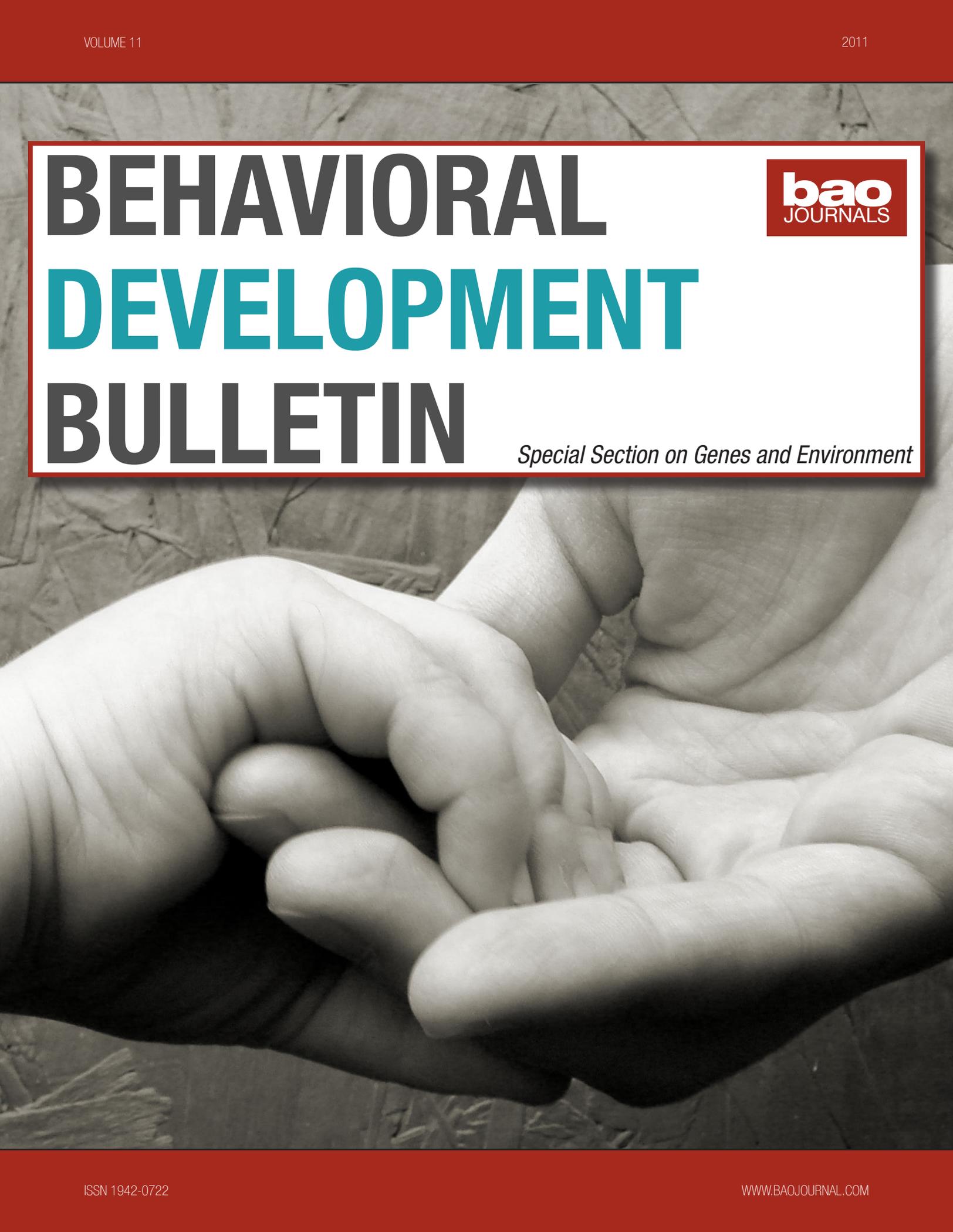


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The Learning-by-Doing Principle

Hayne W. Reese

West Virginia University

Abstract

Learning by doing has been a principle for thousands of years; it has had many proponents, including Plato, Thomas Hobbes, English and Spanish epigrammatists, Karl Marx and Mao Zedong, cultural anthropologists, Montessori, John B. Watson, and B. F. Skinner; and it has had many forms, including learning by doing, discovery versus instruction, practical experience versus book-learning, the practice-theory-practice dialectic, and proof upon practice. The paper includes discussion of several of the forms, with examples, to establish what the principle means; modifications of the principle such as instructed learning-by-doing and a role of reasoning; and possible explanations of its effectiveness.

Keywords

Practical Experience, Trial-and-error, Discovery, Practice-Theory Relation, Practice-Theory-Practice Dialectic

Learning by doing means learning from experiences resulting directly from one's own actions, as contrasted with learning from watching others perform, reading others' instructions or descriptions, or listening to others' instructions or lectures. Of course, watching, reading, and listening are actions, but they are not the kinds of doing referred to as learning by doing because they yield direct experience with demonstrations or descriptions of actions rather than with actions the learner actually performs. In classical psychology and its hangers-on (e.g., Robinson, 1930), "direct experience" meant mental contact with mental phenomena by introspection; but in the present context, it means sensory contact with the results of doing.

The learning-by-doing principle has been advocated widely and in many forms, including learn-by-doing, trial-and-error learning or discovery versus instruction, practical experience versus book learning, the practice-theory-practice dialectic, and "proof upon practice." The word practice in the last two of these versions is sometimes interpreted to mean repetition, as in a study by Keeling, Polacek, and Ingram (2009) discussed in the subsection "Learning to Ask Good Questions." However, it is intended in the sense of praxis, which means a goal-directed behavior. The phrase "goal-directed behavior" can be interpreted in a cognitive sense or in the sense of an operant behavior.

The learning by doing principle is old and many advocates have stated it as a truism. For example, it was cited without documentation by Sam Bonasso, a civil engineer, in an essay on creativity (Bonasso, 1983), and by the "semanticist, economist, and writer" Stuart Chase, in a book against communism and fas-

cism (Chase, 1938, p. 182; the quoted characterization of Chase is from Chase, 1969, unnumbered p. 217). Other examples of uses of the principle are discussed in the next section.

USES OF THE PRINCIPLE

The uses summarized in this section are organized by form or version of the principle. This approach is based largely on convenience, but some versions emphasize aspects of learning by doing that are only implicit in other versions.

■ DISCOVERY VERSUS INSTRUCTION

The first example in this section is more or less from everyday life. Another example of this sort is given in the section "Proof upon Practice."

TRIAL AND ERROR VERSUS READING A USER'S MANUAL

Trying to solve a computer or other mechanical problem by reading a User's Manual often leads to nothing but frustration, either because the manufacturer provides no hardcopy User's Manual or the one provided seems to have been written in a foreign language and badly translated into English or written in geek-jargon and not translated at all. Using trial and error with the computer keyboard and mouse often leads to problem solution, but this is not learning by doing unless the discovered process is remembered.

TRIAL AND ERROR VERSUS INSTRUCTION

Sidman (2010) commented that learning by doing can be errorful as in trial-and-error learning, or errorless as in insight and programmed errorless learning. Harlow's (1949, 1959) concept of learning set is relevant. It involved performing on a series of two-stimulus discrimination-learning problems each with a different pair of stimuli. The research showed that after a prolonged training series, subjects solve new problems in a single

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trial, whether the subjects are animals such as pigeons, rats, and nonhuman primates, or humans ranging from young childhood through old-old age and from below normal in intelligence to normal or better (for reviews, see Reese, 1963, 1964, 1989).

The occurrence of one-trial learning in this situation looks like insight, but only if one is unaware of or ignores the long training series in which the learning on each problem was by trial and error. Actually, at the end of training the one trial on which the new learning occurs can involve an error because the learning set provides no way to foretell which new object is correct. Therefore, the learning set can be described as Win-Stay, Lose-Shift: "Guess on Trial 1; if correct on Trial 1, choose the same stimulus thereafter, and if incorrect on Trial 1, choose the other stimulus thereafter." Normal human adults could presumably be taught the quoted sentence and might subsequently exhibit the learning set, but in this case the learning would be by instruction and the only insight involved would be realizing that the sentence is true.

Programmed errorless learning is a kind of instruction in that its effectiveness in eliminating errors depends not on the nature of the task but on the skill of the programmer. In the standard procedure, only the correct stimulus or only the incorrect stimulus is presented on the first trial or the first few trials of a problem, and then a choice trial is given with both stimuli. Research showed that errors occur on choice trials in the initial part of the series of training problems, indicating that the learning was actually not errorless.

In another procedure, often involving a single discrimination problem, the correct stimulus is presented alone at first and then the other stimulus is faded in before the choice trial. A typical finding is that some subjects make an error on the choice trial. A version of this procedure is being used when a complex behavior is taught by step-wise shaping of the behavioral units that compose it. Sidman (2010) commented that if the learner makes an error in a step, the teacher revises the "instruction." The learner is learning by doing in the sense that he or she is actually performing the behavioral units, but it is not real trial-and-error learning, it is learning by doing as instructed (discussed in the section "Role of Indirect Experience" and other sections cited there). The units are identified by a task analysis done by the teacher. According to my notes, Sidman said that any kind of trial-and-error learning would benefit from task analysis, and for trial-and-error learning in the usual sense, the task analysis should be done by the learner. The usual learner would need to learn how to do effective task analyses, and I suspect that this learning would most efficiently be learning by doing as instructed by an expert at task analysis.

This point is also applicable in "programmed instruction," which is like programmed errorless learning but in an educational context. The aim is to present the course aims and contents in a programmed form designed to allow students to learn on their own, at their own pace, with no errors, or a minimum of errors, and without lectures by an instructor. The effectiveness of the program depends on the program writer's skills not only in analyzing the aims and contents of a course but also in writing the steps that can lead students to learn by their own efforts. Cohen (1962) interpreted the method used by Socrates

and Plato as programmed instruction (he also cited two other interpretations).

A simpler, more direct version of the Socratic and Platonic method has been shown to facilitate problem solving. For example, Grote, Rosales, Royer, and Baer (in press) showed that 4-year-olds' sorting of multidimensional stimuli was facilitated by asking, "What are you looking for?" The question is content-free in that it does not refer to any specific dimension or set of dimensions that could be used as the basis for sorting; it seems to have been effective because it led the children to identify and then to name features that were bases for correct sorting. An example with more specific questions is a study by Lisina showing that young children's performance improved when the examiner asked task-relevant questions such as "How are you going to reach that?" and "What is broken?" The questioning led to greater organization and goal-directedness of the children's actions, presumably because it induced the children to identify an appropriate action or a relevant aspect of the situation (Zaporozhets, Zinchenko, & El'konin, 1971, pp. 214-215). Evidently, the questions in these examples, and in Socrates's and Plato's method, function as instructions. Therefore, these procedures exemplify learning by doing as instructed.

LEARNING THE DIALECTICAL METHOD

Kozulin (1984, p. 131) attributed the learning-by-doing principle to John Dewey; but although Dewey may have popularized it, it was known already by Plato. Plato believed that the way to learn "the philosophical method," by which he meant dialectic, is by using it (Annas, 1981, pp. 276, 292). In *The Republic*, Plato refused to answer young Glaucon's questions about the dialectical method because Plato thought it could be learned only by years of personal experience and practice (Plato, *The Republic*, Bk. 7 [532e-533a, 534], also identified as Pt. 3, chap. 27; 1941, pp. 253, 255).

RELATIONAL-FRAME LEARNING

A research example of discovery versus instruction is a study by Eikeseth, Rosales-Ruiz, Duarte, and Baer (1997) on stimulus equivalence in college students. Eikeseth et al. used instructions rather than training to establish the initial conditional associations, and then they gave symmetry and transitivity tests of stimulus equivalence with 16 interspersed probes of memory for the instructed associations. Only 28 of 58 subjects--about 48%--met a memory criterion of at least 15 correct responses on the 16 probes, and only 50% of the 28 exhibited stimulus equivalence by meeting the same criterion on the symmetry and transitivity tests. Eikeseth et al. said that 50% success is not bad in that it has also been found in the first set of probes when the initial conditional associations were learned by training rather than instructions. For documentation, Eikeseth et al. cited four reports, one covering two experiments. One of the cited experiments (Sidman, Kirk, & Willson-Morris, 1985, Exp. 2) included a normal adult, and his performance on the initial test trials--30% and 41% correct responses--was fairly consistent with the point alleged by Eikeseth et al. However, the other four experiments were irrelevant: three included no adults (Devany, Hayes, & Nelson, 1986; Lazar, Davis-Lang, & Sanchez, 1984; Sidman et al., 1985, Exp. 1) and one included children

and severely retarded institutionalized adults (Sidman, Willson-Morris, & Kirk, 1986). In any case, the learning-by-instruction approach Eikeseth et al. used is not as good as the learning-by-training approach, which involves learning by doing and allows the researcher to continue the learning-by-doing trials until the subject exhibits stimulus equivalence or can be inferred to be untrainable.

In another study, Eikeseth and Baer (1997) used learning-by-instruction and found that 26 of 36 subjects--72%--met the memory criterion, but none of the 26 met all the criteria for stimulus equivalence. They had expected this kind of result because the stimuli were meaningful and therefore had associations that could compete with the equivalence relations. The message I get from the two studies is that discovery is better than instruction for learning stimulus equivalence and perhaps all relational frames.

EDUCATION AND COGNITIVE DEVELOPMENT

The discovery versus instruction principle is a basis of Montessori's (1912/1964) educational methods. Using these methods, a teacher gives no formal instructions but equips the classroom with materials selected to encourage exploratory actions by the children that lead them to discover the principles that the teacher wanted them to learn. Soviet psychologists also endorsed the discovery versus instruction principle. For example, Pavel Blonsky recommended it as a method for school instruction (Kozulin, 1984, p. 131).

Discovery has also been a basic developmental principle, perhaps especially in dialectical theories. Examples are Piaget's cognitive psychology (e.g., Piaget, 1970) and Soviet psychology (e.g., Lisina, 1985, pp. 8-9).

■ PRACTICAL EXPERIENCE VERSUS BOOK LEARNING

BACKGROUND ON BOOK LEARNING

During the Scholastic era, much of philosophy was devoted to interpreting Aristotle's writings and using the interpretations to understand nature. Beginning in the Renaissance a primary aim of philosophy was to repudiate this book-learning kind of scholarship. For example, in 1651 Thomas Hobbes argued that the basis of true knowledge is learning from experience rather than book-learning (for references see the later subsection "Thomas Hobbes"). However, the fight has not yet been won. For example Marxist scholars, especially in the defunct Soviet Union, were still spending much of their time interpreting what were known as "The Classics," which were writings by Marx, Engels, and Lenin (Kamenka, 1967; Payne, 1968; Planty-Bonjour, 1967). The epitome of the continuation of the Scholastic tradition in the Western world has been Biblical scholarship, which by 427 C.E. already had an exegetical literature (Augustine, *On Christian Doctrine*, XXXIX Para. 59; 427/1958, p. 74).

PRACTICAL EXPERIENCE IN POLITICS

The German Marxist Karl Kautsky (1908/1953) endorsed the need for practical experience, and he attributed the principle to Rousseau (p. xii). Kautsky said that a participant in any act understands it better than a spectator does, and that a political

activist therefore has a better understanding of political history than does an historical scholar "who lacks the least practical acquaintance of what makes politics go" (p. xiii).

An example of Kautsky's point can be seen in an article by Ryan Lizza (2008) in *The New Yorker*. The article is about the history and current practices of selecting Vice Presidential nominees in the United States. Lizza discussed three practices that John Kerry identified, grouped roughly by when the candidates are selected: January, August, or October of the election year. The January selections are relevant here because the primary qualification is potential for helping the hoped-for new administration govern, and Lizza implied that this qualification reflects the need for practical experience. He said that the evidence of the required potential is usually "congressional experience and long Washington résumés," and as examples he mentioned Lyndon Johnson, Walter Mondale, George H. W. Bush, Al Gore, Dick Cheney, and Joe Biden. The needed expertness is knowing the inner workings of congress and lobbying by having been there and done that. In short, political experience in Realpolitik is more important than political theory. (Incidentally, for August selections the primary qualification is potential for helping restart a lagging campaign, and for October selections, potential for carrying a geographic or demographic group. Sarah Palin was the August type for John McCain; John Edwards was the October type for John Kerry.)

LANGUAGE ACQUISITION

Seventeenth century students at Harvard University were given theses written in Latin and were required to defend them in Latin. One of the theses in 1643 was, "Linguae foelicus usu, quam arte discuntur" (Morison, 1936, p. 583), which means "Languages are learned better by use than by formal rules" (Ong, 1958, p. 197, citing Morison). This principle is a truism now, but a challenge is presented in the subsection "Learning language by use."

LEARNING TO ASK GOOD QUESTIONS

Much research and a lot of theory indicate that learning is facilitated if the learner asks good questions (for a brief review, see Brill & Yarden, 2003). Keeling, Polacek, and Ingram (2009) wanted to study the effect of practical experience on the quality of questions generated by undergraduates in a real-life situation--a senior-level college biology course that included eight laboratory sessions. Before each laboratory session, each student was required to write at least three questions relevant to the session. A commentator in *Science* (MM, 2009) said that the quality of the questions improved over time, but actually the changes were statistically nonsignificant for the class as a whole, and for individual students the correlation between quality and time was statistically significant for only 3 of 38 students. The problem seems to have been inadequate feedback.

The authors said in their method section, "Brief marginal comments were written for feedback, discouraging lower-level questions and attempting to promote greater clarification and deeper thought" (p. 132). However, in their discussion section they said the results suggested that "learning by doing' is not enough . . . and that more explicit guidance and discussion may be required" (p. 138). They also said that asking good questions

had almost no consequences because full credit could be earned by asking almost any relevant questions and the grade for the questions accounted for only about 1.25% of the course grade. An implication discussed more fully in the subsection “Marxist version” is that feedback about unimportant consequences is ineffective and, conversely, important consequences are effective. The value of this statement can be questioned, because effectiveness is an observed property meaning that the desired behavioral change occurred, and importance is a conceptual property inferred from effectiveness. However, from the functional perspective of behavior analysis the concept of importance has the same epistemological status as the concept of reinforcement; therefore, the statement that important consequences are effective is analogous to the statement that reinforcement changes behavior. Nevertheless, like the relation between reinforcement and behavior change, the relation between importance and effectiveness is definitional rather than causal. Therefore, saying that importance causes effectiveness would be unjustified.

My conclusion is that practical experience without important feedback is mere repetition and is ineffective for learning by doing. That is, the proverb “Practice makes perfect” is wrong if practice means mere repetition, because repetition without feedback can make a habit stronger but cannot make it better (this point is supported in the subsection “Marxist version”). Therefore, learning to ask good questions is a version of learning by doing as instructed, which is discussed in the section “Role of Indirect Experience.” As such, learning to ask good questions is related to asking good questions to facilitate learning, which is discussed in the section “Trial and Error Versus Instruction.”

PRACTICAL EXPERIENCE IN OTHER DOMAINS

Claude Bernard (1865/1927, p. 15) argued that practical medicine should be based on experimental evidence and he said, rather ornately, that direct participation is needed: “We shall reach really fruitful and luminous generalizations about vital phenomena only in so far as we ourselves experiment and, in hospitals, amphitheatres, or laboratories, stir the fetid or throbbing ground of life.”

