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# Learned Industriousness

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Extensive research with animals and humans indicates that rewarded effort contributes to durable individual differences in industriousness. It is proposed that reinforcement for increased physical or cognitive performance, or for the toleration of aversive stimulation, conditions rewards value to the sensation of high effort and thereby reduces effort's aversiveness. The conditioning of secondary reward value to the sensation of effort provides a dynamic mechanism by which reinforced high performance generalizes across behaviors. Applications to self-control, moral development, and education are described.

Some individuals are more industrious than others of equivalent ability and motivation. One student consistently studies harder than a classmate in a variety of courses. A teacher carefully prepares lessons, whereas a colleague uses outmoded and incomplete notes. A factory employee carries out assignments diligently as compared to a coworker who exerts only enough effort to avoid being fired. Learning may make a major contribution to such individual differences in industriousness.

Six decades ago, J. B. Watson (1930/1970) argued that

> the formation of early work habits in youth, of working longer hours than others, of practicing more intensively than others, is probably the most reasonable explanation we have today not only for success in any line, but even for genius. (p. 212)

Although Watson may have exaggerated for emphasis, learned individual differences of industriousness do have an important influence on achievement. As Mowrer (1960) noted,

> Fear of pain is not, of course, the only barrier that obstructs living organisms in their march toward the fulfillment of their needs and wants. *Effort* may likewise cause them to "give up" in circumstances when just a little more persistence would lead to success. (p. 436)

The emphasis placed in recent years by social and personality psychologists on contextual determinants of behavior has been altered by the growing recognition that a number of behavioral propensities show a moderate degree of temporal and situational stability. These include honesty (Burton, 1963), competitiveness and cooperativeness (Bem & Lord, 1979; Kuhlman, Camac, & Cunha, 1986), self-control (Mischel, Shoda, & Peake, 1988), and industriousness (Eisenberger, 1989a; Eisenberger & Shank, 1985; Greenberg, 1977; Merrens & Garrett, 1975). Learning analyses of such individual differences consider both the generalization of training to new situations and the discrimination processes that bring behavior under situational control (Liebert & Spiegler, 1982; Maddi, 1989; Mischel, 1976; Staats, 1983).

The animal behavior literature most relevant to learned industriousness concerns the conditioning processes that influence the persistence of the individual response class (i.e., actions by an organism used interchangeably to satisfy an instrumental contingency; see Skinner, 1938). The production of high rates of responding by schedules of intermittent reinforcement has been carefully mapped (Ferster & Skinner, 1957), and associative learning theories successfully explain the greater extinction performance following intermittent reinforcement than continuous reinforcement (the partial reinforcement extinction effect, or PREE), as well as related phenomena (Amsel, 1958, 1962; Capaldi, 1967, 1971). These approaches have clear value for understanding the persistence of the individual response class but have limited application to the development of individual differences of industriousness. This article considers effort learning that may contribute to generalized industriousness.

## Conceptualization of Effort

Physical effort involves "the subjective experience that accompanies bodily movement when it meets resistance or when muscles are fatigued" (English & English, 1968, p. 171) and has widely been considered to be aversive (Hull, 1943; James, 1890; Logan, 1960; McDougall, 1908; Solomon, 1948). According to Kahneman (1973), a basic difference between the experience of effort and other motivational conditions, such as those produced by drugs or loud noise, is that the performance the individual "invests at any one time corresponds to what he is doing, rather than what is happening to him" (Kahneman, 1973, p. 4). More generally, it is assumed here that the performance requirements of different tasks produce qualitatively similar response-produced sensations of effort.

Associative persistence theories incorporate the effects on learning of one kind of effort manipulation, involving the frequency of responding as required for the receipt of a reinforcer. More often cited as being related to the experience of effort is the intensity of required performance. When studied with rats, intensity usually involves the force required to depress a lever

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(e.g., Brener & Mitchell, 1989; Notterman & Mintz, 1965). Other techniques are sometimes used, including requiring rats to pull a weight while traversing a runway (Lewis, 1964), to run faster (Logan, 1960), and to traverse a steeper incline (Lawrence & Festinger, 1962; Mirsky, 1975). The required intensity of physical performance also produces learning effects in humans (Boyagian & Nation, 1981).

Two other physical-performance requirements may contribute to the sensation of effort. Rats readily learn to increase the duration of their lever presses, and the increased duration carries over to lever extinction performance (Stevenson & Clayton, 1970). Rats can also learn to increase the precision of their performance, which involves refined motor control, in such a task as narrowing the limit of the range of lever force (Notterman & Mintz, 1965). Similarly, humans can be reinforced for the precision of their perceptual-motor performance, such as the fitting of a variety of forms in matching holes (Eisenberger, Mitchell & Masterson, 1985). These differing dimensions of physical performance are assumed, in the present view, to produce similar, although not completely substitutable, qualitative experiences of effort. It follows that learning involving one dimension will generalize, to some degree, to other dimensions.

Cognitive effort is often used to denote the "intensification of mental activity when it is obstructed in some way" (English & English, 1968, p. 171). The comparability of the experiences of cognitive and physical effort has long seemed self-evident (James, 1890; McDougall, 1908), leading to the general definition of effort as involving "the physical or mental application that is devoted to achieving a result" (Hayakawa, 1968, p. 183). This ascribed similarity may be partly metaphorical. As Skinner (1938) noted, language used to denote the world of the external senses is often applied to the internal stimulus field.

The metaphors of intuitive psychology (Heider, 1958) provide a useful starting point for scientific explanation when they describe processes that have similar properties, and there may be a strong natural similarity between the experiences of physical effort and cognitive effort. As with physical performance, the reinforcement of high cognitive performance can involve the number of responses (e.g., the number of spelling words a student must learn for a token reinforcer; see Eisenberger, Heerdt, Hamdi, Zimet, & Bruckmeir, 1979), speed (e.g., reading quickly; see Eisenberger, Mitchell, McDermitt, & Masterson, 1984), and precision (e.g., minimizing pronunciation errors while reading aloud; see Eisenberger et al., 1984). The cognitive manipulation most often used in effort studies involves task complexity, such as the difficulty level of math problems (Eisenberger, Masterson, & McDermitt, 1982). These dimensions of cognitive performance are assumed to produce qualitatively similar experiences of effort. Thus, as with physical performance, learning involving one dimension of cognitive performance should transfer, to some extent, to other dimensions of cognitive performance.

There may be a continuity of experience between physical effort and cognitive effort resulting, in part, from the dependence of both kinds of sensations on meeting performance criteria in goal-oriented behavior. Moreover, prolonged physical performance and cognitive performance both produce fatigue, which refers to a response-produced decrement in the organism's capacity to continue to perform the same activity or similar activities efficiently (Solomon, 1948). Although most research on fatigue concerns physical performance, extended cognitive activity similarly reduces cognitive performance. For example, Mast and Heimstra (1964) found that long bouts of mental arithmetic decreased students' signal detection efficiency. Further, physical fatigue, resulting from muscular exertion, can reduce cognitive efficiency in such tasks as short-term memory, mental arithmetic, and vigilance (Bonnet, 1980). Such fatigue effects may enhance the perceived similarity of physical and mental effort. High physical performance and high cognitive performance would be assumed to produce related discomforting experiences of effort. This implies that learning concerning high physical performance will show some transfer to cognitive performance, and vice versa.

It is also possible that the receipt of aversive stimulation in the course of goal-oriented behavior contributes to the sensation of effort. Glass and Singer (1972) proposed that adaptation to aversive stimulation requires cognitive effort, and Cohen (1980) suggested that such exposure taxes attentional capacity. Hartley (1973) found with humans that cognitive-task difficulty and loud noise had additive effects on fatigue, as indicated by subsequent performance decrements on a serial reaction task. To the extent that active attempts to adapt to aversive stimulation produce the sensation of effort, such attempts may have effects on learning that are similar to other performance manipulations.

## Prior Theory Concerning Effort in Goal-Oriented Performance

According to the law of least effort, performance evolves toward the minimal amount of energy expenditure required for reinforcement (Brener & Mitchell, 1989; Hull, 1943; Solomon, 1948). Hull formalized the principle as follows:

> If two or more behavior sequences, each involving a different amount of energy consumption or work (W), have been equally well reinforced an equal number of times, the organism will gradually learn to choose the less laborious sequence leading to the attainment of the reinforcing state of affairs. (1943, p. 294)

Consistent with this view, rats adjust their force of lever pressing toward the minimal amount required (Brener & Mitchell, 1989; Notterman & Mintz, 1965), and they generally choose the less effortful of two similar reinforced responses, such as the shorter of two runways or the more lightly weighted of two levers (Lewis, 1965; Solomon, 1948). Although the law of least effort demonstrates the aversiveness of added energy expenditure, its application is limited to situations that are rarely approximated in the natural environment. Seldom does the organism face a choice between two degrees of effort that produce roughly the same magnitude of reinforcement. Typical everyday contingencies involve a single task, or a choice among several tasks, in which increased performance leads to a greater magnitude of reinforcement. The law of least effort is silent concerning the required trade-off between keeping performance low and keeping the magnitude of reinforcement high.

Models concerned with the maximization of subjective utility (Rachlin, Battalio, Kagel, & Green, 1981), behavioral conservation (Allison, 1976; Timberlake & Allison, 1974), and behavioral regulation (Allison, Miller, & Wozney, 1979; Hanson & Timberlake, 1983) predict performance from the terms of the instrumental contingency, the utility of reinforcement, and the disutility (i.e., aversiveness) of instrumental performance. These theories have been quite successful in predicting performance as a function of the terms of the contingency. However, they treat the aversiveness of effort as static and fail to consider how effort's hedonic value is altered by experience. Generalized industriousness implies more than a parameter adjustment in the equations incorporating the aversiveness of increased performance for a particular instrumental response. Rather, industriousness suggests that the aversiveness of a broad range of instrumental behaviors may be simultaneously altered by learning.

