a(n) (2) _____ _____.

Q21: If an airplane spotter never sees the kind of plane he is to spot, his frequency of scanning the sky (1) _____ . In other words, his “looking” behavior is (2) * * *. (TT)

Q22: You will not continue to work if your pay checks “bounce” because the (1) _____ generalized reinforcing effect of such a check disappears in (2) _____.

Q23: A simple operant can be conditioned very rapidly if the organism is (1) _____ to the situation and if a reinforcer follows the response (2) _____.

Q24: In shaping any given behavior, we gradually change the criterion for reinforced responses. The desired behavior is approached by * * *.

Q25: To condition a reflex, a neutral stimulus is (1) _____ with a(n) (2) _____ _____.

Q26: In the usual experiment, when a peck operates the food magazine the (1) _____ reinforcement is immediate, whereas the (2) _____ reinforcement is slightly delayed.

Q27: In a reflex, the more intense the stimulus, the greater the (1) _____ of the response and the shorter the (2) _____ of the reflex.

Q28: When a response is elicited by a stimulus without previous conditioning, the sequence is called a(n) _____ _____.

Q29: The pairing of two stimuli is necessary for conditioning (1) _____ behavior; reinforcement is necessary for conditioning (2) _____ behavior.

Q30: Reaching for a glass of water or saying “Water, please” are examples of (1) _____ behavior; any specific instance of such behavior, however, is called a(n) (2) _____.

Q31: Lying generates stimuli which have acquired the power to elicit the conditioned responses which occur in _____.
Q32: A particularly slow learner may require many reinforcements before developing a high rate of responding. He is _____ likely to develop superstitious behavior than a faster learner.

Q33: Operant behavior has direct consequences on the environment. A consequence which results in an increase in the subsequent rate of the operant response is called a(n) _____. (TT)

Q34: If in teaching the shot-put, a coach is “satisfied” with every throw, no matter how bad, he (1) * * * using successive approximation and he (2) * * * using differential reinforcement.

Q35: Smooth muscles change the (1) _____ of various (2) _____ organs.

Q36: A conditioned reinforcer can become a(n) * * * by being paired with several unconditioned reinforcers appropriate to various deprivations.

Q37: The reinforcers used by animal trainers are (1) _____ arranged, but a pigeon foraging for food among leaves in a park is working under (2) _____ contingencies.

Q38: When behavior decreases in frequency and when, so far as we know, no previous conditioning of the behavior has taken place, we call the process not extinction but _____.

Q39: Learning to say “ball” makes it easier for the child to learn to say “fall” because the two responses have * * *.

Q40: The professional winetaster can make very fine (1) _____. He shows little (2) _____ among various wines.

Q41: Availability of reinforcement depends on the passage of time in (1) _____ schedules, and on the number of responses in (2) _____ schedules.

Q42: If a bright white light is often present when a response is reinforced, a light of medium intensity should produce a rate of responding (1) _____ than that of the bright light and (2) _____ than that of a very faint light.
Q43: A response occurring immediately after a reinforcement is never reinforced on a(n) (1) ___-interval schedule. A response immediately after reinforcement is sometimes reinforced on a(n) (2) ___-interval schedule.

Q44: Responses reinforced by the generalized reinforcers of affection, approval, etc., are often extinguished very (1) ____ because reinforcement has occurred (2) ___ due to the subtlety of the stimuli.

Q45: Response magnitude varies closely with stimulus intensity in the case of (1) ____ behavior, but much less so in the case of (2) ____ behavior.

Q46: An organism may emit the same response to two fairly similar stimuli when only one of them has been present during reinforcement. The term for this phenomenon is * * *.

Q47: When a response is under the control of a single property of a stimulus (which cannot exist alone), we call it a(n) * * *.

Q48: Intermittently reinforcing temper tantrums makes them very ____ to extinction.

Q49:

Q50: In operant discrimination we speak of a *three-term* contingency. Events are arranged in this order: (a) present the (1) ____ , (b) wait for the (2) ____, and (c) (3) ____.

Q51: In establishing a discrimination, a response is (1) ** * in the presence of one stimulus and (2) * * * in the presence of another stimulus.