John B. Watson’s (1928) position was not so stringent. He said that literary authors need to have direct experience with their subject matter, but he added that authors can get their direct experience by observation rather than participation. That is, authors do not need to live the lives they observe, and indeed in some cases they should not live these lives. As an example, he said that being a reveler would interfere with clear observation of revelry. Although this example may support his point, the qualification--“in some cases”--correctly implies that the point is not universally applicable. An example might be the primitivist writer Jesse Stuart, who spent much of his life in the kind of rural environment in which his stories are set, perhaps accounting for his stories having an air of authenticity and veracity that made them popular even among highly urbanized readers (Foster, 1981). If, as I assume, he was an observer in the rural environment, he exemplifies Watson’s position; but he could have been a participant, thus exemplifying Bernard’s position.

The stance of Sergei Michailovich Tretyakov, a Russian poet, was more consistent with Bernard’s than Watson’s position. Tretyakov (1930) argued that “A close connection should be es-

tablished between author and subject,” which he said does not mean moving through the subject “like a tourist, ‘a respectful looker-on’” but actively participating in the subject (pp. 47, 48). In his own case, he established the close connection by becoming an active participant in a collective farm.

The American poet and Fascist sympathizer Ezra Pound (1931) said that Tretyakov’s position was not new: “There is nothing new for us in a writer’s living the life he writes of” (p. 124). However, Pound himself took a position closer to Watson’s than to Bernard’s and Tretyakov’s. As summarized by Walkiewicz and Witemeyer (1980), Pound’s position was that “the job of the Western writer is to observe his society, to communicate what he has learned about it, and to keep his art free from ideological bias” (p. 448).

■ THE PRACTICE-THEORY-PRACTICE DIALECTIC

ANALYSIS OF THE PRACTICE-THEORY-PRACTICE DIALECTIC

Marxist version. The learning-by-doing principle is seen in the practice-theory-practice dialectic, which is a basic principle in Marxist philosophy, theory, and application. For example, Karl Marx advocated and used it (1939/1973), the Soviet Union child psychologist Lev Vygotsky used it (1929, pp. 418, 431), and Mao Zedong popularized it in China (see inset quotation below). In this dialectic, “practice” means “doing,” not “repetition”; and “theory” is used in a broad sense that includes “knowledge” and “understanding.” The dialectic makes practice primary, like the doing in the learning-by-doing principle, and makes theory, knowledge, and understanding secondary because they are derived. This is a basic ordering in dialectical materialism.

Schram (1983) seems to have believed that Mao Zedong initiated the idea that practice is primary and knowledge is derived, but actually Marx initiated it (however, I believe the problem was in Schram’s wording rather than his belief). Petrović (1983) cited Marx’s third and eighth theses on Feuerbach on the origin (the theses are in Marx, 1845/1976). The gist of the third thesis is that conditions change human acts and are changed by human acts, and the gist of the eighth thesis is that social relations are practical in the “doing” sense. The eighth thesis is an explication of the seventh thesis--human characteristics are produced by social relations.

Petrović also cited a statement from the section “Private Property and Communism” in Marx’s Economic and Philosophical Manuscripts of 1844: “The resolution of theoretical contradictions is possible only in a practical way, only through the practical energy of man” (Petrović, 1983, p. 386). The italics are Marx’s (e.g., 1844/1975, p. 302). The statement was in a section that Marx crossed out, according to the editors, but evidently his crossing it out did not indicate that he rejected the idea; it is consistent with the theses on Feuerbach, which he wrote the next year. (Marx’s frequent use of italics reminds me of Little Orphan Annie’s in the comic strip written and drawn by Harold Gray. However, Marx’s excess can be excused because he was writing notes for his own use; Gray was writing for a readership. Gray’s stories, incidentally, were politically conservative morality plays [Horn, 1976, p. 459].)

Mao (1963/1968) stated the basic idea of the practice-theory-practice dialectic: Knowledge is at first perceptual, but sufficient accumulation of perceptual knowledge results in a dialectical leap to conceptual knowledge. This leap is one process in cognition, from objective matter to subjective knowledge. “Subjective knowledge” is a person’s (“subject’s”) knowledge, that is, an interpretation; but the first dialectical leap does not prove the correctness (truth) of subjective knowledge. Rather, correctness is proved by further practice, which is the practice-theory-practice dialectic. Mao (1937/1965) said:

Discover the truth through practice, and again through practice verify and develop the truth. Start from perceptual knowledge and actively develop it into rational [conceptual, theoretical] knowledge; then start from rational knowledge and actively guide revolutionary practice to change both the subjective and the objective world [i.e., the world as known and the actual world]. Practice, knowledge, again practice, and again knowledge. This form repeats itself in endless cycles, and with each cycle the content of practice and knowledge rises to a higher level. Such is the whole of the dialectical-materialist theory of knowledge, and such is the dialectical-materialist theory of the unity of knowing and doing. (p. 308)

The phrase “the unity of knowing and doing” does not contradict the primacy of practice over knowledge, cited earlier in this subsection. The relevant Marxist principle is “the struggle and unity of opposites” (for philosophical discussion, see, e.g., Planty-Bonjour, 1967, chap. 6; Wetter, 1958, Pt. 2, chap. 3, 1966, Pt. 1, chap. 5; for a brief overview, see Wozniak, 1972).

The inset quotation means that actual doing generates some knowledge, this knowledge leads to more effective doing, which generates improved knowledge, and the cycle continues until the doing attains its goal effectively and efficiently, that is, the cycle continues until the knowledge needs no further functional improvement. The cycle may seem to refer to practice in the sense of repetition; but it does not, because each instance of the doing is different from the preceding one. Furthermore, the differences are improvements in knowledge because they result from improvements in practice, which Mao explicitly said includes scientific experiments (1937/1965, 1940/1963, 1963/1968).

The cycle is like the Hegelian thesis-antithesis-synthesis trilogy, or negation of the negation, but with an historical necessity of improvement rather than Hegel’s logical necessity (for discussion see the subsection “Gap Between Practice and Theory”). The source of the historical necessity is feedback from practice; that is, knowledge changes because each doing in the cycle generates consequences that the doer observes. Therefore, feedback is an essential feature of the practice-theory-practice dialectic. This need for feedback supports the conclusion about the proverb “Practice makes perfect” in the subsection “Learning To Ask Good Questions.” Feedback is also needed because learning by doing requires not only doing something but also learning something from the doing. Learning requires some sort of feedback such as reward or punishment in stimulus-response learning theory and SR⁺ or SR in behavior analysis.

Other versions. Other versions of the learning-by-doing principle do not refer explicitly to theory, knowledge, or understanding,

but they implicitly require something of this sort. In stimulus-response learning theory, it is the concept of habit strength; in behavior analysis, it is the concept of the organism’s history of experiences with specified three-term contingencies; and in Aristotle’s theory it is hexis, which means potentiality in the sense of a person’s being able to perform an action that he or she is not performing right now. Hexis must be preceded by dynamis, which is potentiality in the sense of being able to learn a particular hexis (these are Aristotle’s typical uses of the two Greek words, but he sometimes used dynamis in both senses, e.g., in Aristotle, On the Soul, Bk. 2, chap. 5 [417a 21 - 417b 1]).

These versions demonstrate that Marxism is not the only possible basis of a practice-theory-practice kind of analysis. Like the learning-by-doing principle, it has had several different philosophical bases, and sharing the principle does not mean that these philosophies are compatible. An idealist example is Imre Lakatos’s (1978) philosophy that scientific progress has two forms, theoretical and empirical, and that a new scientific program can be theoretically progressive for a while by making stunning new predictions, but it will not survive unless it becomes empirically progressive by testing and confirming the predictions. Progress needs to be made experimentally, which means made via practice, as well as theoretically.

Lakatos erred on another point: He said that a theory is rejected if the stunning predictions are not confirmed. This assertion is consistent with Karl Popper’s falsificationism theory (1983, pp. xxi, 162, 244, 247-248, 342), which implies the silly notion that scientists do prediction-testing experiments in the hope that the predictions will be disconfirmed. Popper’s theory was that on the one hand, theories cannot be verified by confirming predictions, because the so-called verification would be the logical fallacy of affirming the consequent, but on the other hand, theories are falsified by disconfirmation of predictions, which is the valid argument of denying the consequent. Larry Laudan (1977, pp. 114-118) got the point right in arguing that when a prediction is disconfirmed, only a rival theorist rejects the theory. He also pointed out that proponents of the theory patch it up so that it provides a post hoc explanation of the anomalous observed facts without losing its prior explanatory value, and ideally the proponents then test the patched-up theory by testing predictions that it generates. This is what the practice-theory-practice dialectic means. It is also the standard procedure in behavior analysis: Start with a more or less vague idea or hunch, do research and see what happens, then do follow-up research to refine knowledge about the controlling variables, and the cycle continues.

NEED FOR TRANSFORMATION

Marx (1845/1976) expressed the need for practice in the sense of doing in his second thesis on Feuerbach: The truth of thinking is proved by practice, not by theory. He specified in the 11th thesis that the practice must change something: “The philosophers have only interpreted the world in various ways; the point, however, is to change it” (p. 8). The doing can be a conceptual analysis (i.e., a mental action) or a physical action. In both cases, the doing is transformative, either by transforming concepts or transforming things.

Conceptual analysis. When the doing is conceptual, the practice-theory-practice dialectic implicates Kaplan's (1964) "paradox of conceptualization": "Proper concepts are needed to formulate a good theory, but we need a good theory to arrive at the proper concepts" (p. 53). If "practice" is substituted for "theory," the relevance of Kaplan's paradox is more direct: The proper concepts are needed to formulate good practice, but we need good practice to arrive at the proper concepts. In a conceptual analysis, then, the development of theory, knowledge, or understanding consists of discovering through practice new significance--new empirical relations--of old concepts and dropping old concepts that have lesser significance in favor of new concepts that retain the old significance and promise to have new significance (expected to be revealed in further practice).

Marx (1939/1973, p. 100) used a conceptual analysis in developing *Das Kapital*: Such an analysis begins with a whole that is given concretely by experience; this whole is "chaotic" and it can be understood only by analysis. However, it is the psychological unit, and it can never be understood if it is also the unit of analysis. The needed units of analysis are the parts of the whole and their interrelations, but initially they are abstract conceptions rather than concrete experiences. Therefore, the analysis begins with identification of plausible conceptualized parts, continues with conceptual analysis of the whole into these parts and their possible interrelations, and then conceptually synthesizes the analytic parts and interrelations to create a new understanding of the whole. The process continues with better conceptualized parts and interrelations, and each new analysis and synthesis produces an understanding that is more coherent and less chaotic than the preceding understanding.

Physical analysis. Relevant to physical doing, Mao Zedong said, "If you want knowledge, you must take part in the practice of changing reality. If you want to know the taste of a pear, you must change the pear by eating it yourself" (1937/1965, p. 300). Juan Pascual-Leone, who is a Spanish-Canadian Marxist neo-Piagetian, also made the point, but not as concretely as Mao. Pascual-Leone (1976) said, "To know an object one must interfere with or act upon it; only in this praxis can the constraints of reality . . . create knowledge" (p. 112). Urie Bronfenbrenner attributed the same idea to his graduate-school mentor W. F. Dearborn: "If you want to understand something, try to change it" (Bronfenbrenner, 1977a, p. 284; 1977b, p. 538). I do not know whether Dearborn and Bronfenbrenner were Marxists, but the important point here is that the doing is not just looking at and observing things; it is active mental or physical manipulation that changes concepts or things. This point is examined in more detail in the section "Proof upon Practice."

Other views of transformation. In Pepper's (1942) analysis, organicism is the same as Hegel's philosophy, which was the dialectical idealism that Marx stood on its head when he created dialectical materialism. Dialectical materialism is consistent with Pepper's contextualism (Reese, 1993). Jean Piaget (1970) was an organicist, and he emphasized the role of transformation in the development of knowledge: "In order to know objects, the subject must act upon them, and therefore transform them: he must displace, connect, combine, take apart, and reassemble them" (p. 704). The rationale is that the transformations rule out al-

ternative interpretations of observed phenomena. Experimental methodology in science has the same form and rationale. The transformations are manipulations that change reality to create experimental conditions; the rationale is that by creating the experimental conditions, scientists rule out naturally occurring extraneous conditions as possible causes of the observed phenomena.

■ THE PRACTICE-THEORY RELATION

GAP BETWEEN PRACTICE AND THEORY

The authors cited in this section did not clearly distinguish between two meanings of "practice": practical application and transformative doing.

The philosopher of science Mario Bunge (1967) said:

The doctrine that practice is the touchstone of theories relies on a misunderstanding of both practice and theory: on a confusion between practice and experiment and associated confusion between rule and theory. The question "Does it work?," pertinent as it is with regard to things and rules, is impertinent in respect to theories. (p. 128)

A "touchstone" is "a test or criterion for determining the quality or genuineness of a thing" (Merriam-Webster's, 2002, p. 1243). Therefore, "practice" as the touchstone of theories is the transformative kind of doing; but Bunge's contrasting of "practice" and "experiment" and his associated contrasting of "rule" and "theory" implicate "practice" as practical application. Aside from being confused, Bunge was wrong because the question "Does it work?" is pertinent not only to practical applications and practical rules, but also to theories and transformative doings such as experiments. A theory "works" if it leads to predictions that are verified empirically, according to Lakatos, Popper, and Laudan; and a transformative doing or experiment "works" if it confirms expectations or predictions or disconfirms them but leads to plausible patching of the underlying theory (subsection "Other versions").

Brandtstädter (1980) said, "no logical tracks lead from theory to practice and back again" (p. 16). He was right whichever sense of "practice" is used, but only because the relation between theory and practice in either sense is not a logical relation. Kemp (1992) expressed this point with respect to practical application in saying that engineering at its best is not applied science, it is an art form. Any relation between practical application and theory is empirical rather than logical because a scientific theory does not necessarily have any implications about practical application and vice versa. As in the Marxist practice-theory-practice principle, the relation between transformative doing and theory is dialectical. As a Marxist concept, this dialectical relation is true by historical necessity, that is, it is necessarily true because it is what occurred in fact (Engels, 1894/1987, p. 124; Hook, 1950/1962, p. 68). In this respect, as mentioned in the subsection "Marxist version," it is different from Hegel's triad of thesis, antithesis, and synthesis, which is a logically necessary progression in Hegel's dialectical idealism (Hegel, 1830/1892, chap. 9; Hook, *ibid.*). (A parenthetically noteworthy point is that Marx often said that the dialectical relation is a necessity, most notably in his and Engels's Manifesto of the Communist

Party [Marx & Engels, 1888/1955, pp. 31, 32] but also elsewhere [Marx, 1852/1983, pp. 62, 65, 1875/1989, p. 95]. However, he was not asserting any logical necessity in dialectical materialism, he was talking about past and expected future historical necessities in historical materialism.)

SUCCESS IN APPLIED PRACTICE

“Practice” in this section means practical application in the real world, as in “medical practice.” Baer (1981) said that theory and the basic research it generates enable successful practical application but do not guarantee it, and practical application can be successful even if the enabling theory and basic research are unknown to the practitioner. For example, the art of photography was made possible by basic knowledge about optics, the physical mechanics of cameras, chemistry, and so on, but a photographer does not need this knowledge in order to be successful. Furthermore, as Baer said, to get good pictures of a wedding one hires a photographer, not an optics researcher, and to get treatment for an ailment one goes to a physician, not a physiologist. Preferably one goes to an expert practitioner, but knowledge about a practitioner’s practical expertness is sometimes hard to get.

Baer’s point that practitioners can be successful without relevant book learning means that their successful practice must have come from direct experience. These practitioners would begin as uneducated novices, and being uneducated, they would need to get the knowledge required for successful practice either by using a trial-and-error method to get the direct experience that would generate this knowledge, or by using the method of learning by doing as instructed by an expert practitioner (this method is discussed in the section “Role of Indirect Experience”). A problem with the first method is how the novices could recruit persons to be subjects of the trial-and-error work. Who would volunteer to be subjects of trial-and-error work by a would-be surgeon, or even a would-be professional wedding-photographer?

Juan Huarte solved this dilemma in the 16th century by explaining why theory is needed:

To what end serveth it to spend time in schooles? to this may be answered, that first to know the art of phisicke is a matter verie important: for in two or three yeares, a man may learn al that which the ancients have bin getting in two or three thousand. And if a man should heerin ascertain himselfe by experience, it were requisit that he lived some thousands of yeeres, and in experimenting of medicines, he should kill an infinit number of persons before he could attain to the knowledge of their qualities: from whence we are freed, by reading the books of reasonable experienced phisitions. (Huarte, 1594/1959, p. 181; orthography modernized; spelling and punctuation unchanged)

Consequently:

The perfection of a phisition consisteth of two things The first is, to weete [i.e., know] by way of method, the precepts and rules of curing men in generall, without descending to particulars. The second, to be long time exercised in practise, and to have visited many patients: for . . . there rest in them particularities of such condition, as they can neither be delivered by speech, nor written, nor taught, nor

so collected, as that they may be reduced into art: but to know them, is onely granted to him, who hath often seen and had them in handling. (pp. 174-175)

That is: Book-learning or theory deals with universals, which are abstract, and practice deals with particulars, which are concrete. Therefore, book-learning is insufficient by itself because it is uninformative about regularly successful practice, which requires knowing and dealing with the relevant particulars of each different person. However, direct experience is also insufficient by itself because although it deals with particulars, life is too short for direct learning of all the particulars that are relevant to successful practice. Therefore, effective practitioners base their procedures not only on extensive practical experience but also on theoretical principles. The theoretical principles are learned from books written by well-experienced prior practitioners; the practical experience permits implementing the principles in ways that are effective in particular cases such as a physician’s curing a particular ailment in a particular person. The basic message I derive from Huarte’s discussion is that theory is a distillation of previous persons’ direct experiences and it is needed to guide present seekers of direct experiences.

SUCCESS IN SCIENTIFIC PRACTICE

The message I drew from Huarte’s discussion of the relation between theory and applied practice is also relevant to the relation between theory and practice as transformative doing in science. However, some commentators have emphasized the fact that theory can have scientifically undesirable effects. For example, Farrington (1961, p. 207) said, “If he [a scientist] has a theory he tends to see what supports it and to miss other significant facts.” Lillard (1999, p. 57) made a point consistent with Farrington’s: “People respond not to the world as it is, but to the world as they believe it to be”--“belief drives action.” Skinner (1980) went further:

[Models] evoke contemplation rather than action. The theoretical physicist wants to represent reality; the laboratory physicist wants to do something about it. One changes a model to produce a different picture; the other manipulates independent variables to change a dependent variable. A model is what something is to be done about; it is not what is to be done.

Model is little more than another word for idea--something known by acquaintance. I look forward to greater recognition of the importance of laboratory scientists. The theorists have been sponging on them for decades and getting most of the credit. (pp. 173-174)

Even granting all this, the consensus supports extending Huarte’s message to science: Theory is needed as a guide for direct experience in the form of research. James Mark Baldwin (1895) made the point, a little effusively:

That most vicious and Philistine attempt in some quarters to put psychology in the straight-jacket of barren observation, to draw the life-blood of all science--speculative advance into the secrets of things--this ultra-positivistic cry has come here as everywhere else, and put a ban upon theory. On the contrary, give us theories, theories, always theories! . . . In the matter of experimenting with children,

. . . our theories must guide our work. (p. 38)

Others have made the point without the effusion. (a) Pasteur said, “Without theory, practice is but routine born of habit. Theory alone can bring forth and develop the spirit of invention” (Vallery-Radot, 1923, p. 76) and “Progress with routine is possible, but desperately slow” (p. 146). (b) Kantor (1953, p. 20) said, “Hypotheses, laws, or theories . . . are very often the most effective instruments for discovery and measurement.” (c) The Soviet psychologist S. L. Rubinshteyn (1955/1957, p. 265) said, “Experimental investigation is blind unless its course is illumined by theory.” (d) Farrington (1961, p. 207) said, “In the infinite variety and complexity of the phenomena of nature the scientist is at a loss in which direction to turn unless he is looking for something. If he is looking for something, that means he has a theory.” (e) Lewis (1966, 1988) said that theoretical work is foremost because nontheoretical research is “inscribed (trivial, limited)” (1966, p. 72).

