“Golden Oldies” in a Laboratory Course in the Experimental Analysis of Behavior

G. E. Zuriff
Wheaton College

A common problem in teaching undergraduate courses in the experimental analysis of behavior (EAB) is that the contemporary research literature is largely not comprehensible to most undergraduates. A suggested solution is the use of research articles from the early days of EAB. These are not only easy to understand but provide additional educational benefits. A reading list and an organizational structure for an undergraduate laboratory course in EAB are suggested.

Key words: experimental analysis of behavior, course readings, laboratory course, pedagogy

If there are to be future generations of behavior analysts, the seeds must be sown in undergraduate education. However, as Machado and Silva (1998) lamented, the undergraduate curriculum in learning and behavior is in a dismal state. My purpose is to address one relatively narrow problem in the undergraduate teaching of the experimental analysis of behavior (EAB), namely the use of primary sources in a laboratory course.

Most teaching in EAB uses secondary sources (i.e., textbooks that survey the field), and a number of such textbooks are readily available (e.g., Catania, 2003; Mazur, 2001). Nevertheless, students can also benefit from reading original research articles published in professional journals. These articles illustrate the details of experimental procedure, experimental design, data analysis, and how a research article is written. Thus, they give students insight into how the science of behavior is practiced and what might be expected in graduate school. However, even a cursory scanning of a contemporary basic research journal such as the *Journal of the Experimental Analysis of Behavior* quickly reveals that current articles far exceed the comprehension of most college students. Today's research reports are densely written, loaded with jargon and technical

terms, layered with quantitative analysis, and assume specialized familiarity with previous work.

I have struggled with this problem in an EAB laboratory course I have taught at Wheaton College for over three decades. The course is constructed as a sequence of experiments and demonstrations of operant conditioning principles, using rats as subjects. Our apparatus consists of an operant chamber, including a lever, a pellet dispenser, a small light, and a rod suspended from the chamber ceiling. Recording is accomplished with a stopwatch and a counter. I have used a variety of textbooks in learning and behavior as background, but these are not designed specifically for laboratory courses. A more relevant textbook is Johnston and Pennypacker (1993), which emphasizes research tactics. Unfortunately, the few laboratory manuals in EAB (e.g., Lane & Bem, 1965; Michael, 1963) are now out of print.

Faced with the problem of finding appropriate primary source readings, I have devised a solution, one I term the “golden oldies.” I have found it educationally beneficial to use research articles from the very early days in the history of EAB. Besides being understandable, they afford other pedagogic advantages. Because, for the most part, an undergraduate lab will consist of the replication of classical experiments in the discipline, the experiment described in an early article is often very

Address correspondence to the author at 120 Foster Street, Cambridge, Massachusetts 02138 (e-mail: gzuriff@wheatonma.edu).

similar to the experiment the students are performing in the course. Students can thus readily identify with the research and feel that their own experiment is also of value. Second, in many cases, students can compare their data with those reported in the article, occasionally quantitatively, otherwise qualitatively. Third, most articles suggest further hypotheses or research directions, and in the case of the golden oldies, the instructor can actually preview the following decades of research, pointing out which suggestions proved fruitful and which were revised over time. A fourth benefit to using the golden oldies is more subtle. In reading these articles, one can sense the excitement felt by these pioneering researchers as they worked to establish a new science and every finding was new and important. Ideally, students can share this excitement as they conduct their own work.

Nevertheless, the use of golden oldies is not without several disadvantages. First, many of these articles are hard to find, and not all libraries have them. However, with today's technologically proficient systems of interlibrary loan and Internet access, this disadvantage should not be hard to overcome. Second, occasionally the language in a golden oldie is archaic. One finds terms, statistical analyses, and concepts no longer in use. Similarly, the style and format of the articles no longer fully conform to American Psychological Association guidelines, and if one wishes to teach students how to write research papers, this disadvantage may be a serious one. Depending on the goals of the course, however, these problems may not be insurmountable.

Perhaps the chief objection to the replication of classic experiments and the use of golden oldies is the perception they may create. They may serve to confirm the false negative stereotype that behaviorism and behavior analysis are dead vestiges of the past, a stereotype often suggested in introductory psychology courses and textbooks.

One way to counter this perception is to be sure that the laboratory exercises and golden oldies serve as a stimulus for the teaching and discussion of the scientific developments that evolved directly from this early research. Rather than seen as a relic, EAB can be portrayed as a cumulative endeavor that has spanned 70 years and is still vigorously adding to a growing coherent body of knowledge and theory. Few other approaches to psychology can match this record.