THE END
Appendix G

Comparison of Experimental Groups (5-second delay)
Appendix H

Comparison of Experimental Groups (no delay)
Active Feedback (no delay)

1. Click “Begin Unit”
2. Participant reads the question, types an answer into the response box, and clicks “Submit Answer”
3. A screen with the question, correct answer, and participant’s response appears
4. The participant scores the correctness of the response by typing “C” or “I” and clicks “Submit Scoring”
5. A screen with the question, correct answer, participant’s response, and “Proceed to Next Question” button will appear
6. The participant clicks “Proceed to Next Question” to move to the next question

Passive Feedback (no delay)

1. Click “Begin Unit”
2. Participant reads the question, types an answer into the response box, and clicks “Submit Answer”
3. A screen with the question, correct answer, participant’s response, and “Proceed to Next Question” button will appear
4. The participant clicks “Proceed to Next Question” to move to the next question

No Feedback (no delay)

1. Click “Begin Unit”
2. Participant reads the question, types an answer into the response box, and clicks “Submit Answer”
3. A screen with just the question and “Proceed to Next Question” button will appear
4. The participant clicks “Proceed to Next Question” to move to the next question
Appendix I

Feedback Only Screenshot
Unit 1

54 questions total

Q 1: A doctor taps your knee (patellar tendon) with a rubber hammer to test your ___.

Your answers
reflexes

Correct answer(s)
reflexes (reflex)

Proceed to next question
Appendix J

Self-Evaluative Feedback Screenshot
Q 1: Phase 1. The pigeon is on a(n) (1) __ * * (TT) schedule with an average interval of 1 minute. A response maintained on this schedule will be extinguished rather (2) ____ when reinforcement is discontinued.

Your answers

(1) variable interval

(2) quickly

Correct answers:

variable-interval

slowly

Was your answer correct? Score with c or i
Appendix K

No Feedback Screenshot
Q 1: A doctor taps your knee (patellar tendon) with a rubber hammer to test your ___.
Appendix L

Initial Email with Experimenter
E-mail Script: Initial Contact

Hello ________,

Thank you for your interest in my study. Before you begin your first session, I need you to meet with one of my research assistants so that he or she can explain the study to you, and you can make a decision as to whether or not you would like to participate. Assuming you decide to participate, we will also schedule your second on-campus meeting at this time. Furthermore, if you decide to participate, we will begin your first session immediately following this initial meeting. You should allow 30 minutes for both of these on-campus meetings. If you decline to participate, you will not begin the first session, and the initial meeting will take no more than 15 minutes.

In addition to the two on-campus meetings, you will be asked to complete 21 online lessons (approximately 20-30 minutes each) at a location of your choosing. Both on-campus meetings and all lessons are expected to be complete within three weeks of your first meeting. The total time commitment for this study is approximately 8 hours. If you complete all 21 modules and tests within a three-week period, you will earn $15, regardless of your posttest test score. You also have the opportunity to earn an additional $5 for meeting or exceeding a specific score on the test.

Please send me the days and times you are available to meet during the next week, and I will schedule your initial meeting.

Best,

Anna Conard
Appendix M

Follow-up Email
**E-mail Script: Follow-up**

Hello ________,

Let’s plan on meeting at (time) on (day).

You should plan on having the initial meeting last about 30 minutes. We will meet in Wood Hall, in room 2521 (which is down a hallway labeled 2505: Psychology Research Labs). During the meeting, we will schedule the second on-campus meeting, so please bring your weekly schedule.

You are not obligated to participate in this study by meeting with an assistant or myself. If you wish, you are free to decline after the initial meeting (or at any point during the study).

Best,

Anna Conard
Appendix N

Informed Consent Document
Principal Investigator: Douglas A. Johnson, Ph.D.
Student Investigator: Anna E. Conard, M.A.
Title of Study: An Investigation on Different Types of Online Learning Formats

You are invited to participate in a study titled “An Investigation on Different Types of Online Learning Formats.” The following document will explain the purpose of this study, and will explain the time commitments, the procedures used in the study, and the risks/benefits of participating. Please read this consent form carefully and completely, and feel free to ask any questions if you need more clarification.

What are we trying to find out in this study?
This purpose of the current study is to investigate the effect of different types of computer-based instruction formats. You will be randomly assigned to an experimental condition.

Where will this study take place?
Two sessions will be conducted in Wood Hall 2521. All other sessions will be completed in a location (with internet access) of your choosing.

What is the time commitment for participating in this study?
You will be asked to attend two, 30-minute sessions in the university laboratory (Wood Hall 2521). You will also be asked to complete 21, 20-30 minute sessions in a location of your choosing. The total time commitment for this study is approximately 8 hours.

What will you be asked to do if you choose to participate in this study?
If you choose to participate in this project, you will be asked to complete two tests (pretest and posttest) and 21 computer-based instructional sets. Your performance over both tests will be measured and at the end of your last session (posttest), you will be asked to complete a brief questionnaire regarding the study.