## A Secondary Reward Theory of Industriousness

Pairing the response-produced sensation of effort with a reinforcer may cause that sensation to take on secondary reward properties in the same way as pairing an external stimulus with a reinforcer. Incentive-motivational and expectancy approaches to operant behavior emphasize the learning of stimulus–reinforcer relationships in which stimuli associated with reinforcement acquire secondary reward properties and come to elicit approach (e.g., Bindra, 1974; Bolles, 1972; Miller, 1963; Mowrer, 1960; Spence, 1956). According to these accounts, behavior is guided toward the response-produced stimuli that possess the greatest conditioned reinforcement value. The present approach extends these accounts by assuming that effort is a basic dimension of response-produced experience that is highly sensitive to the conditioning of secondary reward value.

Various ways of increasing the degree of required performance in a given task would contribute to experienced effort. Reinforcement of increased physical or cognitive performance, or the toleration of aversive stimulation, would classically condition reward value to the sensation of high effort, thereby reducing its aversiveness and extinguishing some of the preexisting secondary reward value of low effort. Correspondingly, reinforcement of reduced physical or cognitive performance would condition secondary reward value to the sensation of low effort and would extinguish some of the previously established secondary reward value of high effort.

In contributing secondary reward value to high effort, and thereby reducing its aversiveness, reinforced high performance would strengthen the subsequent performance of different tasks. Performance in a given task would be affected by the terms of the current contingency and by previously conditioned changes in the aversiveness of effort. Following the reinforcement of high performance, organisms would increase their performance in tasks that provided greater reinforcement for higher effort (i.e., an increased quantity or quality of reinforcement, or its more immediate receipt). In choice situations, organisms would increase their preference for high-effort tasks that produced a large magnitude of reinforcement relative to low-effort tasks that yielded a small magnitude of reinforcement.

The sensations of effort associated with high degrees of required performance in different dimensions (e.g., frequency and intensity) are assumed to be similar but not completely substitutable. Reinforced high performance involving a given dimension in one task should transfer to other performance dimensions involving different tasks. However, because the experiences of effort produced by different performance dimensions are assumed to be somewhat different, differentially reinforced effort in a given dimension should result in greater performance in that same dimension of transfer performance than in other dimensions.

The secondary reward value of effort is assumed to be conditioned in relation to the stimulus context and to generalize according to the similarity between the effort-training situation and the transfer situation. The degree of primary stimulus generalization would depend on the number of stimulus elements shared between the effort-training situation and the transfer situation. Increasing the variety of tasks in which high performance was reinforced would condition the secondary reward value of high effort to a greater variety of stimuli and thereby increase the generalization of high performance across tasks. In addition, humans' mediated generalization, in the form of verbal labeling, would influence the extent to which the conditioned reward value of effort would transfer to new situations. A person's identification of the effort-training task as belonging to a general category (e.g., school work as opposed to a specific training task) would broaden such mediated transfer of the secondary reward value of effort (cf. Burton, 1963). Discrimination training would be assumed to bring generalized effort under some degree of stimulus control. For example, a stimulus continually paired with the reinforcement of high performance would evoke a greater secondary reward value for high effort than would a stimulus that was paired with the reinforcement of low performance.

## Implications

The secondary reward theory makes a range of predictions for humans and lower animals concerning the generalized effects of reinforced high performance and has implications for human self-control, moral development, and education.

### *Generalized Effects of Effort Training on Extinction Performance*

Most conditioning analyses of effort learning have focused on the PREE. Historically, this phenomenon attracted considerable interest because it was ubiquitous and often was of great magnitude (Skinner, 1938), was contradictory to Hullian learning theory (Humphreys, 1939), and was counterintuitive (Bower & Hilgard, 1981, p. 341). The PREE has been one of the most studied and best documented effects in the field of animal learning, with applications to a wide variety of human behaviors (e.g., Chapin & Dyck, 1976; Fowler & Peterson, 1981; Halpern & Poon, 1971; Nation & Woods, 1980).

Although the conditioning of the instrumental response to anticipatory frustration (Amsel, 1958, 1962) and to the stimulus trace of unrewarded trials (Capaldi, 1967) both appear to be strongly involved in the PREE (Domjan & Burkhard, 1982), conditioned changes in the aversiveness of effort may also play a role. According to the view expressed here, requiring the completion of an increased response ratio contributes to the PREE by pairing high effort with reward, thereby enhancing effort's secondary reward properties and reducing its aversiveness.

An increased secondary reward value of high effort, conditioned by a response ratio, should enhance the extinction performance of other behaviors besides the training behavior. For example, Wenrich, Eckman, Moore, and Houston (1967) gave one group of rats food for each trip down a runway and gave a second group food for 15 trips. Next, all animals were required to perform an entirely different activity, lever pressing, with each response being rewarded. Finally, lever pressing was observed when it no longer produced food. Wenrich et al. reported that rats rewarded for every 15th run in the alley showed greater lever-press extinction performance than did rats that had been rewarded for each run. The intermittent reward of one behavior (alley traversal) had increased the subsequent extinction performance of an entirely different behavior (lever pressing).

Similarly, McCuller, Wong, and Amsel (1976) found that rats' speed of running in a straight alley following the termination of food reward was greater if the animals had previously lever pressed 15 times for each food presentation rather than lever pressing once per food presentation. This transfer effect was quite resilient, being sustained through the reacquisition of runway traversal to a second set of runway extinction trials (Wong & Amsel, 1976). Such generalization of effort learning to the extinction performance of a different behavior was successfully replicated in several experiments using free-operant procedures (Eisenberger, Carlson, Guile, & Shapiro, 1979; Eisenberger, Masterson, & Lowman, 1982).

Similar generalized effects of a required high response ratio have been found with humans (Flora & Pavlik, 1990; Nation, Cooney, & Gartrell, 1979; Pittenger & Pavlik, 1988). For instance, Nation et al. rewarded college students on each trial, or on half the trials, for moving a peg back and forth in a human version of the animal shuttle box; for all the students, this shuttle box phase was followed by extinction trials. Later, the students were rewarded on each trial for button pressing and then extinguished on button pressing. Button pressing performance in extinction was greater following the intermittent reinforcement of peg movement than after continuous reinforcement.

It follows from the secondary reward theory that reinforcing high performance in other dimensions besides the response ratio will reduce the aversiveness of high effort and thereby increase the extinction performance of different behaviors. The force required to depress a lever is the method most frequently used with rats for varying the required intensity of responding. Assessment of the generalized effects of required lever force must take into account presses of inadequate force (Applezweig, 1951; Brener & Mitchell, 1989; Eisenberger, 1989b; Frick, 1986; Mackintosh, 1974; Skinner, 1938). Because of the occurrence of lever presses that lack the necessary force, the actual ratio of responses per reinforcer the during training is often greater for a high-force group than for a low-force group. Therefore, greater generalized performance following a high-force requirement than a low-force requirement could be an indirect effect of the higher number of emitted responses per reinforcer.

This confound can be eliminated by yoking each high-force animal to a low-force animal in such a way that during training, responses by the high-force animal that fail to meet the force criterion are added to the number of responses required of the paired low-force animal. Before using this technique, Eisenberger, Carlson, Guile, and Shapiro (1979) assessed the baseline performance of the future transfer behavior by reinforcing rats for each round trip (shuttle) in a runway. The rats were then divided into groups that were rewarded for exerting low force or high force on a lever. Each rat was then returned to the runway, where shuttling was extinguished. The rats rewarded for high-lever effort, compared with those rewarded for low-lever effort, had a substantially greater rate of extinction performance in the runway.

With humans, the complexity of a cognitive task has been found to influence persistence on a subsequent unsolvable perceptual task. College students were presented with complex anagrams, simple anagrams, or, in a control group, were merely given the anagram target words to read (Eisenberger & Leonard, 1980, Experiment 3). To examine the effects of rewarded high cognitive effort while controlling for the number of successes and failures during training, a yoked group was included. This group experienced the same pattern of successes and failures as the complex-anagram group, but without success resulting from high cognitive effort. This was accomplished by presenting each yoked student with a simple anagram on each trial for which his or her paired complex-anagram student had succeeded and an unsolvable anagram on each trial for which his or her paired complex-anagram student had failed. Thus, for the yoked group, low effort was associated with success, and high effort, with failure. The complex-anagram group showed greater subsequent persistence than the other two groups on unsolvable perceptual problems. With both physical and cognitive tasks, then, increasing the required performance increased the subsequent extinction performance of other tasks.

There is preliminary evidence with humans that, in accord with the secondary reward theory, reinforcement of high physical performance increases subsequent cognitive performance. In a study by Boyagian and Nation (1981), different groups of students were rewarded for pressing a pad with low or high pressure and were then told they would be taking part in a second experiment. A new experimenter brought the students to a different location, where they were given anagram problems. The students who had been rewarded for pressing a pad with high pressure subsequently solved anagrams more quickly than the students who were rewarded for pressing with low pressure.

### *Generalized Effects of the Response Ratio on Reinforced Performance*

By increasing the secondary reward value of high effort, a required response ratio involving one behavior should influence the subsequent reinforced performance of different behaviors. To control for preexperimental individual differences, Eisenberger, Carlson, Guile, and Shapiro (1979) first assessed baseline performance on the future test task. Rats were trained to lever press on a variable-interval schedule until performance stabilized. Next, separate groups were rewarded in a runway for every shuttle (continuous reinforcement group) or for every fifth shuttle (fixed-ratio group). A control group received no runway experience. Finally, all the rats again lever pressed for food on the variable-interval schedule. The rats that had made five shuttles for each food pellet increased their rate of pressing above baseline level and outperformed the other two groups. Similar findings were reported by Eisenberger, Terborg, and Carlson (1979).