■ “PROOF UPON PRACTICE”

The “proof upon practice” proverb means that proof in the sense of a test of truth is given by practice in the sense of one’s own action. One version of it, not discussed herein, is the “successful working” truth criterion of contextualism (Pepper, 1942; Reese, 1993); four other versions are discussed in the following subsections.

“PROOF UPON PRACTICE” VERSION

The 16th century English epigrammatist John Heywood seems to have created the “Proof upon practice” version of the proverb, although its meaning was older. He described it in the following lines from a longer poem:

Practise in all, above all toucheth the quick.

Proof upon practise, must take hold more sure

Than any reasoning by guess can procure.

If ye bring practise in place, without fabling,

I will banish both haste and busy babling. (1562/1966, p. 15; his italics)

“Babbling” is an old, now obsolete version of “babbling” (Oxford, 1989, p. 850); one meaning, which I think is the one Heywood intended, is foolish or meaningless talk (Oxford, p. 848). Heywood apparently used the italics to identify proverbs that he was attempting to explicate by weaving them into a story, and in this quotation their sense is carried by his phrase “proof upon practise,” that is, truth is tested by practice, not by reasoning.

“PROOF OF THE PUDDING” VERSION

According to an English proverb, “The proof of the pudding is in the eating” (Magill, 1965, p. 805); that is, the test of truth is in a relevant action. Stevenson (1967, p. 515) attributed this proverb to in No. 567 of *The Spectator* and to Henry Glapthorne in Act 3 of *The Hollander*. Addison called it “a homely Proverb” (1714, unnumbered p. 2), indicating that he did not originate it. In Glapthorne’s (1635/1874) play the character *Sconce*, who is the Hollander, has bought a “weapon salve” that purportedly can cure wounds without surgery and he questions its efficacy,

saying “The profe of a pudding is the eating” (p. 116). Tilley (1950, p. 558) did not cite Addison, but he cited Glapthorne, two uses earlier in the 17th century than Glapthorne’s use, and eight uses later than Glapthorne’s.

The “proof of the pudding” proverb has also been attributed to Cervantes in *Don Quixote* (Bartlett, 1980, p. 169; Stevenson, 1967, p. 1621), but the attribution is not strictly correct. The proverb was used in a 1700 translation of *Don Quixote* into English, as a substitute for the Spanish proverb “It will be seen in the frying of the eggs” (Magill, 1965, p. 805), which is discussed next. (Bartlett and Magill attributed the translation to Peter Motteux. Bartlett cited Part 4, chapter 10, page 322 in what he called a Modern Library Giant edition, without citing a year. A 1950 edition published by “The Modern Library” contains the pudding proverb at the location Bartlett cited; this edition is a 1719 revision by John Ozell of Motteux’s translation [Doyle, 1950, p. vi], and an editorial note on page 322 indicates that the pudding proverb was substituted for Cervantes’s frying-eggs proverb. Therefore, Bartlett should have known that his attributing the pudding proverb to Cervantes was incorrect. The Modern Library published another translation in 1949, by Samuel Putnam. Putnam [1949] said that critics called the Motteux translation “odious,” “worse than worthless,” and “the very worst” [pp. x, xii-xiii]; he said the Ozell revision was in 1725 [pp. xii, 1037]; and he cited a 1930 Modern Library publication of the Motteux-Ozell translation [note 18, p. 466; p. 1037]. He used Cervantes’s frying-eggs proverb [Cervantes, 1949, Part 1, chap. 37, p. 335]--“you will see when you go to fry the eggs”--and he indexed an unhelpful end-note, in full it was: “5. A proverb” [p. 483]. Stevenson cited Part 2, chapter 24 in no specified edition, but this chapter is not relevant in any edition I have seen, including a facsimile of the 1605 Spanish edition [Cervantes Saavedra, 1605/1905].)

“FRYING EGGS” VERSION

The meaning of “proof upon practice” is expressed in a 15th century Spanish proverb about knowledge based on discovery: “It will be seen in the frying of the eggs” or “On frying the eggs you will see.” Cervantes used this proverb in *Don Quixote* (Part 1, chap. 37; the “It will” version is from Cervantes Saavedra, 1605/1905, p. 322; the “On frying” version is my translation of “Al freir de los huevos lo verá” *ibid.*, spelling modernized). Fernando de Rojas used a version without the eggs in 1499 in *La Celestina*--“Al freyr lo verá,” “On frying you will see” (Rojas, 1499/1913, p. 39; my translation). However, as indicated in the third context described below, the eggs were implicit in his version.

Three main contexts have been used to explain the proverb. The most popular one was given by, for example, the editors of two English translations of *Don Quixote*: A robber stole a frying pan from a house and the mistress of the house saw him and asked him what he had. He answered, “On frying the eggs you will see” (Cervantes Saavedra, 1932, note 2, p. 422) or “you will know when your Eggs are to be fry’d” (Cervantes, 1950, note *, p. 322). Iribarren cited a somewhat different context that had been given in 1574:

Melchor de Santa Cruz, in his *Floresta española de apotegmas* [Collection of Fine Spanish Aphorisms; my translation], published in 1574 (chap. 5, story 10), says thus:

“A charcoal merchant sold a basket of charcoal to a woman, and took a frying pan that was poorly guarded, and put it in the empty basket. Upon the woman’s asking him if the charcoal was of oak, and if it was good, he said, “On frying the eggs you will see.” (Iribarren, 1955, p. 123)

The third context was given in the 1950 edition of *Don Quixote* cited above: “When Eggs are to be fry’d, there is no knowing their goodness till they are broken” (Cervantes, 1950, editor’s note *, p. 322). Cejador gave this context more fully in a comment about the line quoted above from Rojas’s *La Celestina*:

On frying the eggs you will see is another version (Don Quixote, Part I, chap. 37). On frying the eggs is when one sees what they are; in the event, things become known. Eggs that are soft-boiled or scrambled can pass as good; but not so those that are fried, because the yolk is entirely visible. (p. 92 in Cejador’s note 15, in Rojas, 1499/1913; my translation)

(Iribarren also cited Cejador’s comment.) This context legitimizes the substitution of the “proof of the pudding” proverb for the “frying eggs” proverb. The substitution would be “The proof of the pudding is in the eating” for something like “The test of the egg is in seeing the yolk.”

A MODERN VERSION

Skinner (1945) gave a modern version of “proof upon practice”:

The ultimate criterion for the goodness of a concept is not whether two people are brought into agreement but whether the scientist who uses the concept can operate successfully upon his material—all by himself if need be. What matters to Robinson Crusoe is not whether he is agreeing with himself but whether he is getting anywhere with his control over nature. (p. 293)

That is, “the scientist” does not use the mechanistic criterion of truth by agreement, but rather uses proof upon practice, which as noted above is the contextualistic truth criterion of successful working. In Skinner’s statement, the phrase “operate . . . upon his material” refers to a doing kind of practice, and the adverb “successfully” and the “getting anywhere” clause refer to proof.

CHALLENGES OF LEARNING BY DOING

■ Pervasiveness Is Not Relevant

The pervasiveness of the learning-by-doing principle implies that it is more effective than other methods of learning, such as direct instruction; but it equally implies nothing more than that the principle is believed to be more effective. Empirical evidence is troublesome because any one condition can be found to be superior to a comparison condition if the comparison condition is selected for its known or presumable inferiority. Of course,

using this device violates one of the canons of science, stated with some euphoria in 1841 by the astronomer John Herschel:

Another character of sound inductions is that they enable us to predict. We feel secure that our rule is based on the realities of nature, when it stands us in the stead of new experience; when it embodies facts as an experience wider than our own would do, and in a way that our ordinary experience would never reach; when it will bear not stress, but torture, and gives true results in cases studiously different from those which led to its discovery. (p. 233)

A problem is that even if the strategy is used consistently with Herschel’s canon, it is not necessarily sufficient, because research methods can be more subtly flawed. The anthropologist L. Marano (1982) said, “Exposure to primary data source opportunities does not often lead to valid conclusions when inadequate research strategies are employed” (p. 395).

When definitive empirical evidence cannot be obtained, the only alternative strategy may be to use theoretical evidence. In the present case, the evidence would come from a persuasive theory about why learning by doing is effective. I address this issue in the last section. Theory also has another role, discussed next.

■ ROLE OF THEORY

As indicated in the section “The Practice-Theory Relation,” a problem with the learning-by-doing principle is that the doing needs to be guided: Doing, or practice in general, always has an effect—even if only a small or trivial one—and therefore practice is always some kind of efficient cause. However, as Hegel (1830/1892, p. 344) said, efficient cause is blind without final cause. Or as stated in a Soviet manual, *Fundamentals of Marxism-Leninism*, “unguided by theory, practice is doomed to grope in the dark” (1st ed. 1961, p. 114; 2nd ed. 1963, p. 94). The negative “unguided by theory” implies that practice should be guided by theory. This implication is verified in a later version: One function of theory is “to point the way ahead to new knowledge” (*Fundamentals*, 1982, p. 181). That is, theory should function as a purpose of practice, and as a purpose it has the functions—but not the nature—of a final cause.

■ ROLE OF REASONING

John Heywood’s (1562/1966) comment about “reasoning by guess” (in the subsection “Proof upon Practice’ Version”) is relevant here. He did not mean that reasoning is irrelevant to proof upon practice, but that reasoning without practice is “busy babbling.” The role of reasoning was also discussed by 17th century authors.

THOMAS HOBBS

In 1651 in *Leviathan*, Thomas Hobbes endorsed a kind of learning by doing in which scientists’ knowledge is based on facts they obtain directly rather than by revelation or the authority of books. His spin on the principle was that scientific knowledge does not come directly from the directly obtained facts, it comes from reasoning about these facts. He excluded reasoning based on “supernatural revelation” and “the authority of books,” and

the kind of knowledge reflected in “prudence,” or “foresight,” which is based on experience but not reasoning (Hobbes, *Leviathan*, Part 1, remarks in introductory chap., which is chap. 46 in Part 4 of the original work, 1st, 2nd, 4th, and 5th paragraphs; re “foresight,” chap. 3, paragraph marked *Prudence*, see also chap. 5, penult. paragraph; re role of reasoning, chap. 5, *ibid.* and paragraph marked *Science*; re “science,” chap. 9, chart; 1651/1958, pp. 3-4 in intro. chap., pp. 34-35 in chap. 3, 49-50 in chap. 5, 76-77 in chap. 9).

Hobbes also said:

*Men that take their instruction from the authority of books, and not from their own meditation [are] as much below the condition of ignorant men as men endowed with true science are above it. . . . For words are wise men's counters, they do but reckon by them; but they are the money of fools that value them by the authority of an Aristotle, a Cicero, or a Thomas [Aquinas], or any other doctor whatsoever, if but a man. (Hobbes, *Leviathan*, Part 1, chap 4; 1651/1958, pp. 41-42; bracketed “Aquinas” is editor's insertion)*

He that takes up conclusions on the trust of authors, and does not fetch them from the first items in every reckoning, which are the significations of names settled by definitions, loses his labor; and does not know anything, but only believes. (chap. 5; p. 46)

When I read these statements, I wondered why I was reading Hobbes's book; but then I realized that I was reasoning from what he had written rather than accepting his authority. An implication is that book learning can be a useful substrate for reasoning. This implication is consistent with the point of the preceding section.

S. DE COVARRUBIAS OROZCO

In 1611 Covarrubias gave reasoning a role in discovery in his interpretation of the “frying eggs” proverb discussed in the subsection “Frying Eggs’ Version.” He said:

This proverb gives us to understand that if we are not prepared with enough time to avoid haste, and we are advised of the absence of something that is needed for attaining our end, we should take the council of the sage and wise and when the event comes, we will notice the absent thing that we are accustomed not to think of. (1611/1943, p. 668; my translation)

The basic point is still knowledge through discovery, but specifically in cases where the absence of reasoning makes a person unlikely to detect the missing object because the object's *presence* is too commonplace to be noteworthy. Benjamin Whorf (1940/1956) also discussed cases like this and gave the examples of “not missing water till the well runs dry, or not realizing that we need air till we are choking” (p. 209).

■ ROLE OF INDIRECT EXPERIENCE

A preliminary point is that in this section the basis of learning has shifted from *doing* to *direct experience*. This is a standard shift; for example, Peláez and Moreno (1998) used it in a distinction between rules provided by others and self-generated rules, which are generated by one's own direct experience. I discuss an

implication of this shift in the section “Self-Shaping”; the aspect relevant here is the converse, learning from *indirect* experience.

The learning-by-doing principle implies that laboratories of science are useful because they permit direct experiences by doing, but scientific journals, books, and lectures are not useful because the only doings they require are reading or listening and then comprehending and remembering. These doings yield only indirect experiences with their topics. Therefore, only the elite, the few with direct experience, can truly understand phenomena.

A counterargument is that although direct experience is necessary, it can be acquired indirectly. The point is expressed in a Latin proverb, “What should be done must be learned from one who does it” (quoted from Davidoff, 1946, p. 101). This proverb means learning by doing as instructed, which is discussed here and at least mentioned in the sections “Trial and Error Versus Instruction,” “Learning To Ask Good Questions,” “Success in Applied Practice,” “Errors by the Founder,” and “Learning language by use.”

Thomas Huxley implicitly referred to this point in a speech on technical education that he gave in 1877 to the Working Men's Club and Institute in Britain. He had described technical education as “the teaching of handicrafts” (1877/1882, p. 74; his quotation marks), and he said that “many of you” might well wonder “What does this speaker know practically about this matter? What is his handicraft?” (p. 75). He then devoted about two and a half pages to arguing that in his scientific specialty, which was anatomy, he did intricate dissections that required him to be a handicraftsman. I do not think he established his credentials as a handicraftsman, especially because of two further comments: (a) The formal education of boys who will become working men, or handicraftsmen, should end “as early as . . . at present” (p. 82) to allow them to engage in learning their handicraft. In that era, these boy's formal education ended at the age of 13 or 14 years (p. 86). (b) Consistently with the principle of learning by doing as instructed, he said, “The workshop is the only real school for a handicraft” (p. 80). The initial workshops for anatomical dissections probably included work on animal and human cadavers, perhaps animal vivisection, watching experts do operations on live humans, and their own supervised doings of such operations. This sequence involves the method of learning by doing as instructed by relevant experts.

Mao Zedong directly referred to the point under consideration:

All genuine knowledge originates in direct experience. But one cannot have direct experience of everything; as a matter of fact, most of our knowledge comes from indirect experience. . . . [However], what is indirect experience for me is direct experience for other people. Consequently, considered as a whole, knowledge of any kind is inseparable from direct experience. All knowledge originates in perception of the objective external world through man's physical sense organs. Anyone who denies such perception, denies direct experience, or denies personal participation in the practice that changes reality, is not a materialist. (1937/1965, p. 300)

(The phrase “is not a materialist” was a polite way of saying “is an idealist,” which is anathema to a Marxist.)

■ EXCURSUS ON THE INDIRECT EXPERIENCE PRINCIPLE

The alleged role of indirect experience is not necessarily a serious challenge to the learning-by-doing principle because the indirect experience principle also has problems. Four kinds of problems are discussed in the present section.

DISTANCE FROM DIRECT EXPERIENCE

As indicated in the inset quotation above, Mao Zedong assumed that another person’s direct experience can substitute for a person’s own direct experience. A problem with this formulation arises when the direct experience is at the beginning of a chain of tutors passing their indirect experiences to their pupils who in turn become tutors, and the chain is probably often long and increasingly separated from the direct experiences that founded the chain. The problem is that each pupil’s direct experience is not with what the tutor learned, but with the tutor’s words or actions, and as the chain becomes longer, the words or actions might reflect less and less well what the founder had learned by direct experience.

ERRORS BY THE FOUNDER

Another problem is that even the founder might convey knowledge poorly. For example, in the standard procedure for instructing ballet dancers, the choreographer’s instructions consist largely of demonstrating the desired movements by performing them, then leaving while the dancers practice what they remember having observed, and then returning and critiquing their performances verbally and with further demonstrations. An anecdote about the ballet dancer and choreographer George Balanchine provides an example. He instructed his dancers almost entirely by performing the movements he wanted. Taper (1960) described the process:

*What a ballerina may pick up from watching Balanchine dance her part for her is a heightened awareness of her own special style and qualities, which his keen eye has perceived, and which he has rendered in clarified form for her. Still, there is no denying that all his dancers are acutely responsive in copying and appropriating the qualities he sketches out in dance for them. An instance of just how responsive they are occurred when he was choreographing *Bourrée Fantasque* a number of years ago. When he had the ensemble repeat for him a section that he had created the preceding week, he was perplexed to see that all the movements were being danced in a peculiarly cramped and agonized way. When he questioned the dancers, they insisted that this was the way he had shown the steps to them. He could not figure it out until he recalled that the week before he had been suffering from bursitis; the company had apparently picked up all his aches and pains and magnified them into a bursitic *Bourrée Fantasque*. (Taper, 1960, p. 23)*

In terms of the present analysis, Balanchine deliberately used doing for instruction, the dancers deliberately imitated what

they had seen, and they based their imitations largely on what they had already learned by doing. The rehearsal hall is lined with mirrors and the dancers watch themselves and practice until their movements accurately imitate what they remember seeing. That is, their indirect experience of watching Balanchine’s performance-as-instruction became their direct experience of monitoring their own performance.

This example shows that learning by indirect experience can include deliberate verbal or motoric instruction, incidental modeling, and learning by doing. The learning-by-doing aspect involves direct experience with one’s own deliberate and automatic doing in attempting to reproduce a model’s demonstrations. An important point here is that this learning by doing is not learning by imitating, because learning by imitating is learning by observing someone else’s action. As indicated in the example, learning by imitating becomes learning by doing when the learner learns by directly observing his or her own action. However, it is not pure learning by doing; it is learning by doing as instructed or modeled (discussed in the section “Role of Indirect Experience”).

LIMITED SCOPE

A preliminary point is that learning by indirect experience such as watching, reading, listening, and imitating, may be less effective than learning by doing, but it is certainly more efficient as far as it goes and for many purposes it goes far enough (see the section on science education in the April 23, 2010 issue of *Science*, Vol. 329, and letters to the editor in the August 13, 2010 issue). An example is solving problems with a word processor by reading a good user’s manual, such as *Power Point 2003 Just the Steps for Dummies* (Obermeier & Padova, 2006). Nevertheless, the learning-from-indirect-experience argument is not convincing in some cases. I describe four cases in the following paragraphs.