What information is being measured during the study?
Performance gains from pretest score to posttest score.

What are the risks of participating in this study and how will these risks be minimized?
You may experience some physical discomfort, minor fatigue, or stress associated with being required to work on the computer-based instructional sets and paper-based tests. This will be offset by the fact you will be able to work on the instructional sets in a location of your choosing.
What are the benefits of participating in this study?
It is expected that there will be no benefits to you by participating in this study.

Are there any costs or compensation associated with participating in this study?
There are no costs associated with your participation in this study. All participants will have an opportunity to earn $15-$20 following their participation in this study.

Who will have access to the information collected during this study?
All of the information obtained in this study will remain strictly confidential. Your name will not appear on any papers on which this information is recorded, nor will you be identified in public presentations of the study.

What if you want to stop participating in this study?
You can choose to stop participating in the study at anytime for any reason. You will not suffer any prejudice or penalty by your decision to stop your participation. You will experience NO consequences either academically or personally if you choose to withdraw from this study.

The investigator can also decide to stop your participation in the study without your consent.

If you have any questions prior to or during the study, you can contact the primary investigator, Douglas Johnson at (269) 387-4414 or douglas.johnson@wmich.edu. You may also contact the Chair, Human Subjects Institutional Review Board at (269) 387-8293, or the Vice President for Research at (269) 387-8296 at any point during the study.

As indicated by the stamped date and signature of the board chair in the upper right corner, the Human Subjects Institutional Review Board (HSIRB) has approved this consent document for one year. Do not participate in this study if the stamped date is older than one year.

I have read this informed consent document. The risks and benefits have been explained to me. I agree to take part in this study.

Participant's name

Participant's signature   Date
Appendix O

Renewed Informed Consent Document
Western Michigan University
Department of Psychology

 Principal Investigator: Douglas A. Johnson, Ph.D.
 Student Investigator: Anna L. Conard, M.A.
 Title of Study: An Investigation on Different Types of Online Learning Formats

You are invited to participate in a study titled “An Investigation on Different Types of Online Learning Formats.” The following document will explain the purpose of this study, and will explain the time commitments, the procedures used in the study, and the risks/benefits of participating. Please read this consent form carefully and completely, and feel free to ask any questions if you need more clarification.

What are we trying to find out in this study?
This purpose of the current study is to investigate the effect of different types of computer-based instruction formats. You will be randomly assigned to an experimental condition.

Where will this study take place?
Two sessions will be conducted in Wood Hall 2521. All other sessions will be completed in a location (with internet access) of your choosing.

What is the time commitment for participating in this study?
You will be asked to attend two, 30-minute sessions in the university laboratory (Wood Hall 2521). You will also be asked to complete 21, 20-30 minute sessions in a location of your choosing. The total time commitment for this study is approximately 8 hours.

What will you be asked to do if you choose to participate in this study?
If you choose to participate in this project, you will be asked to complete two tests (pretest and posttest) and 21 computer-based instructional sets. Your performance over both tests will be measured and at the end of your last session (posttest), you will be asked to complete a brief questionnaire regarding the study.

What information is being measured during the study?
Performance gains from pretest score to posttest score.

What are the risks of participating in this study and how will these risks be minimized?
You may experience some physical discomfort, minor fatigue, or stress associated with being required to work on the computer-based instructional sets and paper-based tests. This will be offset by the fact you will be able to work on the instructional sets in a location of your choosing.
What are the benefits of participating in this study?
It is expected that there will be no benefits to you by participating in this study.

Are there any costs or compensation associated with participating in this study?
There are no costs associated with your participation in this study. All participants will have an opportunity to earn $15-$20 following their participation in this study.

Who will have access to the information collected during this study?
All of the information obtained in this study will remain strictly confidential. Your name will not appear on any papers on which this information is recorded, nor will you be identified in public presentations of the study.

What if you want to stop participating in this study?
You can choose to stop participating in the study at anytime for any reason. You will not suffer any prejudice or penalty by your decision to stop your participation. You will experience NO consequences either academically or personally if you choose to withdraw from this study.

The investigator can also decide to stop your participation in the study without your consent.

If you have any questions prior to or during the study, you can contact the primary investigator, Douglas Johnson at (269) 387-4414 or douglas.johnson@wmich.edu. You may also contact the Chair, Human Subjects Institutional Review Board at (269) 387-8293, or the Vice President for Research at (269) 387-8298 at any point during the study.