The preceding study (Eisenberger, Carlson, Guile, & Shapiro, 1979) involved the transfer of reinforced performance to a previously learned behavior. The required response ratio has also been found to have generalized effects on the acquisition performance of a new behavior (Eisenberger, Carlson, & Frank, 1979). Rats were fed for every lever press or for every ninth lever press and then were trained to make round trips in a runway for food reward. Rats that had been reinforced for every ninth lever press showed a greater rate of runway traversal than the rats that were previously rewarded for each press.

The occurrence of aversive stimulation in goal-oriented performance may also produce the sensation of effort. By conditioning secondary reward value to high effort, a required response ratio involving one task might reduce the subsequent decremental effects of noncontingent aversive stimulation on task performance. Rats required to make five shuttles per pellet in a runway showed less subsequent suppression of food-contingent lever pressing by periodic shock than did rats that had received continuous reinforcement in the runway (Eisenberger, Weier, Masterson, & Theis, 1989).

Transfer effects of the required response ratio have been found in naturalistic settings with human populations that ordinarily show low persistence on assigned tasks. Psychiatric patients diagnosed as depressed are typically less active and respond with less vigor and persistence than most other patients at the time of admission (Ferster, 1973; Lewinsohn, Biglan, & Zeiss, 1976). Some depressed patients do not eat unless urged to do so or unless partly hand fed. Some must have their morning dressing routine finished by another person and, unless coaxed, fail to go to bed in the evening. The depressed patient's general lack of responsiveness may be maintained, in part, by conditions of reinforcement on the psychiatric ward. Because depressed patients are socially withdrawn, interpersonal contact on the ward is usually initiated and maintained by nurses and attendants. The social reward provided by the staff of many wards is noncontingent, as in a greeting, or is contingent on the performance of low-effort responses. For example, patients may be commended for hair combing after a lapse of several days, or after patients are helped to dress, they may be told how good they look.

An experiment by Eisenberger, Heerdt, Hamdi, Zimet, and Bruckmeir (1979) investigated the influence of the reinforcement structure of the psychiatric ward on the depressed patient's generalized performance. Specifically, these investigators studied whether performing a large number of custodial tasks per approval comment from the ward attendant would affect subsequent persistence on a card-sorting task rewarded with approval from a staff psychologist. To obtain a baseline measure of persistence, each patient was asked by the staff psychologist whether he or she would be willing to sort data punch cards. The patients were told that participation was optional and could be terminated by the patient at any time. In each of four sorting sessions, the psychologist checked for sorted cards every 15 min and thanked the patient for each new set of cards sorted. Subsequently, one group of patients was treated as was usual on the ward, and two groups were asked for help on 8 to 10 occasions by the ward attendant, as a favor, with cleanup and maintenance tasks that were normally the attendant's responsibility. On each of these occasions, the high-ratio patients were rewarded with approval following the completion of four or five tasks, whereas the low-ratio patients received approval for the completion of an individual task.

Next, the patients were once more asked for help by the staff psychologist in sorting data punch cards. Figure 1 illustrates the durability of the obtained transfer effect. In the first test session, the high-ratio group's amount of time spent sorting and number of sets of cards sorted were substantially greater than in the baseline condition. Although these values deteriorated across sessions, they were consistently greater than those of either of the other two groups. Therefore, a required high response ratio involving one set of behaviors enhanced mental patients' reinforced performance of other behaviors.

Lack of persistence in academic tasks is typical of children categorized as learning disabled (Myers & Hammill, 1976). These students often score normal or higher on spoken intelligence tests, but their performance in various academic tasks is poor, purportedly because of deficiencies in learning processes. A token economy was used to reward learning disabled schoolchildren on a low- or high-ratio schedule for the learning of spelling words and reading words (Eisenberger, Heerdt, Hamdi, Zimet, & Bruckmeir, 1979). The high-ratio children were rewarded for every four or five words correct, whereas the low-ratio children were rewarded for each word correct. Transfer of performance was tested on a mathematics test and a handwriting assignment that were administered and rewarded by the teacher as part of classroom's ongoing token economy. During the 50-min math test, each child was rated for active work 10 s out of each minute by the teacher's aide, who was unaware of the children's group assignments. As shown in Figure 2, the children in the high-ratio group spent far more periods working and solved many more math problems than the children in the low-ratio group. Similar results were reported for the handwriting assignment. Thus, a reinforced high response ratio countered the general deficiency of performance on reinforced tasks that is usually found with learning disabled children and depressed psychiatric patients.

### *Generalized Effects of Other Performance Requirements on Reinforced Performance*

The preceding findings with animals and humans indicate that the required number of responses involving one behavior influences the later reinforced performance of different behaviors. To see whether the intensity of required performance would produce a similar transfer effect, Eisenberger, Carlson, Guile, and Shapiro (1979) first reinforced rats on a variable-interval schedule for runway shuttling. After performance stabilized, the rats were divided into separate groups that were rewarded for exerting low or high force on a lever. A control group that received no lever training was also included. Each rat was then returned to the runway, where it was once more rewarded on the variable-interval schedule. The rats rewarded for high lever force showed a substantially greater rate of shuttling than

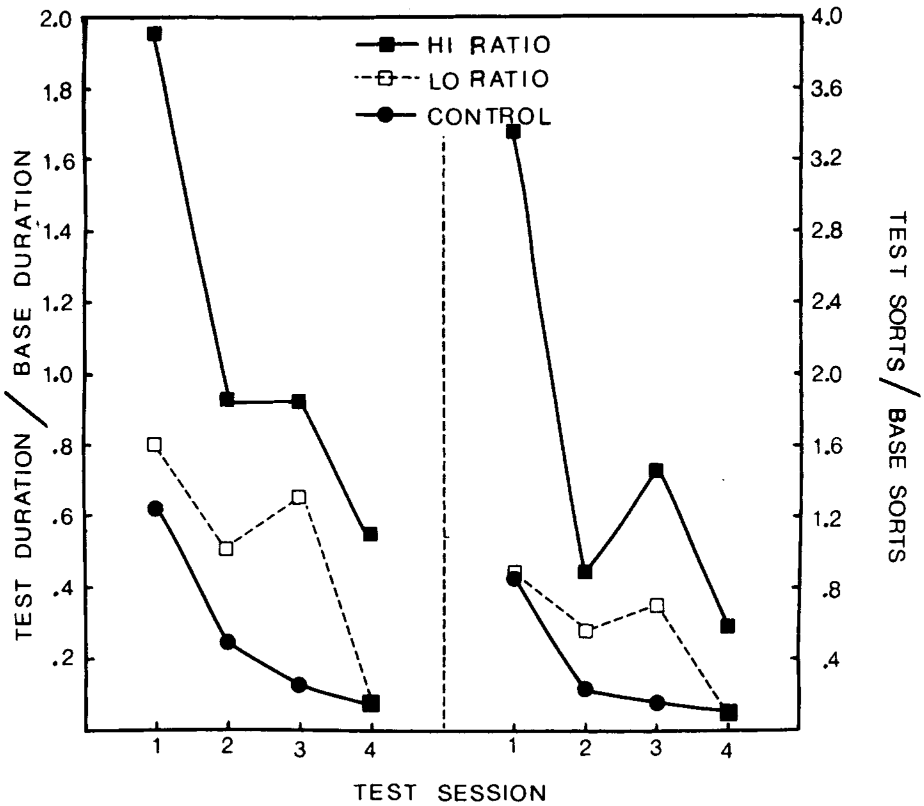


*Figure 1.* The mean ratios of the duration of time spent sorting data punch cards (left) and the number of packets correctly sorted (right) per test session to the same baseline measures for the high-ratio (HI), low-ratio (LO), and control patients.

the other two groups. A subsequent study showed that the effect would persist across several test sessions (see Figure 3).

With humans, cognitive task requirements found to produce generalized effects on reinforced performance include the complexity of math problems given to college students (Eisenberger, Masterson, & McDermitt, 1982, p. 504) and the reinforced accuracy and speed of reading aloud by preadolescent learning disabled students (Eisenberger et al., 1984). The results with animals and humans reviewed thus far suggest that a variety of effort manipulations can influence the performance of different tasks. With rats, raising either the required ratio of responses or the required response force increased the subsequent reinforced performance and extinction performance of different behaviors. With humans, raising the required response ratio in physical or cognitive tasks, the required response force, the complexity of cognitive problems, and the speed or accuracy of cognitive performance produced greater transfer performance in different behaviors.

## *Generalized Effects of Effort Training on Self-Control*

Self-control refers to the individual's decision to undergo the increased costs that may be necessary to achieve the larger of alternative goals. Most research on self-control with animals and humans involves delay of reinforcement, that is, the choice between the early receipt of a small reinforcer versus the deferred delivery of a large reinforcer (Ainslie, 1974, 1975; Ainslie & Herrnstein, 1981; Logue, 1988; Mazur & Logue, 1978; Mischel, 1974; Millar & Navarick, 1984; Navarick & Fantino, 1976; Rachlin, 1974, 1976; Rachlin & Green, 1972). Often, however, self-control in the natural environment also entails high performance (Eisenberger, Mitchell, & Masterson, 1985; Mischel, 1974; Mischel & Staub, 1965), toleration of aversive stimulation in goal-oriented performance (Dollard & Miller, 1950; Renner, 1964, 1966a, 1966b, 1967), or acceptance of a small, early punishment over a large, late punishment (Deluty, 1978; Navarick, 1982; Rachlin, 1989; Solnick, Kannenberg, Eckerman, & Waller, 1980).

Adding a response requirement to delay was found to lessen pigeons' choice of a delayed large reward (Grossbard & Mazur, 1986), and similar effects were found with children (Mischel & Staub, 1965), indicating that required high performance may reduce self-control. By conditioning secondary reward value to high effort and thereby reducing its aversiveness, a reinforced high response ratio would be predicted to increase generalized self-control involving different tasks.