An animal analogue. One case is a study by Held and Hein (1963) on the development of visually guided behavior in kittens that were reared in darkness and then were given visual experiences. The kittens were paired and the kittens in a pair received highly similar visual experiences in the apparatus shown in Figure 1. One kitten received varying visual stimulation that it actively produced by walking in both directions, stooping, and rearing. The paired kitten received the same varying visual stimulation passively, by riding in a gondola yoked to the first kitten’s movements by the chain across the top, the bar, and the pivot (the cylinder on the bar is a moveable counterweight). Head movements also provide varying visual stimulation, but the active kitten’s head movements were not transmitted to the passive kitten, and its head movements were not controlled and therefore provided unyoked, independent variations in visual stimulation. The findings indicated that the active kitten developed normal vision, but the passive kitten did not until it was allowed 48 hours of unrestricted activity in a lighted room. Evidently, normal visual development requires actively produced variations of visual stimulation, and merely looking at scenery that happens to change is not sufficiently active to be effective. Analogously, in humans watching, reading, listening, comprehending, and remembering are not sufficiently active kinds of doing.

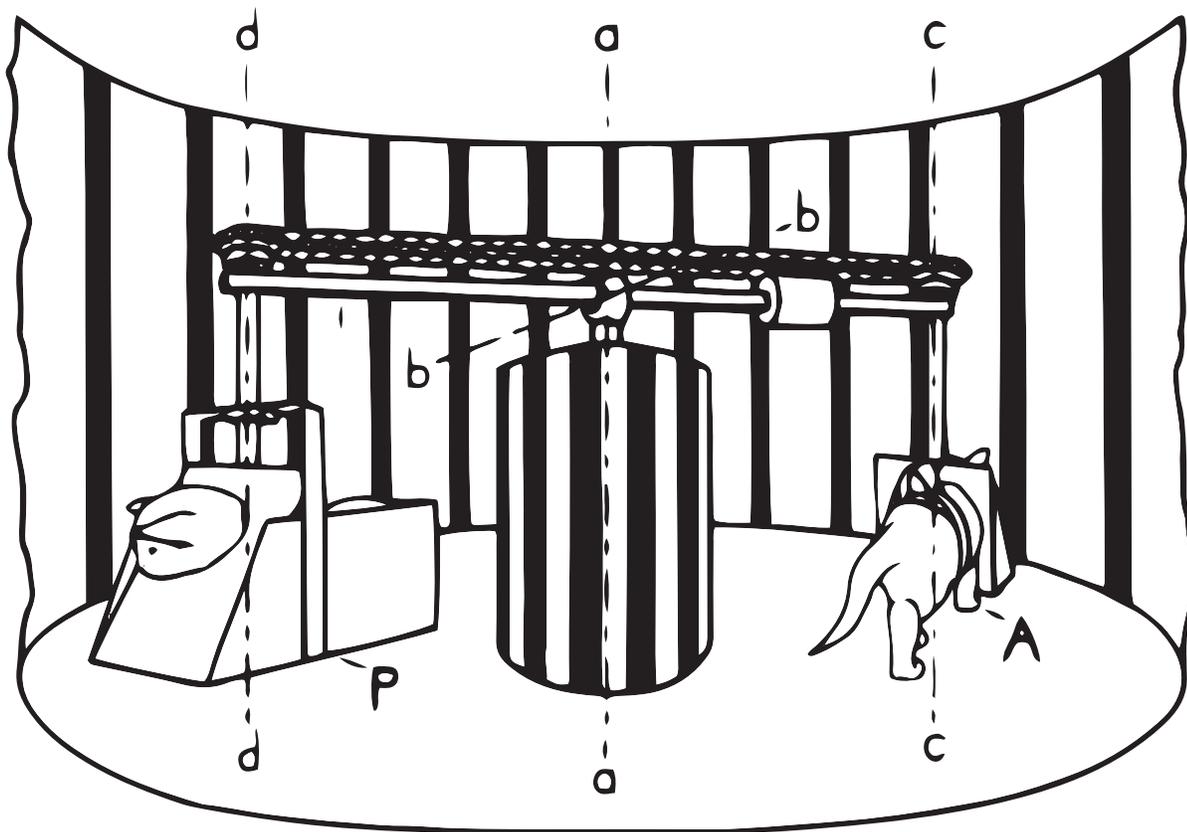


Figure 1. Apparatus used by Held and Hein. See text for explanation. (From Held & Hein, 1963, Fig. 1, p. 873. Used by permission.)

Learning paired associates by imagery. Research on verbal learning was once dominated by the paired associates task, which required learning arbitrary pairings of items. In the classical task, the paired items were nonsense syllables to rule out cognitive effects on learning, based on research by Ebbinghaus (Hoffman, Bringmann, Bamberg, & Klein, 1987, pp. 58-60). Eventually, however, researchers realized that meaning is the essence of verbal learning and they switched to arbitrarily paired real words presumed to be known by the participants. One of the great discoveries thereafter was that pairs of concrete nouns can be learned and remembered very easily by imagining an interaction between the referents of the nouns in each pair. This was actually a rediscovery of a principle that had been known in ancient Greece and thereafter (Yates, 1966). One 19th century writer gave a circular explanation: “Images are easily formed and never forgotten” (I am quoting from memory, having lost the reference).

Atkinson (1975) described a practical application that involved English-speakers’ learning a foreign-language vocabulary. The learner is instructed to encode each foreign word in the list as a concrete English noun that is acoustically related to the foreign word and then to imagine an interaction between the referents of the correct English word and the code word. One of his examples was learning that duck is pato in Spanish: Pato is pronounced roughly like “pahtoh,” so the acoustic code word could be pot and the interaction could be the image of a duck with a cooking pot on its head worn like a baseball cap. The research showed that using the imagery technique to

learn English-Spanish associations, for example, automatically yielded backward, Spanish-English associations, which had to be learned separately when rote memorization was used. The research also showed that the use of imagery improved long-term memory of the associations--a finding also obtained in research on learning pairs of English words (reviewed in Reese, 1977a, 1977b). Another finding--the one relevant here--is that Atkinson’s research showed that in general, the technique was more effective if the English words used as codes for the foreign words were provided by the researcher than if they were made up by the learner. In this sense, instruction worked better than entirely personal practice.

Learning language by use. The third case is about learning a language by using it. Using a language is interpreted to be direct experience, as implied in the subsection “Language Acquisition,” but it relies on examples and feedback provided by speakers of the language who are more experienced than the learner. In other words, it is a case of learning by doing as instructed (discussed in the section “Role of Indirect Experience”). A fictional example is in the 1985 movie with Mel Gibson and Tina Turner, “Mad Max Beyond Thunderdome.” Mad Max happened upon a community of children who spoke a primitive version of English. The children had survived a nuclear holocaust and afterwards they lived in a commune set up by adults who shortly abandoned them. The older children provided language models for the younger ones, but the older ones had been young children at the time of the isolation from adults, and therefore the language models they provided were developmentally retarded

in vocabulary and grammar. This outcome is consistent with an old saying, “A stream can’t rise above its source” (W. Smith, 1948, p. 625, cited an example of its use in 1700).

Two empirical examples illustrate the same point. First, language proficiency in slum adults and children tends to be deficient relative to middle-class language, presumably because children initially learn language from caregivers who are adults or older children. Second, standardized tests show that twins tend to have smaller measured vocabularies than nontwins, but other evidence indicates that the reason is that twins tend to develop their own words for some things and actions. Both examples presumably reflect group differences in the quality of the input and feedback.

In conclusion, learning language by using it involves a person’s own direct experience with the results of others’ direct experience, but the learner’s direct experience cannot produce a better effect than the others’ direct experience produced for them because the learner’s direct experience is indirect with respect to the others’ direct experience.

Learning methodology from scientific reports. In many graduate programs, students are required to read scientific reports published in journals rather than reading articles and books that are reviews of research findings. The rationale may be, in part, that reading the primary sources is a way to learn how to do research. If so, the effort is wasted, especially for learning how to do bench research. The general reason is that in science, research is conducted in a context of discovery and research results are reported in a context of justification (Reichenbach, 1938, pp. 6-7, 1947, p. 2, 1951, pp. 230-231). Annas said that Aristotle made the distinction in Posterior Analytics: Science begins with the simple and works upward, “not because that is how we discover truths, or even how we first learn them, but because that is the method of rational presentation that will best facilitate understanding of the subject-matter” (Annas, 1981, pp. 291-292). (I did not find this idea expressed so clearly in Posterior Analytics, and Annas gave no specific citation. However, chap. 13 in Book 1 of Posterior Analytics is relevant.)

Kaplan (1964, pp. 14-15) pointed out that different kinds of logic are used in the contexts of discovery and justification: “The ‘logic of discovery’ can be construed as a study of the reasons for entertaining a hypothesis, in contrast with the logic of proof, which deals with the reasons for accepting a hypothesis” (p. 17). Similarly, Vygotsky said, “The course of actual investigation never coincides with its final published record” (1934/1986, p. 209). More fully, Karl Marx said:

Of course, the method of presentation must differ in form from that of inquiry. The latter has to appropriate the material in detail, to analyse its different forms of development, to trace out their inner connection. Only after this work is done, can the actual movement be adequately described. If this is done successfully, if the life of the subject-matter is ideally reflected as in a mirror, then it may appear as if we have before us a mere a priori construction. (from the preface to the second edition of Capital; e.g., 1890/1906, pp. 24-25)

and

The concrete is concrete because it is the concentration of many determinations, hence unity of the diverse. It appears in the process of thinking, therefore, as a process of concentration, as a result, not as a point of departure, even though it is the point of departure in reality and hence also the point of departure for observation (Anschauung) and conception. Along the first path the full conception was evaporated to yield an abstract determination; along the second, the abstract determinations lead towards a reproduction of the concrete by way of thought. . . . [T]he method of rising from the abstract to the concrete is only the way in which thought appropriates the concrete, reproduces it as the concrete in the mind. (Marx, 1939/1973, p. 101)

Similarly, Pepper said he developed his “root-metaphor” theory of world views by examining the origins and features of world views, but in his 1942 book he presented the theory (chap. 4-5) before describing the world views (chap. 7-11). He said he used this sequence “to serve the purposes of exposition” (Pepper, 1942, p. 84) and “for reasons of simplicity of exposition” (Pepper, 1943, p. 603). A final example is that Flavell, Green, and Flavell (1986) called such a method “customary in scientific writing” (p. 4): In reporting the results of several related experiments, effective writers put the experiments in a sequence that best compels the conclusions, not necessarily the sequence in which the experiments were done.

Medawar (1963) and others (e.g., Goodstein, 2002; Madigan, Johnson, & Linton, 1995; Woodward & Goodstein, 1996) believed that the differences between reports of research and actual research is unfortunate because the reports mislead students and others who are not already skilled researchers. For example, it represents research as more organized and logical than it usually is in practice. This problem is especially acute when bench research methods are used. One characteristic of bench research is that in light of the incoming data, the researcher can change the procedures being used and even the research questions being asked. Another characteristic is that the data are recorded as notes in record books, and the notes cover not only observations but also minutiae regarding changes in the questions and procedures. The report of bench research is based on the notes but mercifully does not usually include all their contents, thus leaving uninitiated readers still uninitiated.

Brill and Yarden (2003) obtained evidence apparently contradicting Medawar and the others in a study of question-asking by high-school biology majors. The quality of the students’ questions was better in an experimental group than in a control group, and improved in the experimental group but not in the control group. However, the study was flawed in one way and irrelevant in one way. The flaw was that the topics of the experimental and control classes were different; the point leading to irrelevancy was that the research reports used in the experimental classes had been revised to make them more informative than the original reports. Specifically, students in the experimental classes, on developmental biology, learned by reading research reports that had been revised by adding information about the background of the research questions, simplifying the research methods and the discussion, omitting results not directly relevant to the research questions, and adding a section

on the contribution to knowledge. Students in a control class, on genetics, learned by reading a textbook.

PROBLEMS WITH SECOND-HAND EXPERIENCE

A problem that has often been discussed, and is implied by comments in the preceding subsection, is that second-hand experience is often too incomplete to be useful. An example is in an anonymous review of the first edition of Samuel Butler's *Evolution, Old & New*. Butler was a novelist and an amateur evolutionist, and in the book he challenged Charles Darwin's theory of natural selection and favored theories of inheritance of acquired characteristics, especially Buffon's, Erasmus Darwin's, and Lamarck's. The reviewer said, "One would think that Mr. Butler was the travelled and laborious observer of Nature, and Mr. Darwin the pert speculator, who takes all his facts at secondhand" (quoted in Butler, 1924, p. 343).

The problems of using secondary sources are magnified when they are based on writing a review of the published literature--or, worse, reading such a review, especially if the review involves meta-analysis (Reese, 1999). The reason is that a review--and especially a meta-analysis--is not only inevitably incomplete with respect to the details of direct experience but also likely to be expressed in abstract language. If it is, it is a kind of "etic" description (described in the section "A Language Explanation"). For example, Allik and Valsiner (1980) disparaged authors who merely talk about a phenomenon rather than investigate it directly. Writers who disparage talk-the-talk and praise walk-the-walk are making the same point. An example is a comment by Koffka (1925) about a theoretical description that Lindworsky (1919) had given of the behavior of animals in the transposition task. Koffka said, "Certainly it does not agree with the description Kohler gives of learning in hens" (note 208, p. 369). The implication is that Lindworsky was too far removed from the actual observations to understand the behavior of the animals. A remark by Vygotsky (1929/1981, p. 213) about Köhler's work is relevant and supports Koffka's argument. According to Vygotsky, Köhler observed that the chickens "sometimes fell stupefied to the ground and were completely upset when they were confronted with new shades of gray" (i.e., when they were confronted with transposition-test stimuli).

A literary example is Mayne Reid's inveighing against "closet-naturalists" (quoted from James, 1898/1978, p. 132; Skrupskelis, 1978, p. 220). Skrupskelis (p. 220) quoted an example: "There is one thing that is almost intolerable and that is the conceit of the 'closet naturalist,' who sneers at every thing as untrue that seems to show the least design on the part of the brute creation." The implication, I think, is that the design will be clear to anyone who actually experiences nature.

Another literary example may be remarks by "Jim Venture, Outdoorsman" in television and cartoon advertisements for Eveready batteries in the 1950s and 1960s. For example, a fishing or hunting party led by Venture would be awakened during the night by animal noises and Venture would shine his flashlight and reveal an untoward event such as a beaver chewing a canoe paddle or an animal raiding the food supplies. He would then say "A little tip from Jim Venture" and continue with something like "always store the paddles in a tree because beavers chew on them for the salt," or "always hang your food from a

limb to keep it away from the animals." The point here is that his good advice always came too late, after the untoward event had occurred. Perhaps the writers of the episodes were using a dramatic device based on belief that few persons would be as interested in an episode in which Venture gave the advice beforehand while smugly putting the canoe paddles in a tree, thus losing the drama of being awakened by chewing sounds and the opportunity to use a flashlight powered by Eveready batteries. Or perhaps they were applying the learning-by-doing principle to the fictional participants in the episode. (Or perhaps I have distorted the whole matter; my comments and quotations are based solely on my memory because I have not found any references to this advertising campaign in any literature.)

WHY IS LEARNING BY DOING EFFECTIVE?

In the present section, I discuss three kinds of explanation of why learning by doing is more effective than other methods. The first kind seems to me the most plausible, but all three are speculative. All three are based on assuming that the effectiveness of learning by doing reflects the ease or speed of learning, the relevance of what is learned, or the memorability of what is learned, or combinations of these virtues.

■ SELF-SHAPING

Perhaps learning by doing has the virtues it has because it is learning by self-shaping. Self-shaping would optimize the steps and their sequence because the effectiveness of the contingencies would be suited specifically to the doer by the doer, and the contingencies would therefore more effectively devise and sequence the steps in the learning process.

This explanation has some conceptual support: Peláez and Moreno (1998) suggested that a person who uses a rule that had been provided by others "may have no understanding of how to arrive at, or devise such a rule, because he or she may 'know that' but not 'know how or why' the contingencies specified in such rules are related. Rules taught by others are often learned via imitation processes" (pp. 206-207). Peláez and Moreno did not state the converse principle, which is that a self-generated rule is based on direct experience and therefore it leads to not only "knowing that" but also "knowing how or why" and therefore knowing when and when to generalize the rule. That is, learning by imitation is inferior to learning by direct experience, such as learning by trial and error.

Contrary to the foregoing conclusion, Elizabeth Pennisi--a science writer for *Science*--commented that a study by Rendell and nine collaborators (2010) showed that the best way to adjust to a completely strange and inconstant environment is by imitating others rather than learning by trial and error (Pennisi, 2010). Rendell et al. found that emphasis on imitation was more effective than emphasis on trial and error, in that this strategy turned out to be the winner in a simulation game they devised. A problem with this finding is that the game was unrealistic in all but two ways. The conditions included a set of 100 fictitious actions and a population of 100 fictitious doers called "agents." Each action was identified by an index number but was not defined or given a meaningful label, and each was assigned

an abstract effectiveness value that varied at random across rounds of the procedure. Each agent initially had no actions in its repertoire but had one randomly assigned strategy that was unalterable throughout the agent's life. A strategy consisted of one or more of three "moves," called "innovate," "observe," and "exploit." Innovate was a trial-and-error method of acquiring an action and learning its effectiveness. It meant finding out the assigned effectiveness of one of the possible 100 actions, but the computer rather than the innovator selected the action to be assessed and the selection was random. Observe meant acquiring an action and learning its effectiveness by observing another agent's action, but neither the agent nor the action to be observed was selected by the observer. Rather, the computer randomly selected the action to be observed from those that had been Exploited in the preceding round. The observer received information about the randomly selected action and its effectiveness, but at random the information could be accurate or inaccurate. The part about possible inaccuracy is one of the realistic parts of the simulation. It means that an observer can misperceive a demonstrated action and misconstrue its effectiveness. The other realistic part was that Exploit meant performing an action the exploiter selected from its own repertoire.

Each round in the game consisted of one move by each agent, and the move made was determined by the strategy that had been assigned to the agent. The set of strategies was selected from computer programs submitted in a tournament with a 10,000 euro prize awarded for the program that yielded the largest lifetime effectiveness. An implication is that each of the 100 agents used an assigned, highly complex computer program and could not modify it in the face of nonoptimal feedback. In short, the results of the simulation study might be highly interesting to people who like game theories, but not to anyone interested in real-life problem solving.

■ THE MARXIST VIEW

Psychologists in the Soviet Union (Leontyev, 1981, pp. 134-135; Talyzina, 1975/1981, p. 38) gave a theoretical basis for the primacy of learning by doing: Learning is a reflection directly of the world, not directly of others' consciousnesses, and reflection is an act. Therefore, learning is accomplished by direct acting in and on the world. Consistently with a basic Marxist principle, the relation of learning to doing is mediated by social relations in that other persons provide conditions that encourage (mediate) learning by doing (the principle is Marx's 7th thesis on Feuerbach, identified in the subsection "Marxist version"). The provided conditions can be verbal, as in instructions and other verbal communications (Talyzina, 1975/1981, e.g., pp. 36-42), or they can be nonverbal, as in a Montessori school (Montessori, 1912/1964), or they can be both, as in Balanchine's school (Taper, 1960).

Another version of social mediation is group problem-solving, or group learning. For example, Amigues (1988) found that verbal exchanges between high school sophomores who were working in pairs facilitated problem solving, relative to the performance of students working alone. This kind of finding, for French children, has also been obtained with Japanese and

United States samples (Japan: Kobayashi, 1994; U.S.: e.g., Manion & Alexander, 1997; Yager, Johnson, & Johnson, 1985).