Furthermore, both students and professors need to be reminded that nearly all the sciences, including the most mature natural sciences, teach laboratory skills to undergraduates through the replication of classic experiments. For example, physics undergraduates commonly replicate Cavendish's experiment, first performed in 1771, to measure the gravitational constant using a torsion balance, and they examine the dynamics of masses and pulleys using Atwood machine methods first developed around 1784. Unlike physics and chemistry, however, EAB has the advantage that the research reports for its classic experiments are accessible and comprehensible today.

In what follows I list nine units that comprise a semester-long laboratory course in EAB. Each unit consists of suggested laboratory exercises, data analyses, and a set of related readings selected, with two exceptions, from early articles in the history of EAB, along with a brief explanation of how each can be used in teaching. I also suggest lines of research that can be reviewed in class to teach how the classic studies and the golden oldies initiated later developments in the field.

THE COURSE

Unit 1: Preliminaries

Lab exercises. Students are trained in handling and weighing the rat. The rat is placed in the operant chamber for a period of time to acclimate the rat to its new environment. Students system-

atically observe the rat's behavior and record several baseline behavioral measures described below. During this time a deprivation regimen is begun.

Data analyses. Students calculate target running weight (e.g., 80% of the free-feeding weight of a control rat) and plot weight as a function of days on the deprivation regimen. While observing the rat, the students select at least three identifiable responses (being sure to include lever pressing) and calculate the absolute and relative response rates of each. At the same time, students construct a transitional probability matrix in which they record the relative frequency with which Response Y occurs given that Response X has just occurred. Students should be instructed to include in the matrix a response class ("other") that consists of all behavior other than the responses already specified. Students also observe and calculate the percentage of time (or percentage of time samples) that the rat spends in each half (or quadrant) of the box.

Reading. As students are introduced to their subjects, I use the occasion to discuss the ethics of using animals in experimentation. I have had success using the very concrete discussion in Penslar (1995, chap. 9). A more abstract and philosophical set of papers can be found in Pimple, Orleans, and Gluck (1997). A wide range of other relevant readings can be found in Cothran (2002) and Mur (2004). Students should be encouraged to become aware of and think through the ethical issues involved, specifically in relation to what they will be doing in the laboratory. Even if students conclude that their experimenting with rats is justified, as presumably they must have if they continue in the course, they nevertheless become sensitized as to how they handle their rats and are more careful not to cause unnecessary pain or harm.

The students' struggle to identify response classes can lead to a fruitful introduction to the concepts of response definition, operant response class, and

response individuation as they developed in behaviorist thought (Zuriff, 1985, chap. 3). Another line of discussion based on these lab exercises is the contemporary understanding of the complexity of the operant level and behavioral variation (Staddon, 2001).

Unit 2: Operant Conditioning

Lab exercises. Students shape bar pressing using successive approximation. Once bar pressing occurs, it is maintained by continuous reinforcement (CRF). During CRF, students record the frequency of subclasses of the operant response class (e.g., lever press with left paw, right paw, head) and continue recording the same measures as in Unit 1.

Data analyses. Students compare baseline (Unit 1) and post-CRF (Unit 2) measures of (a) absolute response rates, (b) relative response rates, (c) transitional probability matrix, and (d) relative location time. In addition, they can calculate absolute and relative response rates for each subclass of lever press.

Reading. Verplanck (1955) demonstrated the reinforcement and strengthening of verbal behavior in normal humans. This study shows that operant conditioning is effective with humans and that responses and reinforcements are not limited to lever presses and food pellets, but can include verbal responses and stimuli. This early study also nicely demonstrates both ABA reversal designs (i.e., baseline, change in contingencies, return to baseline) and multiple baseline designs as used in EAB as well as applied behavior analysis.

This article can serve as an occasion to introduce the "conditioning without awareness" controversy (Spielberger, 1962) that soon enveloped experiments such as this and eventually contributed to the cognitive revolution against behaviorism. The history of how the contemporary operant analysis of verbal behavior evolved from these early at-

tempts at verbal conditioning is reviewed by Catania (2003).

Unit 3: Intermittent Reinforcement

Lab exercises. The class is divided into two or more groups, and each is assigned a different schedule of reinforcement for the rat's lever pressing.

Data analyses. Students calculate the response rates and reinforcement rates under each schedule, and they compare the response and reinforcement rates among the schedules. Each group can also compare relative rates of the subclasses of the lever-press response class to those during CRF. Other analyses depend on which schedules are selected. For example, if a fixed-ratio (FR) schedule is used, students in that group can calculate the mean post-reinforcement pause and the mean interresponse time during the run to see if a pause-run pattern has developed.

Reading. If the groups differ on the value of the FR schedule used, then Felton and Lyon (1966) is the classic study. It demonstrates the within-subject design used in much EAB research in which each subject is run for many sessions through each of the values of the independent variable. A good idea is to assign this article along with Boren (1961), because the results of the two studies are in apparent contradiction and because the students' data are more likely to confirm Boren's results. This serves as an opportunity to discuss the differences between the two studies and the importance of parameters in discovering functional behavioral laws.