To test for such an effect baseline self-control was first established by giving rats choices between a compartment that afforded a large food reward for high lever force versus a second compartment that provided a small food reward for low lever force (Eisenberger et al., 1989). Next, the animals received food in a runway for each shuttle or for every fifth shuttle. Yoked

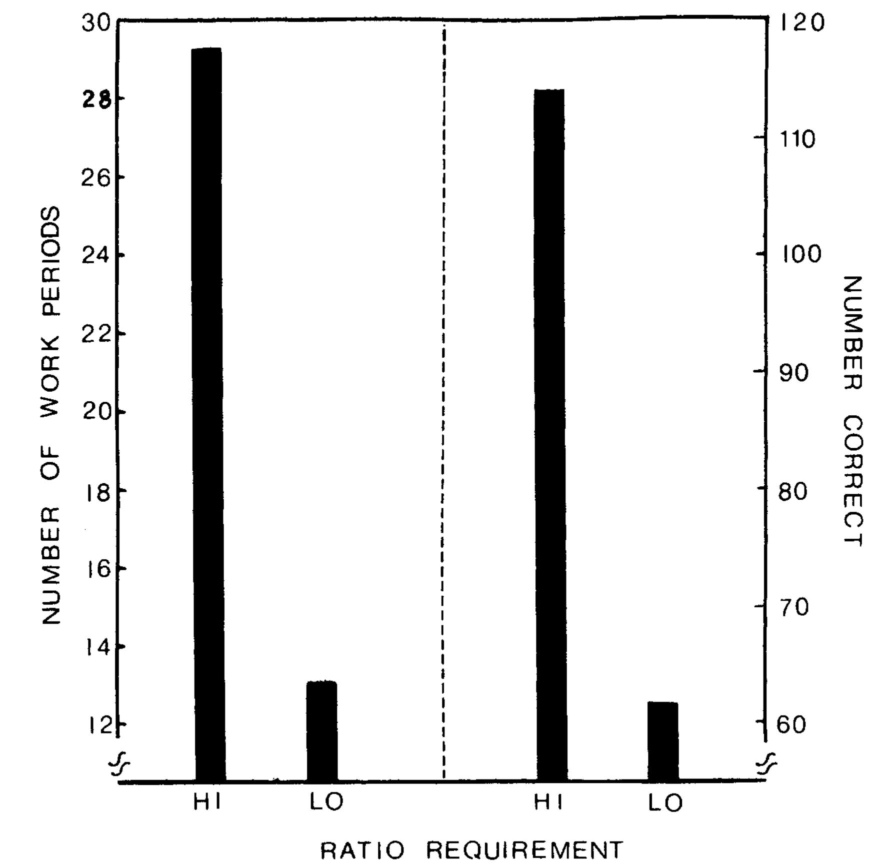


*Figure 2.* The number of periods spent working on mathematics problems (left) and number of problems solved (right) for the high-ratio (HI) students and low-ratio (LO) students.

control groups received free food in the runway at the same temporal intervals as these groups. When again given self-control choice trials, the group that had made five shuttles per food reward increased its selection of the high-effort, large-reward compartment well above the group's baseline level. The other groups showed no change in preference. As indicated in Figure 4, the effect was quite resilient, lasting across the 12 test sessions. Thus, consistent with the assumption that different performance dimensions produce similar sensations of effort, a required response ratio raised subsequent self-control involving both a different behavior (lever pressing rather than runway shuttling) and a different dimension of reinforced performance (response force rather than frequency).

Corresponding effects were found with second- and third-grade students whose baseline self-control was first assessed by giving them repeated opportunities to choose between the tedious task of copying nonsense works for a large monetary reward versus receiving a small monetary reward without working (Eisenberger et al., 1985; see also Eisenberger & Adornetto, 1986). During the next several days, some of the children were paid for high performance in a combination of three tasks involving object counting, picture memory, and shape matching, respectively. Other children were paid for low performance in these tasks, and still others did not receive the tasks. Finally, the children were again tested for self-control. As illustrated in Figure 5, the children who had been reinforced for high performance increased their number of choices of the handwriting task for the large reward above the baseline level, whereas the other two groups showed no change from their earlier preference.

Related results have been reported with self-control involving punishment. The receipt of aversive stimulation during goal-directed performance may increase the sensation of effort. By reducing the aversiveness of effort, a reinforced response ratio should increase the subsequent preference for a large reward involving punishment over a small reward available without punishment.

Rats were initially administered choices between two compartments that offered different amounts of free food (Eisenberger et al., 1989). All the rats developed a strong preference for the compartment providing the greater reward. The rats then received food for runway shuttles on either a continuous-reinforcement or a fixed-ratio schedule, or were given free food presentations in the runway at intervals yoked to individual animals in these groups. Next, the rats were returned to the choice apparatus for a series of self-control sessions in which the selection of the large-reward compartment was now accompanied by periodic electric shock. The fixed-ratio group displayed a durable preference for the compartment affording the combination of large reward and shock, whereas the remaining

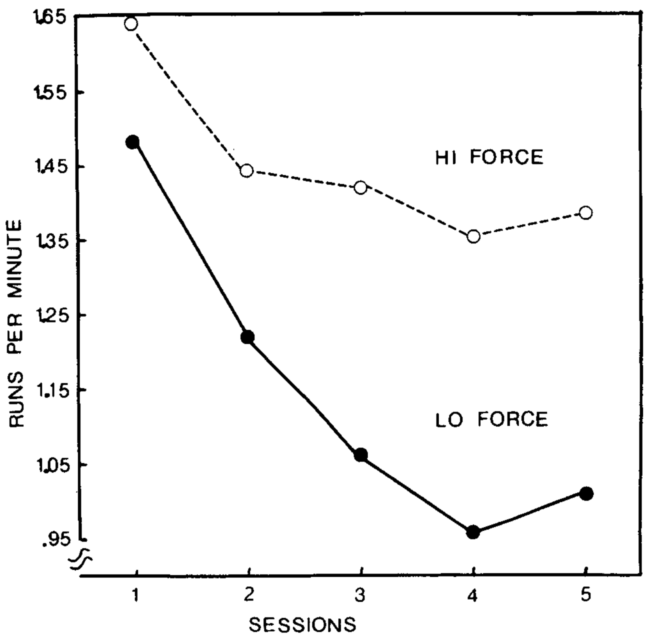


*Figure 3.* The mean number of round-trips per minute in a runway per test session for groups previously reinforced for high (HI) lever force or low (LO) lever force.

groups showed a strong preference for the small-reward, unshocked compartment. This effect was quite resilient, lasting over 12 test sessions. In sum, reinforced response ratios increased rats' generalized self-control involving either intensive performance or the toleration of punishment and increased children's self-control involving the choice of a greater response ratio.

### *Intradimensional Generalization of Effort*

In accord with Logan (1956, 1960), it is assumed that organisms learn which quantitative dimensions of performance are related to reinforcement magnitude. An incentive-motivational or expectancy mechanism would guide performance toward response-produced stimuli having increased secondary reinforcement value. If several independent dimensions of performance were associated with reinforcement for increased effort, each dimension would be influenced by the generalized effects of reinforced high performance. Consistent with this prediction, required high performance had generalized effects on two quantitative response dimensions concurrently: (a) rats, following reinforcement contingent on increased lever-press force, ran more quickly during operant runway shuttling and paused for shorter durations between successive runs (Eisenberger, Carlson, Guile, & Shapiro, 1979); and (b) college students, after solving more complex cognitive tasks, increased the length of subsequent essays and the quality per unit length (Eisenberger, Masterson, & McDermitt, 1982).

Because the experiences of different forms of effort are assumed to be only partly substitutable, differential reinforcement of a given dimension of performance should result in greater generalization of performance in that dimension than in other dimensions. Preadolescent learning disabled students who received points for reading with high accuracy subsequently produced more accurate drawings and stories than did

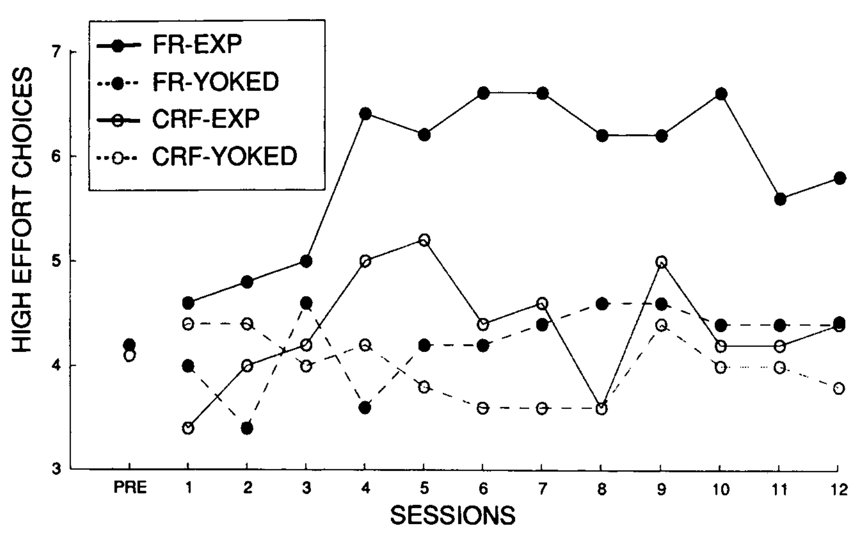


*Figure 4.* The mean number of choices, out of eight possible, of a compartment providing a reward of two pellets for exerting high lever force versus a compartment providing a reward of one pellet for exerting low lever force. (The number of high-force choices averaged over the last 6 baseline sessions [PRE] is given first, followed by each of the 12 test sessions. The fixed ratio–experimental [FR-EXP] group was previously rewarded in a runway for the completion of every five round-trips, whereas the continuous reinforcement-experimental [CRF-EXP] group was rewarded for each round-trip. The FR-YOKED and CRF-YOKED groups received food presentations in the runway at the same temporal intervals as the FR-EXP and CRF-EXP groups, respectively, without an instrumental requirement.)