Another version is college work-study programs conceptualized as providing work experience in students' areas of interest. However, the practice apparently often deviates from the concept. My impression is that in United States colleges, a professor's work-study students not only provide free labor but also are likely to be scut workers who, for example, score research data or course-work tests and tabulate the scores without learning anything else about the research or course. This procedure is unfortunate in that it is contrary to the intention of work-study programs, but it is admirable for the professor's purposes in that it tends to make the work-study students blind about the research or course and therefore unbiased in the scoring and tabulating.

Work-study programs were also used extensively in China in the Mao Zedong era, "in line with Mao's desire to merge the practical with the theoretical, link labor with learning, make everyone work-conscious for nation-building, reduce differences between intellectual and manual workers, and eliminate elitist superiority from those in responsible positions" (Parker, 1977, p. 14). One kind of program was intended to relate the practical and theoretical aspects of specialty areas. For example, middle-school students repaired motors to gain experience and knowledge about electronics, or they grew small crops on school grounds to learn about agricultural practice and theory; and pharmacy students produced drugs commercially in a small factory. Another kind of program involved work outside one's specialty area, and it was required of faculty as well as students. For example, the electrical engineering faculty spent part of the year as farm laborers. The ostensible goal of this program was ideological--to reduce differences between intellectuals and manual workers in order to eliminate feelings of elitism in the intellectuals. However, both kinds of work-study reflected learning by doing because Mao believed that "only through practice (learning by doing and by participating in productive and political activities, etc.) can man gain true knowledge" (Kuo, 1976, p. 81).

■ A LANGUAGE EXPLANATION

A possible explanation of the effectiveness of learning by doing in humans is that it reflects at least in part the value of concrete language. The distinction between "etic" and "emic" methods in cultural anthropology (Keith, 1984) is relevant. This distinction is analogous to the phonetic-phonemic distinction in linguistics, from which anthropologists borrowed the italicized suffixes. As implied by this origin, etic versus emic is a structure versus meaning distinction. Both methods are attempts to understand a culture or a group by interpreting observed behaviors and informants' reports. The etic method is based on book-learning in the form of preconceived concepts, theories, or interpretations, and therefore the descriptions it generates are very likely to be stated in abstract language. The emic method begins with no preconceptions (or as few as possible) about the meanings of behaviors and symbols that will be encountered; the descriptions generated are based on direct experience and therefore are likely to be stated in concrete language. The emic method

continues with repeatedly “working through” the descriptions to obtain attempted interpretations in a kind of practice-theory-practice dialectic, such that the sequential interpretations are ever-improving but likely to stay closer to the concrete level of the initial descriptions. Dewey (1920, pp. 159-160) implicitly endorsed the emic method in saying, “It is nominally agreed upon as a commonplace that definitions ought to spring from concrete and specific cases rather than be invented in the empty air and imposed upon particulars.” (For other discussions of the etic and emic methods, see Beall & Eckert, 1986; Fry, 1986; Fry & Keith, 1986, p. xxi.)

For the present purpose, the most important feature of the emic method is that it requires direct experience with the topic under investigation. Thus, Marano (1982), who gave an “essentially Marxist” (R. Smith, 1982, p. 404) explication of the etic/emic distinction, disvalued “second” and “more remote” levels of analysis (p. 389)--levels at which authors cite primary sources or even more remote sources without benefit of personal direct experience. Marano said that some anthropologists “have never seen a bush Indian in their lives” (p. 389).

The likelihood that etic descriptions are abstract and emic descriptions are concrete has an important implication about memorability. A vast amount of research on verbal memory demonstrates that abstract nouns are less memorable than concrete nouns, most plausibly because concrete nouns have higher imagery values (see the subsection “Learning paired associates by imagery”). The probable outcome is that etic descriptions are less memorable than emic descriptions, which would make book-learning and other kinds of instruction less effective than learning by direct experience and other kinds of learning by doing.

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Gene-Environment Interactions and the Functional Analysis of Challenging Behavior in Children with Intellectual and Developmental Disabilities

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Abstract

It is argued that an approach characterised by either genetic or environmental determinism fails to adequately describe the contingencies involved in the evocation and maintenance of challenging behaviors in children with intellectual and developmental disabilities. Instead, challenging behavior should be considered as a result of the interaction of genetic and environmental variables. This argument is illustrated through a conceptual model for the development of challenging behaviour and recently gathered data on differences in the functions of challenging behavior in children with different genetic syndromes. The findings are further discussed in the context of a developmental systems model, in which neither the influence of genetic nor environmental contributions can be fully understood without taking account of the other. This expanded model may hold important implications for the understanding of challenging behavior.

Keywords

Intellectual and developmental disability, challenging behavior, functional analysis, gene-environment interaction, developmental systems

Challenging behavior in certain cases is clearly influenced by genetic sources of variability. Evidence suggests that certain forms of challenging behavior may constitute part of the behavioral phenotype of a number of genetic syndromes. Gene to behavior associations of varying specificity have been repeatedly demonstrated across a number of syndromes, including fragile X syndrome (Symons, Clark, Hatton, Skinner, & Bailey, 2003), and Smith-Magenis syndrome (Finucane, Dirrigl, & Simon, 2001).

Few would subscribe to the view that genes 'cause' such behaviors. There is considerable within-syndrome variability in the extent to which individuals with a given syndrome go on to develop behaviors considered 'phenotypic' (Hodapp & Dykens, 2001). Environmental factors have been shown to contribute to such variability (Hessl et al., 2001). Even in cases where strong gene-behavior associations do exist it does not necessarily follow that these occur independent of environmental influence. For example, even at the molecular level, the environment has

been shown to alter gene expression (Restivo et al., 2005). Gene-behavior associations reflect not only the direct effect of genes but also the effects of environment and, where present, the effects of gene-environment interactions (GxE). It is not necessarily the case, therefore, that a strong gene-behavior association indicates the absence of environmental influence. Despite the apparent ubiquity of GxE, however, most behavioral phenotype research has failed to go beyond the demonstration of simple gene-behavior associations (Hodapp & Dykens, 2001).

The continued neglect of environmental influences in behavioral phenotype research may limit our understanding of the development of challenging behavior and paradoxically the role that genes play in this process. As Moffitt, Caspi and Rutter (2005) state:

Ignoring nurture may have handicapped the field's ability to understand nature (p.478).

The functional effects of genes upon behavioral development remain poorly understood. There is a need for behavioral phenotype researchers to go beyond gene-behavior association and to begin to incorporate GxE relations into the study of challenging behavior.

Others have focused exclusively on the environmental determinants of challenging behavior. Functional analysis is the hallmark of the applied behavior analytic approach to the assessment and treatment of challenging behavior (Hanley, Iwata, & McCord, 2003). Over the past decade, investigators have begun to incorporate an individual's biological functioning into the

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analysis of such behaviors (e.g., Langthorne, McGill, & O'Reilly, 2007). This has had a profound impact on the assessment and treatment of challenging behavior displayed by people with intellectual and developmental disabilities.

However, the influence of genetic and other biological variables has not yet been integrated with models of the early development of challenging behavior. For example, despite the status of genetic syndromes as significant 'risk markers' for the later development of self-injurious behavior (McClintock, Hall, & Oliver, 2003), a conceptual model that accounts for their influence on early behavior-environment relations is lacking. Secondly, the focus of behavior analysis on behavioral function has led to a neglect of form. As has been repeatedly demonstrated there are highly specific relationships between certain genetic syndromes and particular topographies of challenging behavior which current 'operant' models say little about.

The omission of genetic influences from functional analysis stems from a 'misunderstanding' of the relations between biological and behavioral events and an assumption that such factors are private, inaccessible and in some cases hypothetical (Thompson, 2007). Such an omission is particularly striking given that central to the operant model, from which functional analysis has itself evolved, is the phylogenic and ontogenic selection of behavior (Skinner, 1966). Behavior analysis as a philosophy and a science is contextual (Morris, 1988), and the occurrence of any response can only be understood in regard to the historical and current context (both genetic and environ-

mental) in which that act is embedded. Paradoxically, despite the prominence Skinner gave to genetic influences, their analysis has remained largely outside the realm of applied behavior analysis.

■ GXE AND THE EARLY DEVELOPMENT OF CHALLENGING BEHAVIOR

A GxE approach is based on the assertion that environmental 'pathogens' cause behavioral disorders and genes influence susceptibility to these 'pathogens' (Caspi & Moffitt, 2006). Several studies have recently demonstrated that the effects of exposure to an environmental 'pathogen' may be conditional on a person's genotype. For example, Caspi et al. (2002) demonstrated that a functional polymorphism in the gene encoding the neurotransmitter-metabolizing enzyme monoamineoxidase A (MAOA) served to moderate the effects of child maltreatment on the later development of anti-social behavior. Similar GxE have been shown to influence the development of psychosis in adolescent cannabis users (Caspi et al., 2005), and the development of ADHD symptoms (Brookes et al., 2006).

Genes do not code for specific behaviors, rather the effects of genes upon behavior-environment relations are by virtue of their effects on the organism as a whole developmental system (Johnston & Edwards, 2002). This system comprises of bidirectional relations between environmental, behavioral, physiological, neural and genetic sources of variability (Gottlieb, 2003). The role of DNA is to specify the production of mRNA, which

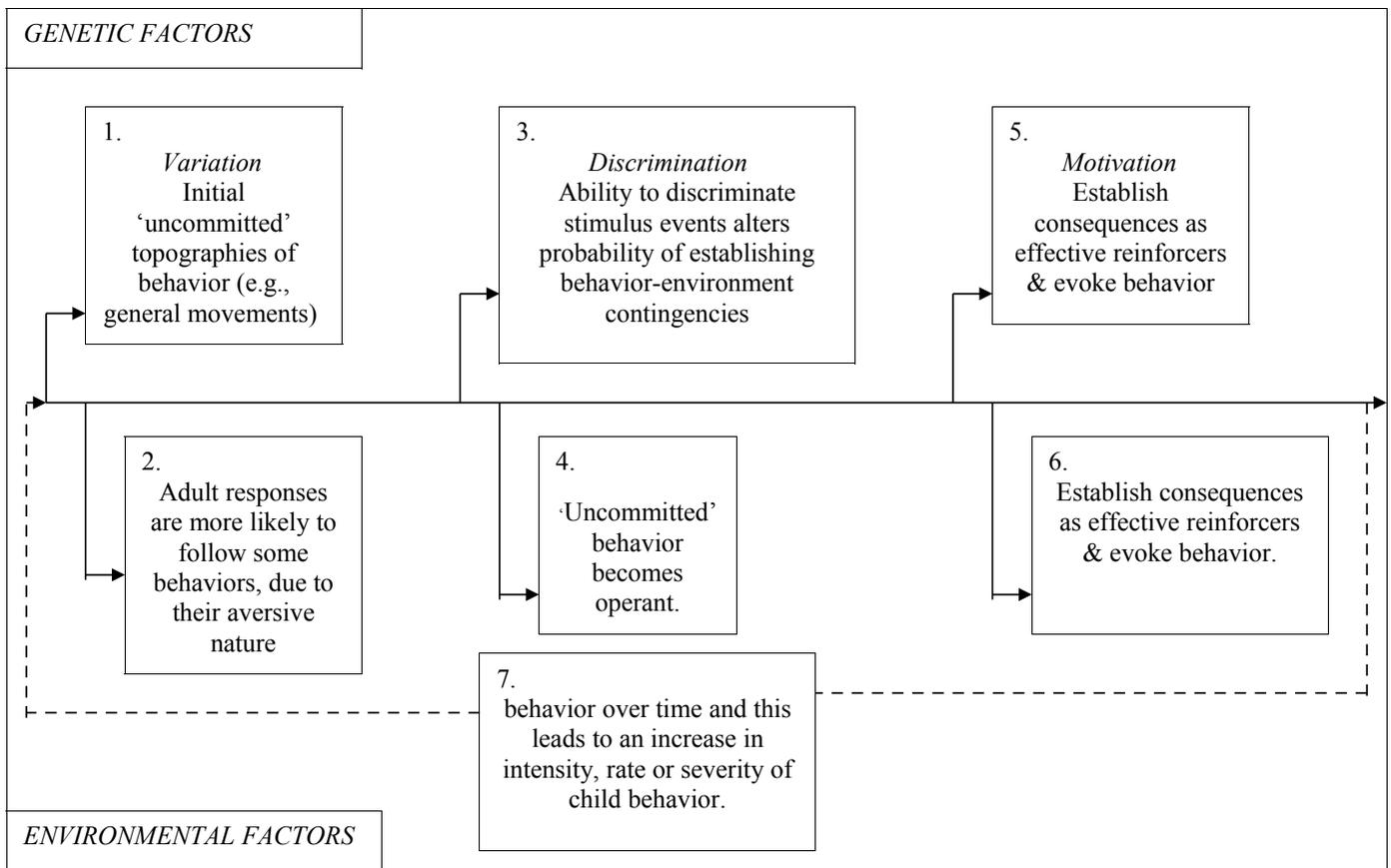


Figure 1. Model of the early development of challenging behavior

then in turn determines the production of the polypeptides that form proteins. It is these proteins that act upon the development of the individual. This process is epigenetic and is itself influenced by environmental factors. The role of genes, therefore, is to influence the development of the organism as a whole (across neural, physiological, and behavioral pathways); it is this whole organism which then interacts with the environment.

Extending the GxE model to the study of challenging behavior leads to the thesis that in some cases genes may influence susceptibility to known environmental 'pathogens' for the development of such behavior. We investigate this thesis in two ways below. First, we provide an operant analysis of GxE in the development of challenging behavior suggesting that genes may alter basic behavior-environment relations by virtue of their effect on the developmental system. Second, we investigate differences between the functions of challenging behavior in children with fragile X syndrome and Smith-Magenis syndrome.

■ A FUNCTIONAL ANALYSIS OF THE EARLY DEVELOPMENT OF CHALLENGING BEHAVIOR

Genes may influence behavior-environment relations in a number of ways (cf., Moore, 2002). Conceptually, such factors may alter the developmental system in a way that influences: (1) the stream of 'uncommitted' behavior from which an operant response evolves, that is they may contribute to initial behavioral variation; (2) the sensitivity of the individual to changes in environmental stimulation, that is they may either facilitate or inhibit the discrimination of stimulus events; and (3) the value of certain environmental consequences that serve to reinforce or punish behavior, that is they may establish or abolish the 'motivation' for the consequences that maintain challenging behavior. These effects are likely to be achieved by the influence of genes on neurobiological and physiological pathways.

Figure 1 provides a schematic representation of a model of the early development of challenging behavior based on the relations discussed above. Many of the environmental elements to this model have been comprehensively addressed in previous accounts (especially of the development of self-injurious behavior e.g., Guess & Carr, 1991). The influence of genetic factors and the role of certain other biological factors (such as health conditions), however, have to date escaped systematic appraisal. The model consists of seven stages, which for schematic purposes are presented in a linear fashion; this is not to imply that the model necessarily follows a linear path of causation or that all stages are necessary for the development of challenging behavior.

In stage 1, genetic events alter the development of the individual in a way that influences the emission of 'uncommitted' topographies of behavior from which an operant response evolves. For example, the analysis of general movements may hold particular clues for our understanding of the later development of self-injurious behavior (Symons, Sperry et al., 2003). Thus, genes contribute to initial behavioral variation, albeit pre and post-natal environmental factors may also influence this. In stage 2 it is recognized that some forms of uncommitted behavior are more likely to elicit a social response than are others and this waxes and wanes over time as the environment itself

adapts to the behavior of the child. This stage is critical in the evolution from uncommitted behavior to challenging behavior. In stage 3 genetic events (in addition to pre- and post-natal environmental factors) alter individual development in such a way that determines the discrimination of stimuli. Thus genetic factors may in part determine the discrimination of certain stimulus events and thereby alter the likelihood with which certain contingencies are formed. In stage 4 challenging behavior contacts socially and non-socially mediated contingencies of reinforcement to become operant. Both genetic (stage 5) and environmental (stage 6) events establish these contingencies as effective forms of reinforcement and evoke challenging behavior by functioning as motivating operations. Finally in stage 7, the process of habituation shapes increasingly severe topographies of child behavior. Langthorne and McGill (2008) provide an extended discussion of this model, with particular reference to self-injurious behavior.

■ DIFFERENCES IN THE FUNCTIONS OF CHALLENGING BEHAVIOR IN FRAGILE X (FXS) AND SMITH-MAGENIS (SMS) SYNDROMES

FXS is the most common inherited cause of IDD, occurring in 1:3,600 males and 1:8,000 females in the general population (Turner, Webb, Wake, & Robinson, 1996). The genetic locus of FXS lies in a mutation on a single gene on the X chromosome known as the FMR1 gene (Verkerk et al., 1991). FXS is associated with a heightened prevalence of both aggression (Einfeld, Hall, & Levy, 1991) and self-injurious behavior (SIB) (Symons, Clark, Hatton, Skinner, & Bailey, 2003).

SMS occurs sporadically and has an estimated prevalence of 1/25,000, with an equal distribution between the genders (Greenberg et al., 1991). SMS is associated with an interstitial deletion of chromosome 17p11.2, although Slager et al (2003) suggest that haploinsufficiency of the RAI1 gene is the primary genetic cause of the syndrome. In comparison to other groups, SMS is associated with relatively high levels of aggression, as well as a range of stereotypical behaviors (Dykens & Smith, 1998) and a high prevalence of SIB (Martin, Wolters, & Smith, 2006).

Research on FXS and SMS to date has predominantly examined the form of problem behavior rather than its function. There is, however, some preliminary evidence to indicate that people with FXS and SMS may differ in the probability of displaying problem behaviors that serve certain functions. It appears that individuals with FXS may be less likely to display problem behavior that is maintained by the provision of social attention than would typically be expected and more likely to be maintained by the removal of aversive stimuli, and/or the provision of tangibles (e.g., Hall, DeBernadis, & Reiss, 2006; Symons, Clark, Hatton, Skinner, & Bailey, 2003). Symons et al., for example, using a modified version of the *Functional Assessment Interview* (FAI; O'Neil, Horner, Albin, Storey, & Sprague, 1990) reported that only 3% of children with FXS displayed attention-maintained SIB. In comparison, 65-87% were reported to display SIB in response to task demands and changes in routine.

In contrast several studies (e.g., Dykens & Smith, 1998; Smith, Dykens, & Greenberg, 1998) have noted the apparently

high level of ‘attention seeking’ behaviors in SMS. Taylor and Oliver (2008) reported that, for four out of the five children with SMS in their study, problem behavior was more likely to occur following periods of low adult attention or following reduced levels of demands and was likely to lead to an increase in attention or demands for those same children. Such evidence indicates that attention may hold different reinforcing properties for children with SMS than for other groups, such as children with FXS.

These groups, therefore, provided potentially fertile ground for the investigation of GxE. We conducted two studies. In the first (Langthorne & McGill, in press) we examined both between- and within-syndrome differences in the function served by problem behavior in FXS and SMS, in comparison to one another and to a control group of children with non-specific IDD. The *Questions About Behavioral Function* scale (QABF; Matson & Vollmer, 1995) was used to provide an indirect measure of behavioral function.

We found notable within-group differences for children with FXS. Children with FXS were significantly less likely to display attention-maintained than either escape- or tangible-maintained aggression or self-injurious behavior, with a non-significant trend in the same direction for destructive behaviors. Children with FXS were also less likely to display discomfort-related behaviors than escape or tangible-maintained behaviors across all topographies. In contrast, the within-group pattern of results for children with SMS showed minimal differentiation. Indeed, contrary to what had been predicted, children with SMS were no more likely to display attention-maintained challenging behavior than any other function.