If the groups are using variable-ratio or variable-interval schedules, then two useful readings are Zuriff (1970) and Herrnstein (1961). The former demonstrates how the multiple-schedule method can illustrate, within a single-subject design, the remarkable differences in behavior generated by ratio and interval schedules even at the same rates of reinforcement. The latter study, of course, is the seminal experiment from which the matching law, the most

fruitful organizing principle in EAB research (Davison & McCarthy, 1988), was derived. This article is an excellent occasion to discuss the next several decades' research on choice and response strength (Davison & McCarthy) as well as the gradual integration of the matching law into applied behavior analysis (Pierce & Epling, 1995).

Unit 4: Extinction

Lab exercises. Students continue intermittent reinforcement of lever pressing for a brief period and then abruptly discontinue reinforcement. Throughout the session, students record the number of responses each minute as well as the frequency of subclasses of lever pressing. This procedure continues until some preestablished criterion of extinction is reached.

Data analyses. Students construct a cumulative record from the responses-per-minute data and analyze changes in the behavioral measures over the course of extinction, including variability in the lever-press response class. Students also measure resistance to extinction (i.e., responses and minutes to reach extinction criterion) for each group and compare the groups. In addition, students can analyze the data to see if an extinction burst occurred (i.e., a brief period at the beginning of extinction when the response rate is higher than the response rate before extinction is initiated).

Reading. Weisberg and Fink (1966) used FR reinforcement and then extinction on the bar-pressing response of human infants. This study shows not only that reinforcement is a robust process with humans but that the resulting behavior shows strong similarities between rats and human infants. Students can compare, for example, the course of extinction in their rats with that of the infants. Thompson, Heistad, and Palermo (1963) actually carried out this comparison in their study. They used both rats and young children as subjects while examining the relation between amount of CRF training and

the extinction burst during subsequent extinction. The study is an example of the across-subjects design used when within-subject designs are not feasible. The Boren (1961) study is also relevant in describing the relation between resistance to extinction and the value of the FR. The cumulative effect of all three studies is to provide a context for the students' data as they examine the relation between behavior in extinction, on the one hand, and reinforcement variables during operant conditioning, on the other hand.

Unit 5: Discrimination Training

Lab exercises. Students learn to establish a two-component multiple schedule in which lever presses are reinforced under an intermittent schedule in the presence of a discriminative stimulus, S^D (e.g., a light or sound), and extinguished in its absence, S^A .

Data analyses. Students analyze response rates during S^D and S^A over several sessions to see if behavioral contrast has occurred (i.e., an increase in response rate in the S^D component along with a decrease in response rate in the S^A component). Based on these data, they calculate a discrimination index (i.e., response rate in S^D divided by the sum of the response rates in S^D and S^A) for each of several sessions.

Reading. A study by Pierrel, Sherman, and Fischman (1963) is a good choice for this unit because the procedure and the number of training sessions are similar to those the students are likely to use. It is also a good introduction to the next unit, because one of the experimental groups was exposed to a generalization condition. This reading can lead to a discussion of how more complex discrimination methods were later developed (Sidman, 2000) and integrated into applied behavior analysis (McDonagh, McIlvane, & Stoddard, 1984).

Unit 6: Generalization

Lab exercises. Students present the rat with a sequence of novel stimulus

intensities, along with the S^A and S^D , each for a brief period, and record response rates during each. This is repeated several times and can be conducted either in extinction or while reinforcing in the presence of all stimuli except S^A .

Data analyses. Students learn to construct a generalization gradient using both relative and absolute rates of response. These gradients are then analyzed for peak shifts as well as for changes over time.

Reading. The Pierrel and Sherman (1962) experiment builds on Pierrel et al. (1963) but is devoted exclusively to generalization. Although the number of sessions run in this experiment is larger than what students are likely to run, the students' data may not differ markedly. The experiment is a good illustration of generalization gradients and peak shifts, and students can compare their results to those in the article. Discussions of this article can include a review of later developments in the experimental control of generalization (Herrnstein, 1990) and modern applications to education (Chase, 2003).

Unit 7: Conditioned Reinforcement

Lab exercises. Because the discrimination established in Unit 5 may be degraded by generalization testing, students may need to retrain the discrimination. Once the discrimination has been reestablished, students measure a baseline response rate for some new response (e.g., hitting the rod on the chamber ceiling). Next, the students use contingent presentation of S^D to shape or strengthen the new response.