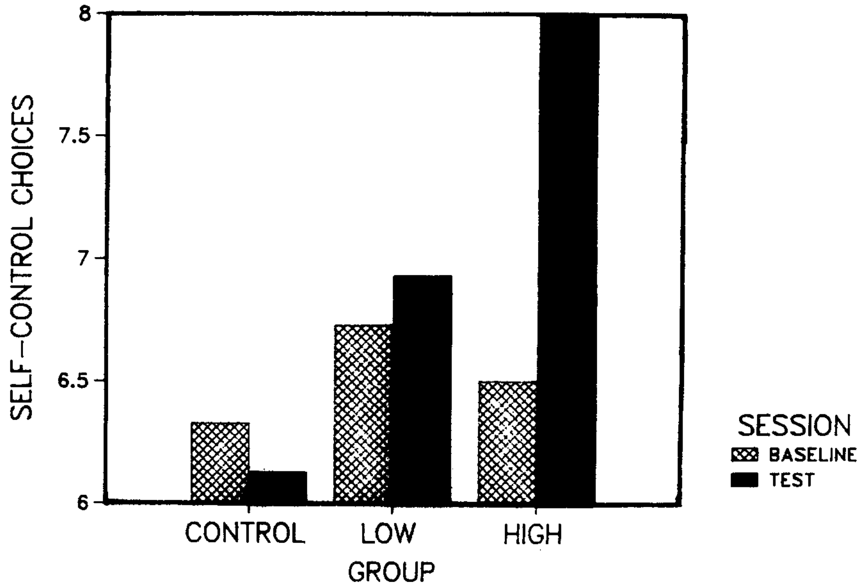


*Figure 5.* The number of choices, out of 10 possible, to copy nonsense words for a large monetary reward versus waiting the equivalent duration without copying. (The baseline performance is given first, followed by test performance. The high group was previously rewarded for high effort in object counting, picture memory, and shape matching, whereas the low group was rewarded for low effort in these tasks. The control group received no effort training.)

students who had been rewarded for reading with high speed or for the mere completion of the reading task. In comparison, students who were rewarded for high reading speed subsequently constructed stories more quickly than did children who had been rewarded for high reading accuracy or for merely completing the reading task (Eisenberger et al., 1984). Thus, differential reinforcement contingent on increased high performance in one of two dimensions produced greater generalized performance in the reinforced dimension than in the alternative dimension.

### *Stimulus Control of Generalized Effort*

The secondary reward value of effort should be conditioned to some extent in relation to the stimulus context and should therefore transfer across behaviors on the basis of the similarity between the situations (Eisenberger, McDermitt, Masterson, & Over, 1983). Given sufficient discrimination training involving the pairing of distinctive stimuli with different levels of reinforced performance, the stimuli should come to exert some degree of control over the effort expended in different behaviors.

In an experiment with college students, two reinforcement agents took turns administering a perceptual task that required the subjects to identify subtle differences between cartoon drawings (Eisenberger et al., 1983). The high-ratio agent required five identifications per pair of drawings, whereas the low-ratio agent required only a single identification. Next, one of the two agents assigned a short essay. Assignment of the essay by the high-ratio agent, as compared with the low-ratio agent, resulted in longer essays and greater essay quality per unit of length. These findings suggest that stimuli repeatedly paired with different required response ratios exert discriminative control over generalized performance.

Increasing the variety of tasks in which high performance is reinforced should condition the secondary reward value of effort to more stimulus elements and thereby produce greater transfer of high performance. Female college students were given a training task involving anagrams, mathematics problems, perceptual identifications, or a combination of all three of these (Eisenberger, Masterson, & McDermitt, 1982). The total number of training trials was equated across groups. All of the students were next asked to write a short essay. The combination of all three high-performance tasks produced the greatest subsequent essay length and quality per unit length. Therefore, with the total amount of effort training held constant, increasing the variety of training tasks produced a greater transfer of high performance across behaviors.

Mediated generalization, in the form of verbal labeling, would also be expected to increase humans' generalization of reinforced effort (Eisenberger & Masterson, 1983). A person's identification of the effort training task as belonging to a general category (e.g., school work as opposed to the specific training task) would broaden the transfer of heightened performance (cf. Burton, 1963). Eisenberger (1990) paid preadolescent children for success on a picture memory task. A low-ratio group was rewarded for recalling small numbers of pictures, whereas a high-ratio group was rewarded for recalling large numbers of pictures. Two additional high-ratio groups were taught to make verbal statements, first out loud and then to themselves, ascribing each success to high effort and ascribing each failure to low effort. In one of these groups, the children were taught to characterize the training situation narrowly, saying to themselves on success trials, "When I try hard, I do well remembering pictures," whereas on failure trials they were taught to say to themselves, "When I don't try hard, I don't do well remembering pictures." In the other high-ratio group, the children were taught to characterize the training context broadly, saying to themselves on success trials, "When I try hard, I do well in all my school work," and saying on failure trials, "When I don't try hard, I don't do well in all my school work."

Next, all of the children received a self-control task involving the choice to write many nonsense words for a large reward versus writing few nonsense words for a small reward. The children who were taught the broad categorization of the high-performance task showed greater subsequent generalized self-control than the three remaining groups (Eisenberger, 1990). The results suggest that mediated generalization in the form of verbal labels increases humans' transfer of learned high performance to different tasks.

Both these findings and previously discussed research concerning intradimensional generalization of high performance indicate several ways in which effort learning interacts with the current context to determine performance. Reinforced high performance appears to generalize widely across stimulus settings and tasks, but the magnitude of such effects is influenced by primary stimulus generalization, by mediated generalization, and by discrimination training that favors the reinforced dimension of performance over alternative dimensions.

### *Moral Behavior*

The secondary reward theory has implications for situations in which a person may choose between pursuing a goal by the sustained performance of a socially sanctioned behavior or by a less effortful shortcut that violates conventional morality, such as cheating, lying, or stealing. Reinforcement interpretations of morality emphasize the individual's history of reward for honest behavior and punishment for dishonest behavior (Burton, 1963; Skinner, 1953). Burton (1963, 1976) suggested that the generalization and persistence of a moral response would be increased by prior intermittent reinforcement of the response and by the intermittent punishment of deviations from the response. This hypothesis was supported by findings with children that intermittent punishment for playing with a preferred toy suppressed the subsequent occurrence of this behavior to the same degree as did double the number of punishments delivered on a continuous schedule (Leff, 1969).

Reinforcement of high effort could help sustain a person's performance in difficult tasks when the person is given the opportunity to achieve the goal with less effort by dishonesty. Mischel (1981) proposed that when a person must wait for a reward, the anticipation of consummating the goal response produces frustration and therefore lessens the person's willingness to delay gratification. Conditions designed to increase the anticipation of the preferred reward's consummatory properties reduced how long children were willing to wait before they settled for a less-preferred reward. For example, the children spent less time waiting if the preferred reward was physically present (Mischel & Ebbesen, 1970) or if they were asked to form a mental image of the reward's consummatory qualities (Mischel & Baker, 1975).

Distraction from temptation by keeping busy is a well-known method of impulse control (Ainslie, 1975). Reinforced high performance could reduce the aversiveness of effort and thereby enhance the individual's task orientation (Eisenberger & Masterson, 1983). By concentrating on working for a desired goal, rather than dwelling on the goal itself, a person would be less inclined to resort to dishonest shortcuts.

An experiment with college students tested whether rewarded high performance would increase the subsequent resistance to cheating on a different task (Eisenberger & Masterson, 1983). One group was required to solve difficult mathematics problems and perceptual identifications. A second group received easier versions of these problems, and a third group was given no training at all. Next, using an "improbable achievement technique" (Hartshorne & May, 1928), the students were asked to work on a series of anagrams that were almost impossible to solve in the short time allotted for each word. The students were told that speaking out loud interfered with the anagram task and that they should try to solve the anagrams without speaking. When the time was up for figuring out an anagram, they would be shown the correct answer. They were simply to place a plus sign on the answer sheet if they had figured out the answer they were shown or to put a zero if they had not had not achieved the solution. It would seem easy to the students to cheat because they never actually had to supply an answer—they could simply claim they had reached the solution after it was shown to them.

Most of the students did cheat. However, the students who had previously been required to solve difficult anagrams cheated less than the others. Rewarded high performance on preliminary tasks reduced the number of anagrams that students falsely claimed to solve. These results, replicated in a second study with a different cheating procedure (Eisenberger & Shank, 1985), suggest that an individual's honesty is affected not only by prior direct reinforcement of honesty but also by the conditioned secondary reward value of effort.

## Similarities and Differences With Related Approaches

The relationship of the secondary reward theory to other approaches concerned with the generalized effects of performance requirements is considered next.

### *Learned Helplessness*

According to learned helplessness theory, uncontrollable aversive stimulation results in generalized motivational, associative, and emotional deficits (Maier & Seligman, 1976; Overmier & Seligman, 1967; Seligman, 1975; Seligman & Maier, 1967). Overmier and Wielkiewicz (1983) pointed out that the original helplessness studies confounded the controllability and predictability of aversive stimulation. Recent evidence suggests that unpredictable aversive stimulation yields generalized associative deficits, whereas uncontrollable aversive stimulation results in motivational deficits (Ferrandiz & Pardo, 1990; Overmier, 1985; Overmier & Wielkiewicz, 1983).

If noncontingent reinforcement produces generalized decrements of performance, will contingent reinforcement have the opposite effect? Contingent reinforcement did immunize organisms against the subsequent decremental effects of noncontingent aversive stimulation on performance, as compared with a control group that received no initial experience with the aversive stimulation (e.g., Seligman & Maier, 1967; Williams & Maier, 1977). However, other studies found that contingently reinforced animals did not outperform control groups in the subsequent acquisition of a new response (Maier & Seligman, 1976; Overmier & Seligman, 1967).