The between group comparison was generally supportive of these results. Children with FXS appeared to be less likely than

either group to display attention-maintained challenging behaviors. Significant differences were found with the SMS group across all topographies of challenging behavior and against the mixed etiology group for self-injurious behaviors and aggression. In contrast, children with SMS appeared to be more likely than either comparison group to display discomfort-related challenging behaviors. Significant differences were found against the FXS group for all three topographies on this subscale and against the mixed etiology group for self-injurious behaviors and aggression. No between group differences were found for the tangible, automatic or demand subscales of the QABF.

In the second study (Langthorne, McGill, O’Reilly, Lang, Machaliecek, Chan, & Rispoli, 2011; Langthorne & McGill, in preparation) we sought to overcome some of the problems associated with indirect functional assessment methods by using experimental functional analysis methods with a group of eight children with FXS and six children with SMS. Each group was representative of those who took part in the previous study.

There was notable individual variation in the occurrence of challenging behavior. The pattern of results was, however, broadly consistent with those reported in the indirect study. Specifically, no child with FXS displayed any response class of challenging behavior that appeared to be attention-maintained. In contrast, four children with SMS displayed a response class of challenging behavior that was, at least in part, attention-maintained. Four of the six participants with SMS displayed challenging behaviors that were maintained by escape from demands and/or access to tangibles. This seems to support the findings of the previous study that children with SMS may not necessarily be any more likely to display attention-maintained behaviors than behavior that serves other functions.

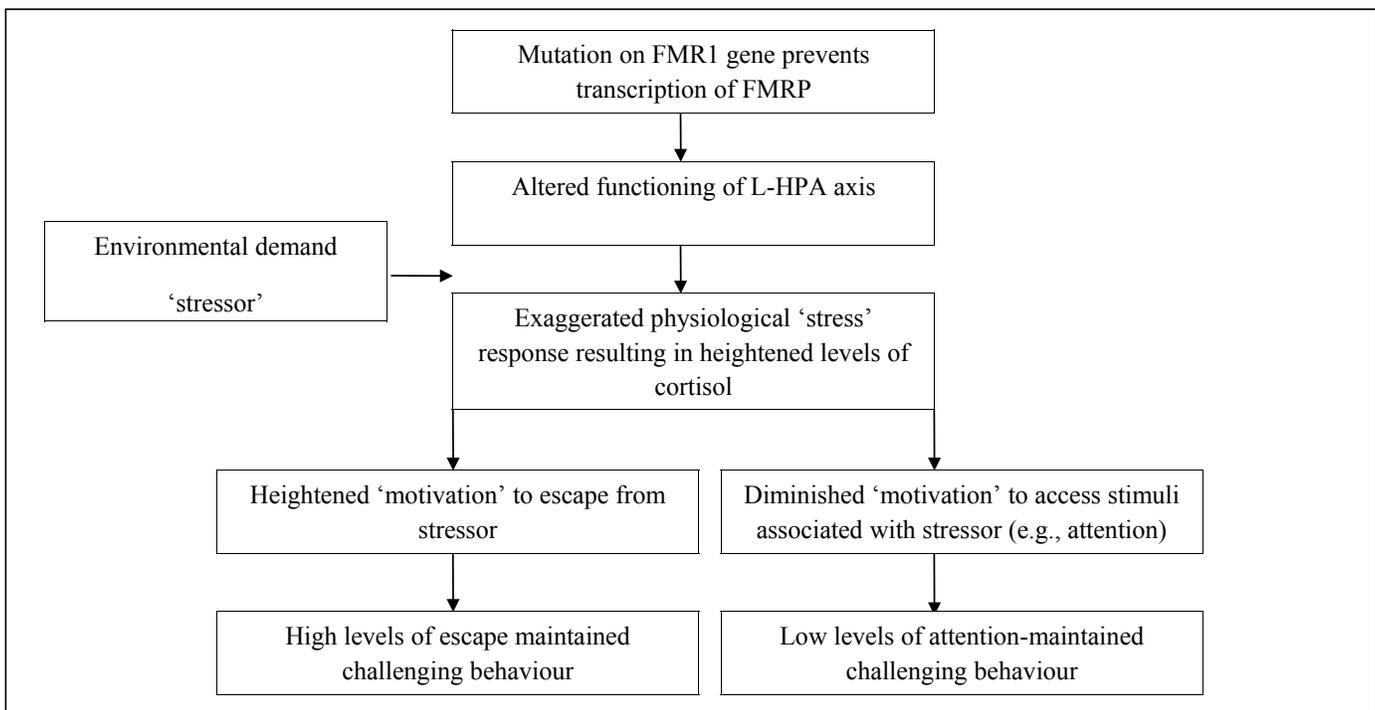


Figure 2. Hypothetical pathway between gene and behavioral function in FXS

■ GXE AND A DEVELOPMENTAL SYSTEMS MODEL.

The effects of genes on the developmental process involved in the emergence and subsequent maintenance of challenging behavior must be via neurobiological pathways (Moffitt, Caspi, & Rutter, 2005). For example, FXS has been associated with the impaired functioning of the limbic-hypothalamic-pituitary-adrenal (L-HPA) axis, which plays an important role in the mediation of the human stress response. It has been suggested that the L-HPA axis may influence the occurrence of challenging behavior in FXS, indeed positive correlations have been reported between levels of cortisol (an indicator of the functioning of the L-HPA axis) and parental report of behavioral problems (Hessl et al., 2002). Hypothetically, changes in brain circuitry that result from the mutation on the FMR1 gene that causes FXS, may lead to the altered functioning of the L-HPA axis. The onset of an environmental 'stressor', such as a demand, may lead to an exaggerated physiological stress response in children with FXS. This would be expected to enduringly heighten the child's 'motivation' to escape from such aversive stimuli and may explain the relatively high levels of negatively reinforced challenging behavior observed in this group. One would also expect children with FXS to show a diminished 'motivation' for stimuli correlated with the onset of demands, such as attention, perhaps accounting for the low levels of attention-maintained challenging behavior observed for this group. Figure 2 provides a depiction of this hypothetical pathway between gene and behavioral function in FXS.

Evidence of the complex interplay between the biology of the individual and their environment suggests that the environmental and genetic determinism that have to date characterised the investigation of challenging behavior may ultimately hamper the field and our ability to identify the determinants of such behavior. The findings above suggest that an expanded model is required to account for relations between variables at different levels of analysis, such as genes and environment, on the development of a response such as challenging behavior.

It has been argued for some time that the nature-nurture debate is 'dead in the water' (Schneider, 2003). Rather than being caused by genes or environment, development is better understood as being driven by the 'coaction' of elements that form a single integrated system (Gottlieb, 2003). Both genes and environment must work together as part of this system to produce any aspect of any living thing (Schneider, 2007).

Historically the application of behavior analysis has been concerned with addressing only part of this developmental system (i.e., the influence of behavior-environment relations). However, the radical behavioral philosophy that underpins applied behavior analysis is consistent with a developmental systems model, stressing the importance of interactions between the individual and the context in which they are embedded (Morris, 1988). Schneider (2007) notes that behavior analysis is entirely consistent with the developmental systems model, although its emphasis is on making the role of environmental factors and the behavioral principles therein explicit (p. 101). Within this approach, the question of whether a particular response is genetically or environmentally determined becomes redundant;

rather the salient issue becomes what function each variable serves in relation to observable behavior (Thompson, 2007).

One contribution behavior analysis can make to the developmental systems model is to explicitly relate the influence of variables (whether endogenous or exogenous to the organism) at varying levels of analysis to underlying principles of behavior. As Thompson (2007) notes, endogenous variables, such as genetic, hormonal and neurochemical influences, can alter the reinforcing value of certain behavioral consequences (e.g., Kennedy, 2002), can function as discriminative stimuli that set the occasion for a given response (e.g., Schuster & Brady, 1971), and can function as a reinforcing consequence for certain responses (e.g., Sandman, Spence, & Smith, 1999). Relating genetic or neurobiological variables to operant principles of behavior will aid the delineation and understanding of the processes involved in GxE. Such an enterprise may hold important implications for our understanding of challenging behaviors, such as self-injury.

In sum, it is suggested that neither genetic nor environmental determinism provides an adequate model to account for challenging behavior displayed by individuals with intellectual and developmental disability. GxE may play an important role in the development and subsequent maintenance of such behaviors. The developmental systems model, which is consistent with the tenets of radical behaviorism, provides a means with which both endogenous and exogenous variables can be brought to bear on the functional analysis of challenging behavior.

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The Bigger Picture: Development, Genes, Evolution, and Behavior Analysis

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Abstract

Behavior principles interact with the other principles that apply to the many elements of living systems--all of which develop and change over time. As scientific knowledge of these interactions grows, behavior analysts are more able to contribute to and learn from interdisciplinary work in the life and behavioral sciences. This article provides examples from a sampling of these varied fields.

Keywords

Developmental systems theory, nature-nurture, operant learning, genetics, epigenetics, evolution, imprinting, evo-devo

This article briefly discusses behavior analysis and some of its interdisciplinary nature-nurture cousins: genetics, epigenetics, evolution, and neuroscience, for example. As in nature-nurture relations themselves, exciting interactions are the rule--and behavior analysts have as much to gain as they have to contribute.

The developmental principles studied and applied by members of this SIG are a common theme in these areas. Indeed, "developmental systems theory" is the formal name for an inclusive scientific approach to nature-nurture (see Schneider, 2007), and it's been discussed previously in this journal (e.g., Meinhold, 1999).

■ WORKING TOGETHER

When it comes to nature-nurture relations, a basic principle is profound but simple: Every aspect of every living thing stems from 100% genes *and* 100% environment. That includes the behavior principles that are the focus of behavior analysis.

Simplistic genetic determinism is logically doomed by this genes-*and*-environment principle. The classic case of eye color provides a good illustration: With other factors held as equal as possible, for example, a single gene appears responsible for a *difference* in fruit fly eye color. BUT that gene can't be taken to code for eye color, which is the result of many genes and many environmental factors working together. Indeed, either genetic or environmental abnormalities (in combination with the standard building blocks) can result in heterochromia: two eyes of different colors. (The condition is rare but regular in humans, and relatively common in cats.)

For additional recommended readings in nature-nurture, please contact the author at sschneider@pacific.edu. This article is based on "Behavior Analysis and the Bigger Picture," invited discussant comments presented at the 2009 conference of the Association for Behavior Analysis: International. I thank Robert Lickliter and Bryan Midgley for looking over the manuscript.

The situation gets stranger: Even in "genetic" disorders, having the problematic allele (gene form) never guarantees that the disease will occur (e.g., Morange, 2001). Conversely, it is possible to get the disease even without the problematic allele. Multiple pathways to anywhere are the rule in a system that's turned out to be very complex indeed.

Further, as David Moore (2001) put it, "a critical recognition is the understanding that traits that seem impervious to experience are no more 'genetic' than are traits that seem 'open' to such influence" (p. 185). Species-typical behaviors like neonatal imprinting are a good example. In a masterful research line, Gilbert Gottlieb showed that "instinctive" imprinting depended on unhatched ducklings hearing their own or siblings' calls, and was readily malleable (see Schneider, 2003 for a summary). In quail neonates, my colleagues Harshaw, Tourgeman, and Lickliter (2008) were able to eliminate and even reverse the normal imprinting preference with just 5 min of a contingent imprinting call of a different species.

■ PRIMATES AND PARENTING

Closer to the human applications of interest to this SIG are Stephen Suomi's impressively interdisciplinary primate studies: behavioral, physiological, genetic, and longitudinal. With respect to neurotransmitter genetics, for example, rhesus monkeys raised by peers do especially poorly if they have the short form of the serotonin transporter gene (Suomi, 2004). (This sort of effect has also been suggested to exist in humans, but, according to Munafo, Durrant, Lewis, & Flint's 2009 meta-analysis, the evidence is merely suggestive at this point). In a cross-fostering study, other short-form and long-form monkeys were raised not by peers, but by mothers who weren't genetically related to the youngsters. Unexpectedly, the short-form youngsters proved to have some advantages over their long-form peers: for example, they consumed less alcohol (Suomi, 2003). Nonlinearities like this are part of the fascination of the nature-nurture picture.

Previously, Suomi had examined the role of parenting style in a different way. After selective breeding for “temperamental reactivity,” cross-fostered high-reactives exhibited problems when reared by control mothers, but reaped advantages when reared by high-nurturing mothers--and a high proportion of these individuals rose to the top of the dominance hierarchy despite having what had been considered a genetic disadvantage (Suomi, 1999; control youngsters were intermediate).

Suomi (2003) concluded that, although characteristics like impulsivity and aggression were highly heritable in his rhesus monkeys, “they are also subject to major modification by specific early experiences, particularly those involving early social attachment relationships” (p. 132). Heritability is a construct with many problems (e.g., Moore, 2001; Reese, in preparation).

■ NONGENETIC INHERITANCE

Suomi’s research has documented that rhesus daughters tend to adopt the parenting style of their mothers, with consequent effects on the behavior of the offspring--and that these parenting behaviors are learned (Suomi & Levine, 1998). Behavioral inheritance mechanisms (of which parenting is only one) are the most flexible of all, and the ones most familiar to behavior analysts. Both operant learning and classical conditioning are ubiquitous at this level.

More surprisingly, hormones are in on the action too. From a series of well-known studies with gerbils, female embryos that happened to be next to males in the womb received more testosterone exposure and more licking after birth as a result. These animals later showed more aggression than female-adjacent females. Because the male-adjacent females tended to bear more males than females, their daughters were similar to them and the effects were inherited nongenetically (e.g., Clark & Galef, 1998; Clark, Karpiuk, & Galef, 1993).

Even more of a foreign field to most behavior analysts are the cellular-level inheritance mechanisms classified as epigenetics. Epigenetic inheritance includes, for example, changes in the material that constitutes the chromosomes (i.e., “chromatin marking” mechanisms). It’s long been known in invertebrates: fruit flies and paramecia, for example. DNA methylation is an epigenetic inheritance mechanism known to occur in mammals. It’s affected by the environment during the lifetime of an individual, and it’s reversible. Epigenetic mechanisms can thus be much more flexible than the genetic mechanisms with which they work in tandem, but the extent of their influence is still being determined (see Schneider, 2007 for more examples).

■ INTERACTIONS EVERYWHERE

The spontaneously hypertensive “SHR” strain of rats was developed through selective breeding to provide a model for high blood pressure in humans. However, these animals don’t develop hypertension *unless* they’re raised by SHR mothers. Conversely, normal rats don’t become hypertensive when raised by SHR mothers (e.g., Cierpial & McCarty, 1987). The environmental mechanisms appear to include maternal behavior, because simple handling of SHR infants also alleviates the normal development of hypertension in this strain (Tang, Gandelman, & Falk, 1982; see Zicha & Kunes, 1999 for a review).

It’s long been known that environmental variables like radiation, mutagens, and reverse transcriptase can directly alter the genes. More commonly, gene activity and timing are modified by a host of variables, including many categorized as environmental/behavioral (see, e.g., Gottlieb, 1998). In humans, for example, stress reduces mRNA activity in the interleukin 2 receptors, adversely affecting immune system responses. Operant learning and classical conditioning can reduce or add to stress, of course.

Indeed, associative learning, the focus of behavior analysis, affects and is affected by all the nature-nurture levels (see Schneider 2003, 2007). Of particular importance to developmental behavior analysts are the processes that make and break reinforcers. Nizhnikov, Molina, Varlinskaya, and Spear (2006) found that prenatal exposure of rats to ethanol increases ethanol’s reinforcing value; the level of exposure is well below that which produces fetal alcohol syndrome. According to Spear and Molina (2001), the evidence suggests that these results have a corollary in humans. Cruz, Quadros, Planeta, and Miczek (2008) found that an apparently unrelated manipulation--early maternal separation and consequent stress--had similar effects in mice: The reinforcing value of alcohol increased.

Conversely, the beneficial effects of environmental and behavioral enrichment are now well recognized in both animals and humans, especially when they occur at an early age. Over its history, behavior analytic research has contributed strong support, culminating in Hart and Risley’s 1995 developmental behavior-analytic classic, *Meaningful Differences*.

■ DEVELOPMENTAL PLASTICITY

Both applied and basic researchers can contribute to the increasing influence of behavior analysis within the bigger nature-nurture picture. For example, the skill described as “joint attention” has become of increased interest to behavior analysts recently because of autism: As is the case for other social relations, those suffering from autism spectrum disorders often manifest deficits. Behavior analysts have developed ways to teach joint attention (e.g., Rocha, Schreibman, & Stahmer, 2007).

The fact that it’s also possible to do so in nonhumans is of special interest for nature-nurture relations. Initial studies in canids suggested that dogs might be “innately” capable of joint attention, but that wolves were incapable of learning it even after significant training effort. However, controlling for past confounds, Udell, Dorey, and Wynne (2008) showed that joint attention was indeed learned: Unsocialized dogs did not show it, but socialized pet wolves could and did. (Indeed, they tended to do better than the socialized dogs.)

Such results harken back to Gottlieb’s finding of unexpected environmentally-based malleability in duckling imprinting. Degrees of malleability vary, but it has been demonstrated under many unexpected circumstances. Although it contains only one chapter on associative learning, West-Eberhard’s 2003 compendium, *Developmental Plasticity and Evolution*, offers a valuable summary across a wide range of nature-nurture relations.

■ EVOLUTION AND NEUROSCIENCE

I conclude this brief survey with two areas integral to both nature-nurture and developmental behavior analysis. The role of environment and behavior in evolution was recognized long ago (e.g., the Baldwin effect of the turn of the 20th century, and, even earlier, back to Darwin and Lamarck). After all, phenotypes are the subject of natural selection, and environments do the selecting. Environments are inherited as well, *or else*: Imagine being born into a world without oxygen. “Evolutionarily stable strategies” rely on behavior; so do unstable ones, for that matter. And behavior change routinely leads evolutionary change, with niche construction being just one of many examples. When flamingo foraging style changed--and that’s an operant behavior--flamingo beaks followed (see Schneider, 2003 for additional examples). The behavior change came first.

It’s also worth noting that “evo-devo”--evolutionary developmental biology--has demonstrated that the regulation of gene products is what gets moved around and modified most often in evolution, not the genes themselves (e.g., Carroll, 2005). Because of the many interactions of behavior and environment with gene expression, and with physiology more generally, there’s growing recognition of the involvement of psychological principles.

Evolution is conservative, and many of the proteins that genes code for have multiple functions (*pleiotropy*). Similarly, most if not all neurotransmitters have multiple functions. What are the neurophysiological underpinnings of associative learning? Despite 21st century technology, there’s still a long way to go to find out. Scientists *have* established that neural plasticity is immense, and at last it’s known in some detail how behavior and environment change the brain. These results enhance movement toward a more complete understanding of associative learning for, as Skinner fully recognized (e.g., Morris, Lazo, & Smith, 2004), there is no “black box,” and knowing the physiological correlates of behavior principles can only be beneficial all around. Recent work with fMRI scans has confirmed earlier physiological research in showing that very different positive reinforcers appear to have similar effects. That goes for punishers too, and Eisenberger, Lieberman, and Williams (2003) found that an aversive as different as social exclusion causes the standard “pain regions” in the anterior cingulate cortex to light up. By supporting the common behavioral effects that behavior analysts have long researched, these results help integrate behavior analysis into the larger interdisciplinary realm.