Data analyses. Students compare the response rates for the new response (e.g., rod hitting) before and after reinforcing it with the S^D . They should also calculate the latency from the time S^D appears to the first lever press. They can analyze how this latency changes over the course of training.

Reading. Crowder, Morris, and McDaniel (1959) and Crowder, Gill, Hodge, and Nash (1959) should be re-

quired reading for all undergraduates who take a course in learning. Students typically have a hard time distinguishing between the eliciting and reinforcing functions of stimuli. In my experience, at the end of a semester-long learning course, students not uncommonly talk about how the pellet “elicits” lever pressing. In these two simple but elegant companion experiments, the difference between eliciting and reinforcing stimuli is clearly demonstrated. Furthermore, in the latter experiment, a new response is strengthened by the contingent presentation of a stimulus previously paired with food, a procedure similar to what the students are trying to accomplish in their own experiment.

Unit 8: Backward Chaining

Lab exercises. Students learn to establish a two-link behavioral chain using the following procedure: Rod hitting is reinforced by S^D presentation, and, in the presence of S^D , lever pressing is reinforced (under an intermittent schedule) by an unconditioned reinforcement (e.g., food pellet). Once the two-link chain is established, students can attempt a three-link behavioral chain by adding a third response (e.g., placing the nose in a particular corner of the chamber) and a second stimulus to the two-link chain.

Data analyses. For each link, students compare response rates before and after the chaining contingencies are established. They can perform the same analysis for latencies.

Reading. Thomas (1964) used a multiple schedule in which one component consisted of a three-member tandem schedule and the other component consisted of a three-member chained schedule. Differences in behavior between the two components can be attributed to the stimulus changes in the chained schedule. This article demonstrates how a multiple schedule can be used to explore different stimulus functions within a single subject. It also is a good exercise in reading

cumulative records, because subtle differences between the components are best observed in them. In a related experiment using chimpanzees, Kelleher (1957) demonstrated the establishment of a token as a conditioned reinforcement in a two-link behavioral chain. However, rather than using backward chaining, Kelleher conditioned each link independently with unconditioned reinforcement. These readings can serve as an introduction to the topic of the token economy and its widespread adoption in applied behavior analysis (e.g., Comaty, Stasio, & Advokat, 2001).

Unit 9: Aversive Control

My attempt to use electric shock in this course failed. I encountered a good deal of student reluctance, and, furthermore, I no longer think that the use of electric shock in an undergraduate course is ethically justified. For those who wish to demonstrate some of the effects of aversive stimuli, Alloway, Wilson, Graham, and Krames (2000) have developed a textbook and a CD-ROM that contains a rather realistic computer simulation of a rat in an operant chamber and includes virtual experiments on conditioned suppression using virtual shocks. One drawback of this simulation is that it includes no demonstrations of punishment, escape, or avoidance. It consists exclusively of conditioned suppression of an ongoing positively reinforced response as a measure of classical conditioning. A good reading to accompany this simulation is the original conditioned suppression experiment by Estes and Skinner (1941).

Alternatively, the semester may be completed by replicating an interesting and clever human experiment designed by Thorndike (1931, pp. 38–46). In this study of human paired-associate learning, Thorndike compared the effect of telling a subject “wrong” (a punishment) after an incorrect response with the effect of telling a subject “right” (a reinforcement) after a cor-

rect response. Each time I have tried this experiment with my students, we have obtained the counterintuitive results Thorndike predicted, namely, that although a “right” increases the probability that a correct response will be repeated, a “wrong” does not appear to decrease the probability of repetition for an incorrect response. This surprising result is an excellent occasion to discuss the debate over the use of punishment in learning and applied behavior analysis (e.g., Horner, Dunlap, Koegel, & Carr, 1990; Iwata, 1988).

CONCLUSION

The “golden oldies,” classic experiments from the early days of EAB, are a rich source for teaching about the science of behavior. I have suggested one syllabus I have found effective, but the recommendations in this article should not be taken as rigidly prescriptive. Instructors should feel free to choose golden oldies and classic experiments suitable for their own goals and teaching styles. Similarly, not all courses run the same number of weeks, and the list of experimental activities may have to be appropriately adjusted. Because the experiments are generally cumulative in nature, if some experiments need to be omitted, it is reasonable to eliminate the ones at the end. This means dropping the unit on aversive control (Unit 9) and then, if necessary, the unit on backward chaining (Unit 8). Alternatively, the units on extinction (Unit 4) and generalization (Unit 6) can be eliminated without serious damage to the sequence of experiments.

Use of the golden oldies is not without its drawbacks. In many ways they show their age, but paradoxically, they also offer a freshness and directness that may compensate for this apparent disadvantage. My own impression is that students are more engaged while reading them than they are with a textbook or while struggling with more contemporary articles. I recommend at least considering them.

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