The absence of superior learning of a new response following contingent reinforcement, as compared with the absence of experience, may have been due to a ceiling on performance. More recent studies with animals (Goodkin, 1976; Volpicelli, Ulm, Altenor, & Seligman, 1983) and humans (Benson & Kennelly, 1976; Eisenberger, Park, & Frank, 1976; Eisenberger, Leonard, Carlson, & Park, 1979), using slowly acquired transfer tasks, found that pretraining with contingent reinforcement did produce superior subsequent acquisition performance. The ceiling effect interpretation was specifically tested with rats by Volpicelli et al., who found a positive transfer effect with a slowly acquired, delayed reinforcement test task and, as predicted, no such effect with a more rapidly acquired test task.

Making reinforcement contingent on high performance should enhance such transfer effects by reducing the aversiveness of effort (cf. Miller, Rosellini, & Seligman, 1977; Nation & Woods, 1980). For example, previously described evidence suggests that an animal's resistance to the decremental effects of noncontingent reinforcement is increased by prior reinforced high performance. Rats required to make five runway shuttles per pellet showed less subsequent suppression of food-contingent lever pressing as a result of periodic noncontingent shock than did rats that had received continuous reinforcement in the runway (Eisenberger et al., 1989). These findings suggest that required high effort increases the benefit of contingent reinforcement in immunizing the organism against the decremental effects of noncontingent aversive stimulation.

### *Reversed Partial Reinforcement Effect*

Brown and Logan (1965) gave two groups of rats continuously reinforced runs in a black alley, with one of the groups additionally receiving intermittently reinforced runs in a white alley. The speed of runway traversal during extinction in the black alley was greater for rats that had received intermittently reinforced runs in the white alley. This generalized PREE was successfully replicated in a number of runway studies (e.g., Amsel, Rashotte, & MacKinnon, 1966; Spear & Pavlik, 1966). Such generalization is consistent with both associative persistence theories and the secondary reward theory.

The generalized PREE, as just described, involves training in which animals are alternated between two discriminative stimuli. One group receives continuous reinforcement in the presence of both stimuli. A second group receives continuous reinforcement in the presence of one stimulus and intermittent reinforcement in the presence of a second stimulus. During testing, the performance of both groups is compared in the presence of the stimulus previously associated with continuous reinforcement. This comparison almost invariably produces the generalized PREE.

A second set of findings considers the extinction performance of only one of these two groups; namely, the animals alternated between intermittent reinforcement and continuous reinforcement. Some runway studies found that for this switched group extinction speed was equally great in both alleys (Amsel, Rashotte, & MacKinnon, 1966; Spear & Pavlik, 1966). However, Pavlik and Carlton (1965) reported that, using a free-operant lever-press task in which the schedules were signaled by different lights, the switched group lever pressed at a greater rate during extinction in the presence of the light previously paired with continuous reinforcement than in the presence of the light previously paired with intermittent reinforcement. Pavlik's finding was successfully replicated (e.g., Adams, Nemeth, & Pavlik, 1982) and extended to discrete-trial lever pressing (Pavlik & Collier, 1977) and runway traversal (Pavlik, Carlton, & Hughes, 1965).

Pavlik's effect is most readily observed when there are short intervals between the experience of the alternate schedules of reinforcement (Amsel et al., 1966), suggesting a possible contrast effect related to the differing densities of reinforcement associated with the two schedules (Pavlik & Carlton, 1965). It is important to note that Pavlik's findings, although of considerable interest in their own right, do not constitute exceptions to the generalized PREE. Either effect can be observed in the same experiment, depending on whether one is comparing organisms that have experienced different reinforcement schedules (the generalized PREE) or comparing the alternated group's relative performance in the presence of the different discriminative stimuli (e.g., see Adams et al., 1982; Flora & Pavlik, 1990; Pavlik et al., 1965). Pavlik's effect notwithstanding, the evidence indicates that intermittent reinforcement, as with other required increases in performance, raises subsequent extinction performance in different stimulus contexts.

### *Counterconditioning of the Disruptive Effects of Frustration*

Wong and Amsel (1976) suggested that intermittent reinforcement acts to condition a general goal orientation or *try strategy* to anticipatory frustration. Wong (1977, 1978, 1979) noted that anticipatory frustration may result in a strong conflict between the initiation versus avoidance of goal-directed activity. The establishment of a strong general goal orientation would counter the disruptive effects of frustration in the training situation and other situations. Wong's approach is similar to the present account in its emphasis on the conditioning of an active goal orientation in the presence of impediments to reward. However, Wong's approach applies primarily to the effects of the required response ratio and not to the other kinds of performance manipulations encompassed by the secondary reward theory. Furthermore, it is not clear how a generalized goal orientation in the presence of frustration could account for previously discussed findings, predicted by the secondary reward theory, concerning the discriminative control and intradimensional transfer of reinforced high performance.

Amsel's (1972) more recent general theory of persistence assumes that the performance of ongoing behavior in the presence of any disruptive stimulus would countercondition the stimulus's disruptive effects. Frustration, resulting from the absence or delay of anticipated reinforcement, was considered merely one of many possible disruptive stimuli that could be counterconditioned by the maintenance of reinforced performance. Moreover, the counterconditioning of one stimulus' disruptive effects would lessen the disruptive effects of similar stimuli.

Consistent with this view, a schedule of intermittent reinforcement increased (a) a response's later persistence when punished with aversive stimulation (Brown & Wagner, 1964; Dyck, Mellgren, & Nation, 1974; Halevy, Feldon, & Weiner, 1987) and (b) a different behavior's subsequent resistance to punishment (Eisenberger et al. 1989). Moreover, habituation to aversive stimulation increased the later extinction performance of an appetitively reinforced response (Chen & Amsel, 1982). With the exception of the latter finding, these results would also follow from the secondary reward theory. Whether habituation to aversive stimulation would produce generalized industriousness, according to the secondary reward theory, depends on whether such adaptation can be viewed as involving a voluntary response that is experienced as effortful.

Amsel's (1972) general theory of persistence, like Wong's (1977, 1978, 1979) account, has difficulty explaining the stimulus control and intradimensional transfer of generalized high performance. To explain why the differential reinforcement of, say, speed produces a greater transfer of speed than accuracy to a new task (Eisenberger et al., 1984) one would have to assume that the disruptive properties of frustration in one performance dimension were quite different from the disruptive properties of frustration in other performance dimensions. Under this assumption, learning to cope with frustration in a given performance dimension would reduce the disruptive effects of frustration primarily in the same dimension of subsequent tasks.

The general theory of persistence also does not explain the distinct etiologies of generalized self-control involving delay versus generalized self-control involving effort. According to the broadest version of the general theory of persistence (Chen & Amsel, 1982), any impediment to reward should countercondition the disruptive effects of any other impediment. In contrast, according to the secondary reward theory, the reinforcement of active responding is central to generalized effort effects. The general theory of persistence, but not the secondary reward theory, would predict that increasing the interval between free presentations of a reinforcer would increase subsequent self-control involving effort.

Long delays in the presence of cues for reward were found to increase subsequent self-control involving the choice of large reward requiring long delays over small rewards requiring short delays (Eisenberger & Masterson, 1986; Eisenberger, Masterson, & Lowman, 1982; Logue & Mazur, 1981; Logue, Rodriguez, Pena-Correal, & Mauro; 1984; Mazur & Logue, 1978). A previously described study with rats that was concerned with generalized self-control of effort included groups that were trained with short intervals or long intervals between free presentations of food (Eisenberger et al., 1989). The longer intervals, similar to those that were effective in increasing generalized self-control involving delay, had no measurable effect on generalized self-control involving high lever force (see Figure 4). Another study with rats found that long delays between food presentations, but not a required high response ratio, increased generalized self-control involving delay (Eisenberger, Masterson, & Lowman, 1982). Findings with preadolescent children are consistent with these results. Low or high required cognitive performance was paired factorially with short or long delays of reinforcement (Eisenberger & Adornetto, 1986). Rewarded high performance and long delay of reinforcement each increased their respective type of generalized self-control (effort or delay), but there was no measurable influence of one type of training on the alternative type of self-control.

The pattern of findings suggests that generalized self-control involving high effort has an etiology largely distinct from generalized self-control involving delay. The repeated failure to find an effect of delay training on subsequent self-control involving high performance suggests that the habituation of frustration cannot entirely account for the transfer of reinforced high performance across behaviors. As supposed by the secondary reward theory, active responding appears to have a major influence on the development of generalized self-control involving high performance. On the other hand, the secondary reward theory is not intended to account for a wealth of verified predictions made either by Amsel's (1958, 1962, 1972) or Capaldi's (1967, 1971) theories concerning the PREE and response-specific learning.

### *Increased Attractiveness of the Reinforcer*

The cognitive dissonance interpretation of the PREE (Lawrence & Festinger, 1962; see also Festinger, 1961) holds that expending high energy to obtain a reinforcer creates a discomforting state of arousal in animals and humans that can be ameliorated by ascribing "added attractions" to some aspect of the situation (Festinger, 1961; Lawrence & Festinger, 1962). Dissonance might be reduced, Lawrence and Festinger suggested, by increasing the subjective attractiveness of (a) the instrumental response, (b) the reinforcer, or (c) the ambient stimuli paired with the reinforcer. Following required high performance, the increased value of the primary reinforcer and related secondary reinforcers should strengthen the subsequent performance of different behaviors on which they were contingent (cf. Lewis, 1964).

Seemingly contrary to the cognitive dissonance view, stimuli that had been paired with intermittent reward were not preferred to stimuli that had been paired with continuous reward (D'Amato, Lachman, & Kivy, 1958; Mason, 1957; vom Saal & Jenkins, 1972). However, Lawrence and Festinger (1962) disputed the relevance of such findings on the grounds that a rich (continuous) schedule of reinforcement might generate greater secondary reward value than a sparse (intermittent) schedule of reinforcement, even taking into account the added attractions produced by cognitive dissonance.