The functional processes that behavior analysts study are an especially important element in any aspect of nature-nurture that involves behavior. General principles of associative learning are well-established, for example (see Schneider, 2003). But interactions are again the rule, and a better understanding of the neuroscience will help researchers delineate the different behavior categories. Many years ago, imprinting stimuli were shown to serve as reinforcers for a variety of behaviors (e.g., Bateson & Reese, 1968; Peterson, 1960). But relatively little is still known about how species-typical released behaviors and operant contingencies relate. Even operant-Pavlovian interactions require further study--and many of these questions are developmental in nature, interdisciplinary to the core. In this, as in so many

ways, the future for behavior analysis, development, and nature-*and*-nurture is bright.

■ CONCLUSION

Nature-nurture systems are large and complex beyond imagining, abounding with nonlinear interactions across analytic levels. Those interactions are necessarily developmental in nature, and “developmental systems theory” has been suggested as the new overarching context for the life sciences (see, e.g., Oyama, Griffiths, & Gray, 2003; Schneider, 2007). By any name, behavior analysis holds a position of critical importance in this grand scientific effort.

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How a Future Species of Superior Hominids Might Negotiate to Promote the Survival of Homo Sapiens: An Application of the Model of Hierarchical Complexity

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Abstract

Using ideas from evolution and stages of development, as conceived by the Model of Hierarchical Complexity, a hypothetical scenario, premised on genetic engineering advances, portrays the development of a new humanoid species, Superions. If such a species of Superions were created, how would this impact current humans? If the Superior scenario came to pass, might this eliminate Homo Sapiens? This might happen not so much because Superions would plan to eliminate current humans, but it might be an inadvertent effect, in which new occupations and niches are created that Homo Sapiens does not fill as well. Our purpose is to examine the processes and impacts that may come into play if a new species were genetically created from current humans. In order to explicate how the two species might interact most effectively, we introduce the use of the Model of Hierarchical Complexity. The Model describes what underlies stages of development and in addition has elaborated on the idea of higher stages of development. As will be discussed, in Homo Sapiens, the mean stage is formal operations, a stage during which individuals are able to effectively deal with single-variable causal relationships. Only some humans (about 20%) reason at the Systematic stage, in which multiple interacting variable systems can be considered. Even fewer reason at higher stages called Metasystematic (comparing two or more systems) and Paradigmatic (inter-relating metasystems). In developing Superions, scientists would be assumed to bring about changes that would raise the effective mean stage of the new species. The mean stage of Superions might be Systematic or above. The paper discusses how a new species would apply systematic, metasystematic and paradigmatic stage problem solving to the issue of how to maintain the survival of Homo Sapiens.

For probably interesting psychological reasons beyond the present scope to discuss, many parents want their children to be born and mature as “perfectly” as possible. In Western societies, people with the financial means to do so are already making genetic selections that ensure their children are born with the desired gender (Fugger, Black, Keyvanfar, and Schulman, 1998) and without certain genetic defects (Baker, 1999) that science has thus-far been able to engineer out.

More sophisticated means of performing genetic selection for many more characteristics would likely have its research funded by wealthy individuals and/or groups. Early on, this would not be an organized endeavor, but individually sought out. We would expect that scientists thus-equipped would begin to advertise, as fertility clinics already do. Instead of having crudely discriminated embryos implanted, parents could consult a long list of possible traits and pay for the design of embryos with those traits. Such embryonic engineering is possible by inserting the correct genes to produce the traits. This idea is not unique. Silver (cited in Danovsky, 2000) has already predicted that high-end baby making will be available in fertility clinics, and Stock (2002) believes such germline engineering is inevitable.

Creating non-human life forms with particular characteristics is already taking place. As a result it seems likely in the near future that some scientists will begin to genetically engineer human beings with much more superior capacities than have yet been attempted. This scenario, discussed here, uses ideas from evolutionary psychology (Buss, 1999) and the Model of Hierarchical Complexity (Commons et al., 2008; Commons & Miller, 1998; Commons & Pekker, 2008), among others, to project into the future some of the challenges this may present.

■ GENETICALLY ENGINEERED BIOLOGY

With the mapping of human genome, the foundations for this future have already been laid (About the Human Genome Project, 2002). Individual genes’ locations and the characteristics they are related to are already archived in growing database form. This kind of information will enable this historic social change to become more prevalent, more rapidly: a gene is just a database search away. Finding information about a gene now takes only minutes, compared to the former method of finding out about a gene, PCR (Polymorase Chain Reaction), which would take hours.

Even so, acquiring the locations and characteristics of genes is not enough. A great deal of additional information exists and is needed, which is not available from inside genes. A larger portion of human DNA contains instructions on when genes should be activated (e.g. Plomin and Colledge, 2001). Furthermore, because the whole process underlying the heritability of behavioral traits is very complex (McGufún, Riley, and Plomin, 2001), it is not yet well enough understood to actually engineer such traits in a controlled, predictable manner .

Nevertheless, this science is progressing rapidly, such that we believe it is not so distant in time when these greater intricacies of heritability will be known to future humans. At this time, most such research is done with other animals, and only some with humans. Johnson and Harding (2001) reported the birth of the first genetically modified non-human primate: a rhesus monkey with a jellyfish gene (which controls the ability to fluoresce) inserted into its DNA. To correct infertility problems, Barritt, Brenner, Malter, and Cohen (2001) transferred a small amount of genetic material from a fertile woman into the egg cells of infertile women. The material is detectable in the cells of the resulting, healthy offspring. Blaese et al. (1995) initiated some of the first human gene therapy, which involved two children. It was designed to treat severe combined immunodeficiency that stemmed from a mutation in the adenosine deaminase gene. Although the therapy did not produce the ideal results intended, it demonstrated that such gene therapy should become possible.

Genetic engineering has become ubiquitous, especially with animals. Rather than forecasting bans on it, it is more realistic to note that there is so much of it happening already that government regulations may only be able to regulate it, but not stop it. There is such demand for some of the beneficial effects, the work will continue. One indicator of this is that the U.S. Food and Drug Administration recently issued a “guidance document” for comment on how Genetically Engineered animals should be regulated (U.S.F.D.A., 2011). In the market of customers likely to be most interested in this, financial means are currently ample. This is probably as true for human engineering as for animal engineering.

■ WHENCE COMETH THE SUPERIONS?

In the conception we present here, the new species is developed rapidly. Scientists and their sponsors could select a whole complex of beneficial genetic traits, from humans representing a variety of cultures, to engineer it. *Superions*, as we call them, could be engineered more efficiently than current humans with superfluous parts eliminated and organs designed for easy transplant and upgrades. The expected result is that all of this expertise, paired with human motivations to innovate, would result in an extremely smart species of hominids. We predict they would be smarter than humans, initially by at least one standard deviation, but with greater numbers of individuals engaging in more complex thought than seen in current humans. They would also be healthier and longer-lived by 30–60 more years, and more attractive, emotionally stable, creative, and yet still genetically diverse. With the benefits of a number of current genetic engineering techniques, plus others to be developed, the entire species could be developed in a relatively short period of

time (surely less than 20 years), with the following caveat. Gene manipulation alone would not be enough to create Superions. In addition, an interdisciplinary group of scientists would have to apply what is known about environmental influences in order for Superions’ development to reflect their genotype to the greatest extent possible.

While there are clear ethical concerns that arise from possibly creating a new species, it is also the case that genetic engineering of humans needs to also be seen as just part of evolution. People think of it as artificial selection, but because we were created through natural selection anything we do to genetically engineer ourselves is also part of natural selection. Extracting and modifying DNA is just another mechanism for adapting to one’s environment. Humans are applying to themselves the same type of engineering they have done with other species.

■ THE EFFECTS OF SPECIES-SEPARATION OF SUPERIONS AND HOMO SAPIENS

An assumption of this scenario is that creators of Superions may have the generation of a separate species as their objective. Such a species would be unable to breed with humans, just as humans cannot breed with other species. To create a new species, they would insert or delete whichever genes could make it impossible to reproduce with humans. For example, they might design an allergy to human sperm into Superior women, or render Human/Superion crosses infertile.

What impacts could be hypothesized for humans if such a new species were developed? It would depend on the designed-in characteristics of Superions by different groups, including by some governments. If militant low-stage functioning Superions were even developed, and happened to be in power, they would likely just kill the humans off, much like humans’ ethnic genocides. However, in this scenario we are proposing the most beneficent case. Even in that case, the future for humans may not necessarily be all positive. Superions would be genetically superior, and thus they would compete more effectively for the resources that humans currently control. Superions would occupy the niche of humans more effectively than humans have, without a need to be violent, competitive, or unethical. They would also be likely to create niches that would most likely be a better fit for Superior characteristics rather than human characteristics, thus potentially leaving humans without constructive roles in their new society. Superior capacities would simply make them more successful.

The replacement of humans by a more advanced form, as proposed here, has a basis in the evolution of Homo Sapiens. Although historically the evolution of Homo Sapiens has resulted in only one hominid species, there were many earlier hominid species throughout the previous six or so million years of human evolution. Even as recently as 35 thousand years ago Neanderthal co-existed with Homo Sapiens (Brown, 2001). At some point, only one species remained, although there is not enough information yet to know how that came to be the case.

In the case of the creation of Superions, various causes could contribute to the extinction of Homo Sapiens. Easiest to imagine is that during droughts or other adverse conditions, for example, competition for resources would intensify between humans

and Superions. The intellectual superiority of the latter predicts they would have enough of an edge to win out in the end. For example, they may be more creatively adaptable in conserving water and other resources while still producing bare essentials, coping more successfully with effects of climate change worldwide. The wiping out of humans might also be inadvertent. For example, Superions could be created to be resistant to diseases to which humans are not, because scientists could design built-in disease resistance (see Leal and Zanotto, 2000). Finally, humans might still die out even if Superions did everything possible to prevent it. The more benevolent Superions might want to save the humans, but the evolutionary problem could be the lack of a role for humans.

■ BEHAVIORS PREDICTED FOR SUPERIONS

To attempt predictions of how Superions would behave, we use the Model of Hierarchical Complexity (Commons et al., 2008; Commons & Miller, 1998; Commons & Pekker, 2008). It enables us to consider the kinds of actions they could take in a Superior-human co-existence, depending on their stage of development.

The Model of Hierarchical Complexity (MHC) is a measure of the a priori difficulty of tasks. Because less complex tasks must be completed and practiced before more complex tasks can be acquired, the Model argues that this accounts for the developmental changes seen in individuals' performance on tasks. For example, persons cannot perform arithmetic until they can truly and correctly count. In order for difficulty to be precisely measured, the Model proposes a metric. That is, that Task A is considered to be hierarchically more difficult or complex than Task B if Task A is made up of two or more simpler actions (such as Task B and a third task, C), and these simpler task actions are coordinated in a non-arbitrary way. If Task A consisted of a combination of Task B and Task C, then it would be what is called one Order of Complexity higher than Tasks B and C. This is shown in Figure 1.

The Model specifies that there are 16 orders of complexity, starting with tasks that are completed by the simplest animals and infants, and progressing to highly complex tasks that only some adults complete. These orders are shown in Table 1.

An individual's stage of development or performance is based on the order of hierarchical complexity of the task that he or she correctly completes, and because of that is given the same name and number as the order of complexity of the task. So, if an individual completes a task that is at Order 10 (Formal), their performance on that task is also considered to be at the

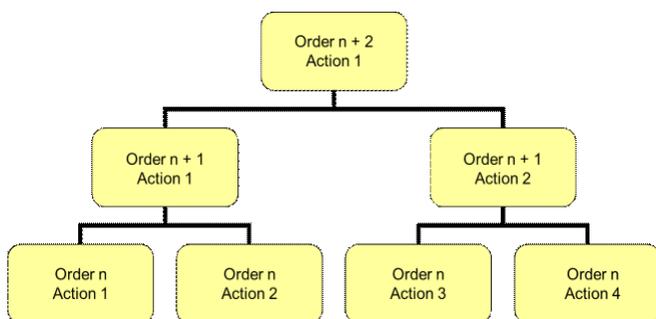


Figure 1. Order of Hierarchical Complexity

Table 1. Orders of Hierarchical Complexity

Order	Complexity Name	Order	Complexity Name
0	Calculatory	8	Concrete
1	Sensory or Motor	9	Abstract
2	Circular Sensory-Motor	10	Formal
3	Sensory-Motor	11	Systematic
4	Nominal	12	Metasystematic
5	Sentential	13	Paradigmatic
6	Preoperational	14	Cross-Paradigmatic
7	Primary	15	Meta-Crossparadigmatic

Formal Stage. Some of these stages in Table 1, it will be noted, have the same name as the stages proposed by Jean Piaget and colleagues (e.g. Inhelder & Piaget, 1958). There are several differences between Piaget's theory and this Model. One important difference is that the Model allows for the characteristics of the task to be specified and varied separately from the individual's performance on the task. In Piaget's research, characteristics of the tasks were not systematically varied; instead inferred mental structures (such as 'schemas' or 'operations') were inferred based on the performance and also named as the explanation for the performances observed. We have found in research with humans, particularly in research across the stages from Stage 7 to Stage 12, that the order of task complexity accounts for large amounts of the variance in the task performance, up to $r = .988$ (Commons et al., 2008; Commons & Li, in press). The average (although not highest possible) stage of development attained by humans worldwide is probably formal operations. In multiple studies that we have completed (citations), we have not only found that formal operations is the mean stage among educated adults, but also that there is roughly one standard deviation between stages. In a recent study of 1263 individuals (Commons, Miller, and Li, submitted) we also found that the distribution of humans at the different stages is most likely as what is seen in Table 2. We will use these percentages to inform some of the discussion to follow.

It is surely useful to have formal operations. For many issues there can often be single variable solutions (e.g. what is wrong with my car?). We predict, however, that the mean stage for Superions would be higher than this. Genetic engineering should enable Superions to function at postformal stages of development. Since the Model of Hierarchical Complexity would suggest that development, even in Superions, would still need to progress through all of the stages, there would be two mecha-

Table 2. Distribution of Stages on the Laundry and Identically Structured Problems

Stage	Percent	Number
Metasystematic	1.5%	19
Systematic	18.5%	234
Formal	37.7%	477
Concrete and Abstract	29.0%	367
Primary	13.1%	166
Total	100%	1263

nisms by which more individuals would reach higher stages. One mechanism would be somehow modifying human genes so as to allow more individuals with higher stages to develop. One way to accomplish this would be to make it possible for progress from one order of complexity to another to proceed more rapidly. The second mechanism would be ensuring that Superior environments would also encourage rapid development. Both the genetic and the environmental modifications would ensure these higher stages of performance would be available in all domains: problem solving, moral reasoning, beneficence toward others, and so on. This breadth of the development of higher stages would help Superions take more beneficent perspectives on the conditions and eventual extinction of humans than humans have taken toward other species' extinctions.

To show specifically how issues of species competition might be addressed at each of the stages, we will now take each stage in turn.

At the formal operational stage, responses to another species and what should happen to them may only be considered in terms of simple one variable causal systems. For example, if humans are having a hard time surviving impacts of climate change, fighting over water or sharing land they are crowded onto, Superions solving these dilemmas at the formal operational level, might do the same kind of thing that humans currently do at this stage for other subgroups of humans. That is, based on their analysis of the situation, they would design a solution they considered beneficial, such as to provide well-supplied, segregated conditions, and impose it on the humans. This might mean placing humans into some kind of a protected or controlled environment (a reserve or a zoo-like situation). Another possible formal stage solution to the "problem" of humans, might be to provide them with limited and predefined roles within Superior society. So, Superions might hire humans to perform personal services and other manual labor jobs, just as some wealthy individuals do with members of other demographically distinguished groups.

It seems unlikely, however, given the possibility that they could be engineered and socialized for higher stage reasoning, that Superions would address this dilemma at the formal operational stage. In data shown in Table 2, we found that about 20% of participants solved problems at the Systematic Stage. We could expect this proportion to greatly increase, if this was the predominant stage for Superions. At the systematic stage, Superions would not act as if there was continuity from one species to the other; that is, they would tend to behave as if the current humans would be subsumed under one system, and that they, the Superions, would function under a different system. Thus, Superions would not judge that they and humans had similar rights for similar reasons. Their solution-finding for humans' issues would be much like humans' prevalent methods: coming up with solutions without real consultation with *all* stakeholders. For instance, they might decide there would be separate elections for the humans, divorced from election systems developed for the Superions. Likewise, there might be separate systems for due process. As do others with similar assumptions, the Superions would grant themselves more rights because of their inherent superiority (Colby & Kohlberg, 1987).

If the average stage attained by Superions were systematic this would have far reaching connotations outside of just how they would deal with humans. For example, it might be easier to pass legislation dealing with climate change, since a greater proportion of the population would be able to understand the environment as a system that changes. It might be easier to change the penal system to be one of reform rather than punishment for multiple reasons. First, the understanding of systems means that the majority of the population could see more clearly that the prison system is failing. Second, there would be enough complex Superions for it to be possible to train and hire more reformers. Third, if the population of humans was drastically decreased, and thus the average stage was one higher, there would be fewer individuals who function at low enough stages in the domain of social perspective taking to commit crime in the first place. The types of crimes would differ somewhat, but the frequency of crimes would go down because of improved perspective-taking.

In our previous studies, as shown in Table 2, we have found that about 1.5% of participants solved problems at the metacognitive stage. The proportion of Superions who would function at the metacognitive level would be expected to greatly increase, perhaps to about 20%. There would be several implications of this. Just as humans begin to develop methods to provide seriously and justly for the rights of other beings at the Metacognitive stage, so also would Superions begin to take the rights of the human species more seriously at this stage. The reason for this is that people begin to feel that they must treat others as they themselves would like to be treated in the same situation (Rawls, 1971). Such societies do not kill retarded people or those of other ethnicities, for example, whereas less morally developed societies may, and do. Superions would be compassionate and devise education and other support systems to help humans adjust to their changed status in the world.

Again, based on our previous data, somewhere between 1.5 and 2 percent of the Superions would perform tasks at the Paradigmatic stage 13 (if each stage of hierarchical complexity is one standard deviation, and Superions are designed to develop to two standard deviations more complex than humans). At that stage, we would expect them to influence and improve processes for dealing with humans—and improve processes for humans dealing within their own species. We would expect these high-stage Superions to be in positions of influence and creative leadership. Although they would be a minority, they would exercise significant positive influence. Even if the culture as a whole is not yet functioning at the paradigmatic stage this minority population of Superions would ensure that humans—and Superions—co-constructed multi-perspective frameworks¹ (each one a metasystem; see Ross, 2006a, 2006b, 2007) to help them ensure they developed ways for humans to co-exist with them without detriment. A key question throughout such discourses would be: What role for humans? Such frameworks would be developed to have deliberative discussions of central issues that could impinge on humans' survival and just treatment. These would surely include apartheid, majority rule, distribution of labor, and other economic considerations.

SUPERIONS' NEW TECHNOLOGICAL PRODUCTS

Superions may become proficient in developing cyborgs, a cybernetic organism that adds to its in-built abilities by using technology. Fictional cyborgs are frequently portrayed with a mixture of organic and non-organic parts, such as the Borg in *Star Trek: The Next Generation* (Rodenberry, Berman & Piller, 1987-1994). Cyborgs' partially organic composition makes them less versatile than robots for certain tasks. Humans have not yet succeeded in creating very sophisticated robots, but it is likely that Superions will master the innovations required. A robot is a device that can perform either under the guidance or direct control of humans, or autonomously and independently of humans—or Superions. Robots may function in environments that neither humans nor Superions could; for example, deep-space or deep-earth resource mining.