As indicated by the stamped date and signature of the board chair in the upper right corner, the Human Subjects Institutional Review Board (HSIRB) has approved this consent document for one year. Do not participate in this study if the stamped date is older than one year.

-------------------------------------------------------------------------------

I have read this informed consent document. The risks and benefits have been explained to me. I agree to take part in this study.

-------------------------------------------------------------------------------

Participant's name

-------------------------------------------------------------------------------

Participant's signature Date
Appendix P

Reminder Emails
Hello ________,

I’m sending you a final reminder that your posttest session is scheduled for tomorrow at (time). At this point, it looks like you have completed (# of completed modules) of the 21 modules. Again, please be sure to complete all 21 modules prior to coming in for your final session.

I look forward to our final meeting tomorrow. Please let me know if you have any questions.

Best,

Anna

E-mail Script: Four-Day and Two-Day Reminder

Hello ________,

Just as a reminder, your posttest session is scheduled for (day) at (time). Also, it looks like you have completed (# of completed modules) of the 21 modules. Please be sure to complete all 21 modules prior to coming in for your final session.

Please let me know if you have any questions or concerns.

Best,

Anna
Appendix Q

Debriefing Script
Debriefing Script

Thank you for your participation in this study. I would just like to briefly discuss the purpose of this study with you. The purpose of this study was to compare how well individuals perform under various conditions when using computer-based instruction.

In addition to differences in performance, we also wanted to collect participant data using a post-participation survey.

Depending upon random assignment, you were placed into one of four conditions: a) Self-evaluative feedback with 5-second postfeedback delay, b) Feedback only with 5-second postfeedback delay, c) No feedback with 5-second postfeedback delay, d) Self-evaluative feedback with no delay, e) Feedback only with no delay, or f) No feedback with no delay.

Please do not discuss this study with anyone else because we have not yet completed it.

Do you have any questions about this study or your participation?
Appendix R

Participation Survey
Participant #: __________________ (completed by experimenter)

1. What alternative activities (if any) did you engage in while completing the modules? Please check all that apply.

☐ Social media (Facebook, Twitter, etc.)
☐ Browsing other Internet sites
☐ Checking e-mail
☐ Playing games on the computer
☐ Talking/texting on your phone
☐ Playing games on your phone
☐ Watching T.V. or a movie
☐ Socializing with friends
☐ Homework
☐ Other: __________________________

2. Of the activities you engaged in (above), please rank order you preference in engaging in those activities.

____ Social media (Facebook, Twitter, etc.)
____ Browsing other Internet sites
____ Checking e-mail
____ Playing games on the computer
____ Talking/texting on your phone
____ Playing games on your phone
____ Watching T.V. or a movie
____ Socializing with friends
____ Homework
____ Other: __________________________

3. Where did you complete a majority of the instructional modules?

________________________________________________________________
Please use the following scale to answer the subsequent questions:

1 = Strongly Agree  2 = Agree  3 = Neutral  4 = Disagree  5 = Strongly Disagree

*Survey continues on the back*

4. In general, I enjoyed working through the instructional modules.
   
   1         2         3         4         5

5. I typically studied the question thoroughly before submitting an answer.

   1         2         3         4         5

6. I feel like I learned a lot from the instructional modules.

   1         2         3         4         5

7. The posttest was much easier than the pretest.

   1         2         3         4         5

8. In general, I was satisfied with the format of the instructional program.

   1         2         3         4         5
Appendix S

Multi-part Response Request Screenshot
Q 22: In Figure 10, the rate was highest between (1) _____ and _____, zero between (2) _____ and _____, and intermediate between (3) _____ and ____.
Appendix T

HSIRB Approval Letter
Date: December 2, 2014

To: Douglas Johnson, Principal Investigator
   Anna Conard, Student Investigator for dissertation

From: Amy Naugle, Ph.D., Chair

Re: HSIRB Project Number 14-11-27

This letter will serve as confirmation that your research project titled "Using Postfeedback Delays to Reduce Racing in Online Learning" has been approved under the expedited category of review by the Human Subjects Institutional Review Board. 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 application.

Please note: This research may only be conducted exactly in the form it was approved. You must seek specific board approval for any changes in this project (e.g., you must request a post approval change to enroll subjects beyond the number stated in your application under "Number of subjects you want to complete the study"). Failure to obtain approval for changes will result in a protocol deviation. In addition, if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the HSIRB for consultation.

Reapproval of the project is required if it extends beyond the termination date stated below.

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

Approval Termination: December 1, 2015