This objection may be overcome by varying required performance in a manner that does not involve the ratio of reinforced responses. Lawrence and Festinger (1962) used an inclined alley to increase required performance and thereby create cognitive dissonance. Using this performance manipulation, Mirsky (1975) established that hungry rats would choose a level alley, as opposed to an inclined alley, for obtaining food. Traversing the inclined alley should therefore create the greater dissonance and enhance the value of the goal-box stimuli. Mirsky then carried out a second experiment in which rats were given food-rewarded trials that were alternated between the level alley and the inclined alley. The rats subsequently received an extended series of choices between the goal boxes that had been attached to the two alleys. Whether they were tested with both alleys inclined or both level, the rats showed no demonstrable preference for the goal box that had previously been attached to the inclined alley.

The cognitive dissonance approach also has difficulty handling some of the generalized effort findings with humans. The perception of choice as to whether or not to take part in a discomforting task has been found to be necessary for producing dissonance effects with humans (Worchel, Cooper, & Goethals, 1988). Yet, as previously described, learning disabled children who were reinforced for mastering an increased ratio of spelling words and reading words, without having a choice concerning their participation in the study, subsequently showed greater performance in math and handwriting tasks (Eisenberger, Heerdt, Hamdi, Zimet, & Bruckmeir, 1979). Similarly, other generalized effort effects with children and adults have been found despite the absence of choice concerning participation (e.g., Eisenberger & Adornetto, 1986; Eisenberger et al., 1985). In sum, the evidence suggests that the possible effects of required performance on cognitive dissonance cannot easily account for the transfer of reinforced high performance across behaviors.

### *Rule Learning*

The possible relevance of Mowrer and Jones's (1945) response-unit interpretation of the PREE to generalized industriousness effects has recently been suggested by H. Rachlin (personal communication, February 1990). Mowrer and Jones argued that a required high response ratio produces the integration of successive responses into a single function unit. The increased number of responses constituting the functional act would enhance the behavior's later resistance to extinction. Applying this hypothesis to generalized persistence, Rachlin suggested that a required high number of responses might result in the organism's abstraction of a concept concerning the necessity of sustained activity for reinforcement. The acquisition of this generalized rule would enhance the subsequent persistence of a variety of behaviors.

The learning of a sustained performance rule could supplement secondary reward processes, and generalized persistence findings are consistent with both explanations. There are, however, two types of transfer effects predicted by the secondary reward theory that cannot be explained by the acquisition of a sustained performance rule. First, a required high response intensity, as well as a required high response ratio, should increase generalized performance. For example, with the number of responses being equal between groups, required high lever force produced a greater subsequent rate of operant runway traversal than did a low force requirement (Eisenberger, Carlson, Guile, & Shapiro, 1979, Experiments 2–4). In these studies, the animals required to exert a high lever force did not take more responses or time to fulfill this requirement than did animals required to press with low force. Therefore, the force of lever pressing, rather than its frequency or duration, was responsible for the transfer effect.

Second, generalized self-control findings with rats and humans are not easily explained by the learning of a rule that prolonged performance or, more generally, high performance is required for reinforcement. A high required number of runway traversals increased the animals' preference for a high-force, large-reward choice over a low-force, small-reward choice, with the effect continuing across the 12 test sessions (Eisenberger et al., 1989). This effect occurred despite the animals' thorough familiarity with the alternative performance–outcome contingencies that resulted from extensive baseline choice training and the forced sampling of both alternatives in testing. Because the animals were familiar with both alternatives, the findings seem more consistent with a decreased aversiveness of effort than with a learned rule concerning the necessity of high performance for reinforcement. Similarly, children who showed a greater generalized self-control following reinforced high performance were thoroughly familiar with the alternative effort–reward combinations available in testing (Eisenberger & Adornetto, 1986; Eisenberger et al., 1985). Rule learning may well supplement the secondary reward process but does not provide a complete alternative interpretation of the generalized effects of reinforced high performance.

### *Cognitive Interpretations of Generalized Effort*

Bandura's (1986) self-efficacy theory places strong emphasis on having confidence in one's own capabilities as a prerequisite for behavioral change. According to Bandura, Adams, and Beyer (1977), self-efficacy expectations are "a major determinant of people's choice of activities, how hard they strive, and how long they will persist in their attempts" (p. 138). Bandura (1977, p. 201) argued that perceived self-efficacy was enhanced by the successful completion of difficult tasks, with generalization "to other situations in which performance was self-debilitated by preoccupation with personal inadequacies" (Bandura, 1977, p. 195).

Generalized self-efficacy expectations have been found to be related to self-control involving high effort. Mischel and Staub (1965) gave adolescent children a choice between a large reward contingent on the successful completion of a difficult problem and an immediate, small reward. Children who scored high on an attitudinal measure of generalized expectancy of success selected the difficult problem more frequently. It is possible that reinforced high performance would increase the individual's general confidence in being able to successfully complete difficult tasks. In this regard, the conditioning-based interpretations do not explain findings that link self-pereived ability to performance.

Both the self-efficacy theory and the secondary reward theory predict that reinforced high performance will enhance subsequent performance on difficult tasks. On the other hand, the secondary reward theory is more specific than the self-efficacy theory about the stimulus control and the intradimensional transfer of reinforced high performance. Furthermore, a person confident of possessing the capability to perform a given task successfully may nevertheless desist because the required effort is too unpleasant.

The secondary reward theory, but not the self-efficacy account, provides an explanation of generalized effort when the training task, the transfer task, or both involve performance well within the individual's self-perceived competence. For example, previously described self-control tasks for children involved the tedious activity of copying nonsense words (Eisenberger & Adornetto, 1986; Eisenberger et al., 1985). Children's concern that they did not possess the ability to perform the self-control task was not a factor because during the baseline self-control session, all of the children successfully performed the repetitious handwriting activity. Learning to tolerate tedium is an important aspect of industriousness.

## Conclusions and Implications for Human Development

Effort appears to be a fundamental response-produced experience, the aversiveness of which is exquisitely sensitive to secondary reward effects. The conditioning of secondary reward value to the sensation of effort provides a dynamic mechanism by which reinforced high performance generalizes across behaviors. Because the sensation of effort is assumed to acquire secondary reward value independent of the behavior involved, broad generalization effects are predicted, both in terms of the types of training tasks that contribute to generalized effort and the kinds of performance that are influenced. In contrast to stimulus–response connectionist theories of persistence, which are applicable to the effects of required response ratios, the secondary reward theory is relevant to the generalized effects of a variety of effort requirements.

The secondary reward analysis incorporates the continuity of experience between physical effort and cognitive effort into a comprehensive theory of learned industriousness. The phylogenetic change from the adaptive primacy of physical performance in lower animals to the increased importance of cognitive performance in humans did not supplant the inhibiting effects of effort in goal-oriented behavior so much as provide a new class of activities that are subject to effort's restrictive influence. Individual differences in cognitive performance, like physical activities, are strongly affected by conditioned changes in the aversiveness of effort.

The reduction of the aversiveness of high effort, which results from the conditioning of secondary reward value, suggests an addendum to the law of least effort. After receiving reinforcement for high performance, the organism would still prefer the less strenuous of two tasks for obtaining a given magnitude of reinforcement, as required by the law of least effort. The aversiveness produced by increased effort, however, should no longer be as great as before. Thus, the reinforcement of high performance produces the subsequent exchange of greater instrumental performance for increased reinforcement. Consistent with this generalization are findings that reinforced high performance increased the subsequent self-control of effort in rats and children.

Theoretical models concerned with the trade-off of higher performance for greater reinforcement contain parameters that incorporate the aversiveness of increased effort. The findings that reinforced high performance produces a generalized reduction in the aversiveness of effort suggest that effort learning can alter the value of these parameters across a variety of instrumental behaviors. In economic models of operant performance (Rachlin et al., 1981), the generalized effects of reinforced high performance would be demonstrable in an increased bowing of the indifference contours that relate the utilities of reinforcement and leisure. For behavioral conservation theory (Allison, 1976; Allison et al., 1979; Timberlake & Allison, 1974), the parameter that specifies the dimension of behavior conserved would be reduced in magnitude. With behavioral regulation models (Hanson & Timberlake, 1983), there would be a reduction in the magnitude of the error signal that occurs when instrumental performance deviates from baseline performance or, alternatively, a decrement in the resistance to change of the instrumental response (see Hanson & Timberlake, 1983, pp. 267–268).

The secondary reward theory explains both the generalization of high performance and the circumstances under which high performance is brought under situational control. On the one hand, conditioned changes in the secondary reward value of effort are in agreement with findings that humans are moderately consistent in the industriousness they show across time and situation (Eisenberger, 1989; Eisenberger & Shank, 1985; Greenberg, 1977; Merrens & Garrett, 1975). On the other hand, stimulus control helps account for situational constraints on generalized effort. For example, the person regularly administering reinforcement for high performance (or for low performance) would constitute part of the training context to which the secondary reward value of effort became conditioned. Consistent reinforcement of high performance by a parent, friend, teacher, or peer would establish requests from that person as cues indicating a greater secondary reward value of high effort. Conversely, a generally permissive reinforcing agent would come to cue a lesser secondary reward value of high effort (Eisenberger et al., 1983).

Persisting individual differences in industriousness may result from long-term differences in the degree of reinforced effort. An experiment with rats demonstrates the positive effect of longer term effort training on industriousness, as well as the considerable generalization of reinforced performance across very different situations (Eisenberger, Masterson, & Over, 1982). Researchers have usually considered the choice of the method of maintenance feeding of laboratory animals too unimportant to mention, let alone justify. Yet, it is possible that the effort experienced in obtaining food and other reinforcers in daily activities affects an organism's subsequent performance in a variety of tasks.