Superions may create new robots or androids, robots that look just like humans (or Superions in this case) to adapt to such hostile environments. Because androids look like hominids, people may treat and them as human (or Superion). Although androids would not necessarily pose a threat to humans' existence, Superions may find androids easier to co-exist with than humans. As humans die out, androids may take whatever functional place in society Superions had helped make for humans. The only difference between Androids and Homo Sapiens is that there would be no reason for Superions to make Androids that resemble current humans; they most likely could make androids who were more similar to them, than to current humans.

To develop technologies such as these, Superions may significantly elevate the state of nanotechnology. This may allow uploads to the brain of any information or problem solving process. Thus, someone sitting at a Learning Center might easily learn a new language, how to do calculus, or how to think in more hierarchically complex ways. Because major advances in science are carried out by people performing at Paradigmatic stage 13 and Cross-paradigmatic stage 14, one could expect more rapid advances in that domain (Commons, Ross & Bressette, 2011).

The downside of having more Systematic, Metasystematic and even Paradigmatic-performing beings around might be the increased power to be effectively destructive. To avoid this, one would need to select against antisocial tendencies. It would also be important for there to be socialization that increased empathy and attachment, among other prosocial tendencies. Also, if many decisions would have to rely on co-construction between disparate parties, this might complicate getting things done.

CONCLUSION

It is natural to expect that the notion of a new species like Superions could be met with fear and negative judgments. However, such a new species could introduce positive improvements more rapidly and without the same kinds of unintended consequences, something that Homo Sapiens seem to have more trouble with. Some positive implications include eradicating most disease and genetic defects. It may also be possible to eradicate or greatly decrease many current mental illnesses. Such benefits developed for Superions could be extended to benefit humans. If Superions were developed to function at least at the Metasys-

tematic stage, with some members of the new species at even higher stages, local to global progress would be accelerated and applied to solving many contemporary issues. Perhaps the damage to the Earth wrought by humans to date could be reversed and sustainable modes of production become the harmonious norm.

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Brief Report on Experiential Avoidance and Valuing in At-risk Adolescents

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Abstract

Approximately 20% of youth in the US have academic or behavioral difficulties that interfere with their daily lives, and some data indicate that these problems may be exacerbated by experiential avoidance (EA). While avoiding unpleasant experiences, youth preclude learning opportunities and contact with potential successes. Therefore, it has been theorized that the relationship between EA and adaptive, value-consistent behavior is tenuous. This correlation, however, had not been tested. Thus, seven participants, aged 11 and 12, were recruited to examine the relationship of EA and behavioral inconsistency with values as measured by the Acceptance and Fusion Questionnaire for Youth and the Bull's Eye Values Assessment, respectively. All participants met criteria for ADHD and/or an LD. Several participants were diagnosed with disruptive behavior disorders as well. Given the small sample size, statistical significance was not reached; however, approximately 22% of the variance was accounted for by the relationship between EA and values ($r(5) = .47, p = .143$).

Keywords

Acceptance and commitment therapy (ACT), experiential avoidance (EA), children, adolescents, values, AFQ-Y, Bulls-Eye

PREVALENCE AND RESPONSE TO YOUTH SUFFERING

Approximately 20% of the United States population has a mental disorder that began during their adolescence (Kessler, Demler, Chui, & Watkins, 2005). Attention Deficit Hyperactivity Disorder (ADHD), Conduct disorder (CD), and Oppositional Defiant Disorder (ODD), also known as disruptive behavior disorders, are among the most common childhood disorders. According to the American Academy of Child and Adolescent Psychiatry (2009), 3 to 5% of children are affected by ADHD, about 1 to 4% of children are diagnosed with CD, and 1 to 6% of children meet criteria for ODD. Learning disorders are also fairly common. According to the DSM-IV-TR, about 5% of the general school age population has been diagnosed with at least one learning problem (APA, 2000). These disorders are often co-morbid and can relate to significant problems for youth and others around them.

The quest to alleviate suffering is intense. Animals, including humans, typically make attempts to escape painful stimuli. If escape is not possible, a specific pattern of behavior called conditioned suppression or learned helplessness will often occur (Maier & Seligman, 1976). Unsuccessful attempts to control the occurrence of aversive events can lead to lack of responding such that there is a decrease in behavior. Consequently, an organism can become rigid and inflexible and have a lowered level of adaptability. Unlike other animals, humans will have similar response patterns to imagined consequences of events. As discussed by Hayes, Strosahl, and Wilson (1999), escape and avoidance behavior is conditioned through negative reinforcement. However, the initial relief may have detrimental long-term

consequences – especially if the avoidance keeps one away from valued activity (Soriano, Valverde, & Martinez, 2004).

EXPERIENTIAL AVOIDANCE

Experiential avoidance can be defined as the tendency to alter the form or frequency of thoughts, feelings, bodily sensations, or related events – even when doing so is problematic (Hayes, Wilson, Gifford, Follette, & Strosahl, 1996). There is now a good deal of evidence, at least in adult samples, that EA is related to a wide variety of emotional and behavioral difficulties. An in-depth review of the EA literature is beyond the scope of this paper. Data gathered in multiple studies reveals that EA predicts symptoms associated with a wide variety of anxiety and mood disorders, personality disorders, substance abuse, and other forms of psychological distress. Further, EA is associated with the exacerbation of symptoms after traumatic events and mediates relationships between other forms of coping and symptom expression. Treatment studies indicate that decreases in EA are related to improvements in functioning and quality of life (for review, consult the following: Chawla & Ostafin, 2007; Hayes et al., 1996; Kashdan, Barrios, Forsyth, & Steger, 2006).

Biglan, Hayes, & Pistorello (2008) propose two processes involved in the maintenance of EA that is reflected in mediation studies. The first process involves “stressful events making experiential avoidance more likely,” and the second process involves “experiential avoidance leading to poor outcomes (including more stress)” (Biglan et al., 2008, p. 141). There could be multiple explanations for this pattern. It is likely that while a person is engaging in EA, he or she fails to attend to private information. As a consequence, learning opportunities are missed and an individual does not make properly informed decisions about

how to behave in more adaptive ways when difficult life events arise again in the future (Hayes & Gifford, 1997) – causing a “snowball effect”. One treatment that specifically targets experiential avoidance is Acceptance and Commitment Therapy (ACT; Hayes, Strosahl, & Wilson, 1999).

ACCEPTANCE AND COMMITMENT THERAPY

The ACT model will only be briefly mentioned here, as this paper is not directly treatment related. Interested readers should consult the Association for Contextual Behavioral Science at www.contextualpsychology.org for additional information. ACT clinicians focus on increasing psychological flexibility through six processes: acceptance, cognitive defusion, self as context, contact with the present moment, valuing, and committed action (Hayes, et al., 2004). Psychological flexibility can be defined as becoming aware of the current context (including external environmental and internal factors, such as thoughts and feelings) and responding to it mindfully based on values. For the purpose of this paper we will briefly discuss the two components of ACT that most directly address avoidance and the corresponding restriction of behavioral flexibility and reinforcement: acceptance and values. Readers should note that the importance of clinicians remaining flexible with clients, and with their own experiences, and rely on the following descriptions, only as examples of processes – not as definitions as the way to approach the work.

Acceptance can be defined as “a fundamental openness to experience” without moving to alter difficult experiences (Greco & Eifert, 2004). It is often considered at the opposite end of a continuum with experiential avoidance. In essence, acceptance is embracing all of your history, your current circumstances and whatever thoughts and feelings you have about your imagined future as well. Acceptance does not equate to tolerance or to emotional wallowing. This willingness is advocated when control or change efforts have been unsuccessful, and when embrace of experience would likely increase values-based action. In therapy with youth, physically enacting metaphors is a beneficial way to illustrate acceptance. For example, a chair with wheels can be labeled with the thoughts, feelings, or experiences that the child or adolescents has been struggling to get rid of. The clinician can model that the chair is difficult to carry around and that it is hard to pass by, but if the youth is willing to make contact with the chair, and the content it symbolizes, the wheels allow for more easy and flexible movement around the room (and life). The clinician can tie this in directly to values by labeling the door, or some other marker across the room, with information about values.

Values, or valuing, is the process in which clients identify what is important to them. Values are often talked about in terms of motivation, or reinforcement. It is important to note that values are intended to be directional, and they do not have endpoints. However, determining what matters to a client helps you set goals, which do have endpoints, to use as markers for treatment progress. Additionally, from an ACT perspective, valuing is not tied to a feeling state. A teen could, for example, feel angry and tell her sibling that she is sorry because she values their relationship.

A clinician might assess values by asking a child who or what they care about the most. Doing so in concrete, active ways – such as making a treasure chest collage and filling it with symbols of values is often useful. Valuing determines the course of therapy as well as life direction. In the ACT model, clinicians and clients often talk about how consistent behavior has been with respect to values within a certain period of time. Using a concrete target, or bulls-eye, has been used with youth to determine if behavior is “on the mark” (Murrell & Wilson, 2002; Murrell, Coyne, & Wilson, 2004). More recently, a paper and pencil bull-eye measure was developed to assess values with adults. We wanted to test its utility with youth while examining the relationship between EA and valuing in this population.

HYPOTHESES

1. We expected that the youth, with assistance in reading (given that they had LD’s in reading), would understand and respond appropriately to the paper and pencil values measure.
2. As previously stated, the processes of experiential avoidance and problems in valuing appear to be related. Thus, we hypothesized that youth who reported greater experiential avoidance would report more values-inconsistent behavior. The Avoidance and Fusion Questionnaire for Youth (AFQ-Y; Greco, Murrell, & Coyne, 2005) measures avoidance at increasing levels: the higher the score, the greater the prevalence of EA. The Bull’s Eye Values Assessment (Lundgren & Dahl, 2006) measures behavior with respect to values; the farther the distance from the center, the lower the prevalence of values-consistent behavior. Therefore, a positive correlation was expected with the AFQ-Y scores and the Bull’s Eye scores.

METHOD

PARTICIPANTS AND PROCEDURE

Participants were recruited from a charter school for youth with learning disorders, located in a large city in the South Central region of United States. A total of seven participants (ages 11-12) were included. Six of the participants were African American, one participant was Mexican American. Four of the participants were females and three were males. All of them had been diagnosed with Attention Deficit Hyperactivity Disorder and a Learning Disorder (primarily Reading Disorder). Several of the participants had been diagnosed with either Oppositional Defiant Disorder or Conduct Disorder as well.

All participation was voluntary, as youth assented in addition to parental consent. The participants were removed from a study hall class or extracurricular class period, for a period of about 30 minutes. All data collection was done in a small, quiet testing room – one on one, with a researcher who read the questionnaire instructions to the children and then allowed the youth to complete the measures on their own. Three of the youth asked for additional assistance in completing the measures; in those cases, the researchers read the items and responses choices to the youth and the participants completed the forms on their own. Those responses did not appear different from the others

in any meaningful way. Small incentives, including a snack and stickers were given to each youth at the end of the data collection.

MEASURES

Avoidance and Fusion Questionnaire for Youth (AFQ-Y; Greco, Murrell, & Coyne, 2005). The AFQ-Y is a self-report measure that is answered on a 0-4 Likert-type scale, ranging from 0 (“Not At All True”) to 4 (“Very True”). The measure includes 17 items that measure cognitive fusion and experiential avoidance in children and adolescents. The measure has evidenced good internal consistency with multiple child and adolescent samples (alphas ranging from .85-.95). It correlates positively with child-reported anxiety ($r(511) = .37, p < .001$), somatic complaints ($r(673) = .45, p < .001$), internalizing and external problem behavior ($r(673) = .64, p > .001$), and negatively with overall quality of life ($r(673) = -.39, p < .001$) (Greco, Lambert, Baer, 2008). The alpha in this sample was computed; despite small sample size, it was acceptable (.83). The standard error of the measure in this sample was 4.83.

The Bull's Eye Values Assessment Murrell & Wilson, 2002; Murrell et al., 2005; Lundgren & Dahl, 2006). An ACT-consistent experiential exercise to assess values in children was originally developed in a 10-session ‘ACT for Kids’ group (Murrell, & Wilson, 2002). It was described as a measurable task in a chapter in 2005 but not actually developed as a paper and pencil version until 2006. This paper and pencil measure, like the exercise, helps participants identify values and assess the extent to which they are living consistently with their values. The measure consists of three targets that correspond to three value domains. On each target, the participant places an X, depending on how consistently he or she has been living in relation to that value during the last week: that is, the extent to which their behavior has been in line with that value. An X placed directly in the center of the bull's eye means they are living consistently, right on target, with that value. The farther the distance away from the center of the target the X is indicates behavior that has been less consistent (or

more inconsistent) with values. The distance from the center of the target to the X is measured in millimeters. A consistency index is calculated by averaging these three scores. The participant is asked to record barriers to valued living after the three targets. The measure also has a separate target that assesses overall persistency or willingness. At the end of the measure, there are questions that ask about how long it requires to complete the measure and if the participant requires assistance in completing the form.

Preliminary studies have revealed solid psychometric properties. The authors reported a good validity and test-retest reliability of .86 (Lundgren, 2006; Lundgren, Dahl, & Hayes, 2008).

In the original validation study, correlations with previously existing ACT-consistent measures of values as well as measures of distress were used to assess convergent and discriminant properties. The standard error of the measure was 5.72. Prior to this study, the paper and pencil version has only been used with an adult population; therefore, in order to assess developmental appropriateness as well as relationship to EA, the researchers asked questions about understandability and utility and recorded qualitative responses. No adaptations were made to the measure itself; however, there were some cases in which participants needed assistance with its completion. Details about this process are discussed below.

RESULTS

To test hypothesis one, qualitative information was gathered about the understandability and utility of the paper and pencil version on the bull's eye measure. Four of the participants were able to complete the measure without assistance from the researchers. These four youth described the task as generally understandable. Two of these participants did note that it was somewhat difficult to list barriers and to describe persistence/willingness across three valued domains, as opposed to having response options for each target. On average, it took them just over 5 minutes to complete the measure. Three of the four re-

EXPERIENTIAL AVOIDANCE AND INCONSISTENCY WITH VALUES

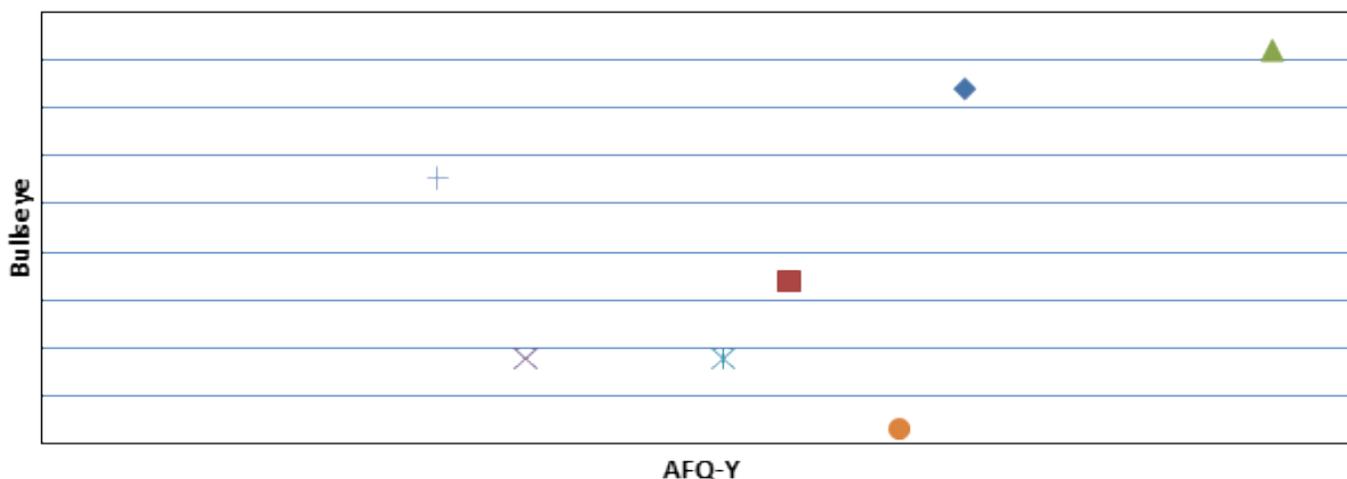


Figure 1. Figure 1. Scatterplot of AFQ scores and Bullseye scores

ported that the completion of the measure was helpful to them in thinking about their feelings and behavior. The three students who needed assistance with the measure generally requested help because of reading concerns, rather than problems in comprehending the concept behind the bull's eye measure. However, all three of them did require prompts from the researchers to complete detailed information about barriers to valued actions. Nonetheless, all of these participants stated that the measure was useful. The average completion time for these participants was just over 7 minutes.

The Means and Standard Deviations of the AFQ-Y and Bull's Eye measures were $M = 34.57$; $SD = 12.78$ and $M = 20.33$; $SD = 15.14$, respectively. In order to explore the relationship between the level of experiential avoidance and values-inconsistent behavior in children, a Pearson product moment correlation was conducted using scores from the AFQ-Y and the Bull's Eye Values Assessment, respectively. The total score from the AFQ and the consistency index from the Bull's Eye were used. Results were not statistically significant, but the effect size was large. Specifically, the results of the one-tailed Pearson product moment were $r(7) = .47$, $p = .143$. A scatterplot of the scores can be viewed in Figure 1. Since there were only 7 participants included in the analysis, and because the effect size was large (approximately 22% of variance accounted for by the relationship) but not statistically significant, a repeated random re-sampling approach was used. The 95% confidence interval was calculated for each variable. The AFQ-Y CI was 9.76 – 33.34 and the CI of the Bull's Eye was 8.24 – 28.14. A random number generator was used to create hypothetical data within this interval for an additional sample with 7 participants. The same Pearson correlation analysis was run, with this sample and with a larger sample with all these participants combined. The generated data resulted in a significant positive correlation, $r(7) = .68$, $p < .05$. The sample with 14 participants also resulted in a significant positive correlation, $r(14) = .46$, $p < .05$. These results may indicate that learning disordered adolescents engaging in experiential avoidance also report more values inconsistent behavior.

DISCUSSION

The bull's eye measure may need to be slightly adapted for use with youth. Perhaps, given the feedback obtained from the youth, there should be separate questions assessing barriers and persistence for each valued domain, listed after each target. Additionally, the concurrent use of the experiential exercise may be a good way to help children and adolescents maintain focus and motivation and strengthen the utility of the paper and pencil format. With respect to the relationship between valuing and avoidance, while the initial finding was not statistically significant, the hypothesis was generally supported. It does appear that youth are limiting their opportunities to engage in values based on avoidance.

LIMITATIONS AND FUTURE DIRECTIONS

The greatest limitation of this study is the very small sample size. The study was originally designed to be a classroom based project, with about three times the number of participants that we had. Had the researchers known ahead of time that there would only be seven youth included, we would have used a different

design and measures. Further, the group composition was not well varied and thus generalizability is limited. It is possible, especially given these limitations associated with the sample, that the effect size is a random statistical effect. However, given the results of the correlation analysis with the re-sampled data, this does not seem particularly likely. Future studies should include more participants to address this concern. Another limitation is that we only have self-report. A packet of parent and teacher assessments were distributed but not completed. Future studies could either include larger sample or use alternative measurements. For example, a small group analysis with more qualitative feedback would be a good way to examine the relationship between avoidance and valuing. A multiple baseline intervention study would be ideal. Tracking behavior via observation, utilizing clinicians, teachers, and parents as informants would also be helpful. Lastly, even though validity studies on the scales have been done, a Rasch Analysis would be done to examine if each scale was truly one dimensional.

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