In most laboratories that use rats, daily feedings consist of food chunks placed either on the floor of the home cage or in a hopper attached to the outside of the home cage's wire-mesh front wall. The use of the hopper requires the rats to gnaw the food pellets through the wire mesh. Rats that eat from the hopper work harder than rats given their meals on the cage floor and so should develop greater secondary reward value of high effort. To assess the effects of the type of feeding experience and the amount of such training, baseline runway performance was first established by rewarding rats with food on a series of trials conducted in an experimental room that was quite different from the colony room where the rats were normally fed

(Eisenberger, Masterson, & Lowman, 1982). The animals were then fed for 9 or 27 days in their home cages in the colony room with either the hopper method or the floor method. All of the rats were then returned to the runway, where they received a single rewarded trial followed by daily extinction sessions.

Extinction performance showed a statistically reliable interaction between the amount and type of maintenance feeding. After 27 days of maintenance feeding, but not after 9 days, hopper feeding produced greater subsequent runway performance than the floor method of feeding. These results indicate that reinforced high performance can produce transfer effects across very different stimulus contexts and that the degree of generalized high performance increases with the amount of effort training.

Extended experience with reinforcement of different levels of performance would be expected to result in individual differences of industriousness that have a moderate temporal and situational consistency. In addition to the effects of the number of effort training sessions, previously discussed evidence indicates that, in accord with the secondary reward theory, generalized high performance in humans is increased by the variety of reinforced high-effort tasks (Eisenberger, Masterson, & McDermitt, 1982) and by verbal mediation involving the broad categorization of the effort training tasks (Eisenberger, 1990). These findings suggest that a developmental history of repeated reinforcement of high performance in diverse tasks may contribute to a durable tendency to perform tasks industriously.

Consistent with this view, questionnaire responses and case studies of employees with various jobs who were exceptionally hard workers indicated that almost all had a childhood in which strong reinforcers were used to shape high performance in a variety of tasks (Cherrington, 1980, pp. 120–128; Eisenberger, 1989a). Such long-term conditioning of high effort's secondary reward value could contribute to a durable preference for keeping active and busy at work, which is one component of the personal work ethic (Eisenberger, 1989a; Mirels & Garrett, 1971; Wollack, Goodale, Wijting, & Smith, 1971).

To the degree that reinforced high performance contributes to the personal work ethic, both reinforced high performance and a strong work ethic, as assessed by questionnaire, should be associated with greater industriousness. As with the effects of reinforced high performance, a strong personal work ethic was found to be positively related to persistence in simple, repetitive activities (Greenberg, 1977; Merrens & Garrett, 1975). An additional study was carried out to compare the effects of reinforced high performance and the personal work ethic on cheating (Eisenberger & Shank, 1985). College students' general interest and satisfaction in performing tasks industriously was assessed with the Survey of Work Values (Wollack et al., 1971). On the basis of the median score, the high work-ethic students were differentiated from the low work-ethic students. Next, one group was required to solve difficult mathematics problems and perceptual identifications, a second group had to solve easier versions of these problems, and a third group did not receive effort training. The subjects were then given anagrams having solution words that had been found in pretesting to be unknown to college students (Eisenberger & Leonard, 1980).

As illustrated in Figure 6, among students who did not receive effort training prior to the unsolvable test task, those with a high work ethic persisted almost twice as long, on the average, before cheating as those with a low work ethic. Reinforced high performance did not reliably affect the already high resistance to cheating of the high work-ethic students, but it substantially increased the duration of time spent on the anagrams prior to cheating for the low work-ethic students. The similar relationships that reinforced high performance and a strong personal work ethic have with generalized persistence and with cheating support the view that long-term effort training contributes to durable individual differences in industriousness.

The secondary reward theory has implications for human self-control, moral development, and education. Findings with animals and children indicated that generalized self-control involving effort was influenced by prior reinforcement of high performance. In parallel fashion, waiting for reinforcement increased subsequent generalized self-control involving delay. Recall, however, that each type of training did not measurably influence the alternative type of self-control. These results suggest that the observation of individual differences in generalized self-control depends on whether the situation involves delay or effort. Persons who have repeatedly received the combination of rewarded long delay and rewarded low effort would demonstrate self-control when the choice of a preferred reward involved long delay and little or no effort. Persons with the experience of rewarded low delay and high effort would show self-control when the choice of a preferred reward entailed high effort and little or no delay. Those individuals having the experience of rewarded long delays and high effort would demonstrate self-control when the choice of a preferred reward entailed either long delay or high effort.

Children with high self-control in situations involving delay have been found to cheat less than others (Mischel & Gilligan, 1964). Similarly, as described earlier, reinforced high performance reduced cheating by college students on unsolvable tasks (Eisenberger, Mitchell, & Masterson, 1985; Eisenberger & Shank, 1985). The positive relationship between reinforced high performance and subsequent honesty may be contrasted with findings that a high need for achievement was associated with increased cheating by children (Mischel & Gilligan, 1964) and college students (Johnson, 1981). An increased secondary reward value of high effort, resulting from a developmental history of rewarded high performance in varied settings, might reduce the tendency to take advantage of dishonest shortcuts in pursuit of difficult goals.

With regard to education, Skinner (1954, 1968) argued that to avoid the disruptive emotional effects of failure students should be taught with programmed materials that produced easily attained increments of performance. The natural environment, however, is replete with tasks that require substantial persistence for success. Continuous reinforcement, as compared with intermittent reinforcement, was found to produce less subsequent resistance to failure on academic tasks (Chapin & Dyck, 1976; Fowler & Peterson, 1981). Moreover, reinforced high performance on preliminary tasks had generalized effects on the math and handwriting performance of learning disabled students (Eisenberger, Heerdt, Hamdi, Zimet, & Bruckmeir, 1979) and raised the quality and length of written essays by college students (Eisenberger, Masterson, & McDermitt, 1982; Eisenberger et al., 1983). These benefits of requiring high perfor-

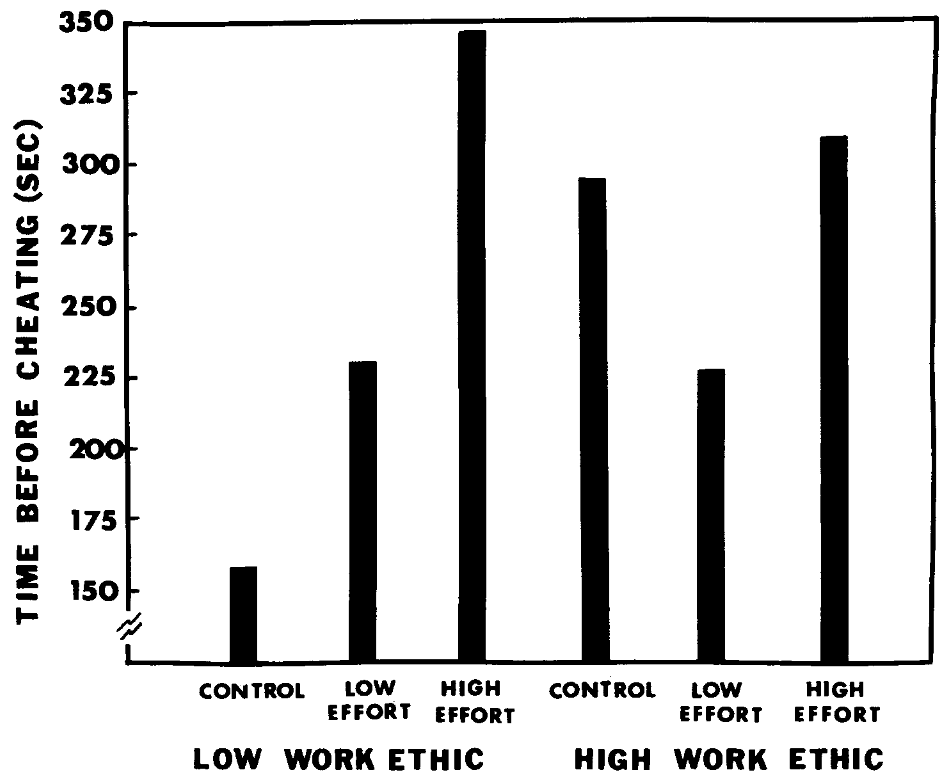


*Figure 6.* The mean number of seconds spent working on unsolvable anagrams before cheating, as a function of personal work ethic (low vs. high) and three pretest conditions (absence of effort training, low-effort training, and high-effort training).

mance for success should not, of course, be confused with the use of impossibly difficult tasks that produce failure and learned helplessness (Hiroto & Seligman, 1975).

The employment of reinforcers to enhance student performance has been challenged on the basis of findings that the individual's intrinsic interest in a task is reduced by extrinsic reinforcement (see reviews by Geen, Beatty, & Arkin, 1984; Deci & Ryan, 1980, 1985). However, Deci and Ryan (1980, 1985) reviewed findings suggesting that, as opposed to the situation in which reinforcement is administered simply for completing the task, the reinforcement of progressively improved performance produced no loss of intrinsic interest. Most academic subjects involve a combination of tasks with varying degrees of intrinsic interest and difficulty. Even if a student finds that an academic subject is generally interesting, the acquisition of a good understanding of the subject matter requires the study of some topics found to be dull and repetitive and other topics that, although interesting, are discouragingly difficult to master. An increased secondary reward value of high effort may encourage selection of, and persistence on, difficult academic tasks. Reinforced high effort on dull, repetitive tasks can even be used to increase subsequent effort in intrinsically interesting tasks. For example, preadolescent children who had been rewarded for accuracy on a monotonous pronunciation task produced more accurate subsequent drawings and stories than did students who had been rewarded for simply completing the pronunciation task (Eisenberger et al., 1984). These findings attest to the heuristic value of the secondary reward theory of generalized industriousness.

The individual's decision concerning the amount of effort to exert in goal-directed behavior is influenced in no small part by the generalized effects of prior reward for low or high effort. The occurrence of learned individual differences in industriousness is indicated by extensive experimental research with animals and humans. Various kinds of rewarded high effort produce broad and durable generalization effects, the magnitude of which depends on the amount and diversity of effort training. The empirical phenomenon of learned industriousness, and the secondary reward theory, help explain differences of industriousness among people of equivalent ability and motivation.

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