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# The Empirical Background for Skinner's Basic Arguments Regarding Selection by Consequences

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Skinner's early research in the 1930's was the foundation for his later formulations regarding the role of selection by consequences for operant behavior in general. One important aspect for Skinner was the demonstrations that operant behavior can change from moment to moment depending on consequences to the behavior. The target article highlights that for Skinner an essential aspect of operant conditioning was that even a single reinforcement may be sufficient for a change in behavior; that is, selection by consequences can be nearly instantaneous. This commentary reviews Skinner's early research that led him to these conclusions and what role this research played for his later expressions regarding selection by consequences. The commentary will also articulate a need for development of a vocabulary regarding instantaneous selection by context, which results from selection by consequences only in a specific context (i.e., stimulus discrimination training results in selection of behavior by the stimulus even before the consequence occurs).

*Keywords*: Skinner's early research, selection by consequences, moment-to-moment effects, single reinforcement, selection by context

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B. F. Skinner was controversial. Many of his arguments about the role of the environment in the control of behavior found in his later writings went considerably beyond the basic laboratory findings that made him famous early in his life. For example, his *Beyond Freedom and Dignity* (Skinner, 1971) brought about considerable commentary in the popular news where he even appeared on the cover of *Time Magazine* (Time, 1971, September 20). A very comprehensive source of comments to and critiques of Skinner's later work is the collection of reprinted articles by Skinner and comments to those articles by a variety of scholars from different fields of study (Catania & Harnad, 1988); the volume also includes Skinner's replies to the comments. The various comments to Skinner's work addressed the arguments that Skinner had put forth later in his life regarding generalizations from his early laboratory work with rats to "man in society", broadly speaking. Skinner's general arguments are rooted in his early research with rats. At the level of the individual organism, he demonstrated lawful relations between behavior and environmental changes in the form of contingencies of reinforcement (e.g., Iversen, 1992). From this early work and subsequent developments in basic research, Skinner drew broad inferences relating to language, teaching, and culture (e.g., Skinner, 1971). In the target article, Skinner (1981) refers to selection by consequences at three levels: selection of species and traits through evolution, selection of behavior in individual organisms (operant and respondent conditio-

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ning), and selection of cultures or cultural behavior. The second level of selection of operant behavior will be the focus of the commentary in this article.

Skinner often referred to his early findings. However, without even superficial knowledge of his early empirical work, many readers may not fully appreciate which findings Skinner refers to when he, for example, states in the target article (Skinner, 1981) that " … operant conditioning occurs at a speed at which it can be observed from *moment to moment*" (p. 502; emphasis added). Similarly, Skinner states: "Operant conditioning is selection in progress. It resembles a hundred million years of natural selection or a thousand years of the evolution of a culture compressed into *a very short period of time*" (p. 502; emphasis added). Readers may not appreciate what Skinner means by "moment to moment" and "a very short period of time". Because the target article also addresses evolution of species and cultures, both of which obviously occur over very long time scales, it is perhaps difficult to fathom that Skinner literally refers to seconds or at most, minutes when he writes that changes in operant conditioning can take place from moment to moment. Yet, that finding is the foundation of his empirical work. In particular, Skinner was influenced by his readings of Pavlov, who conducted research with individual dogs in minute detail, counting individual drops of saliva to individual stimuli under a variety of different experimental conditions (e.g., Pavlov, 1927). Pavlov's experiments demonstrated that conditioning of the salivary glands took several trials of pairings of unconditional and neutral stimuli before the neutral stimuli began to control behavior, and thereby became conditional stimuli. The incredible degree of control of behavior that Pavlov had demonstrated was impressive to young Skinner, and he later stated that Pavlov's work had inspired his own, early laboratory work: "control your conditions and you will see order" (Skinner, 1956, p. 223).

Skinner's early research has to be compared and contrasted both with that of Pavlov (1927) and Thorndike (1911). In his research on selective effects of consequences, Thorndike (1911) placed cats in problem boxes where pressing a pedal had the consequence that the door to the box opened and the cats could walk out to a tray with food. After a while, Thorndike placed the cat in the box again for a second trial, and so on. Thorndike was interested in the time from when the cat was placed in the box until the cat pressed the pedal, the latency. Thorndike plotted these latencies over successive trials and found a general trend of a gradual decrease of the latency as the cat was exposed more often to the consequence of pressing the pedal. Figure 1 is a schematic illustration of what takes place in Thorndike's experiment. On early trials, the cat makes a variety of behaviors (A-D) none of which have any effect on opening the door to the box. At some point in time the cat makes behavior E, which results in opening of the door and the possibility for exit from the box and access to the food tray outside the box. On later trials, the unsuccessful behaviors (A-D) are absent, Thorndike described them as "stamped out", whereas the successful behavior (E) occurs sooner, and Thorndike described this behavior as "stamped in" (Thorndike, 1911). The latency got shorter as the unsuccessful behaviors dropped out. For Thorndike, the gradual shortening of the latency over trials produced a so-called "learning curve".

Skinner's research was different. Skinner (1979) described later in his life how he carefully prepared his rats for their first session of what later was called operant conditioning where rats had to press a lever to produce food delivery (Skinner, 1932). Skinner first habituated the rats to the equipment and to the sounds of the pellet-delivery mechanism so that they would pick up the food as soon as the feeder operated; in addition, the lever was held in its low position. Skinner even placed the rats in a start component for a while before they were automatically released into

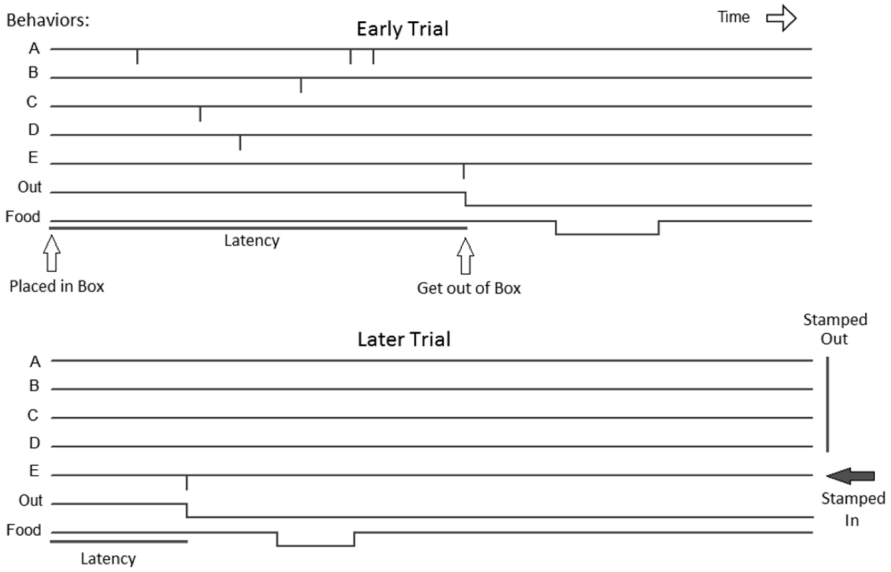


*Figure 1*. Schematic illustration of events in Thorndike's experiments with cats. Downward marks indicate occurrence of an event. On early trials, several behaviors (A-D) occur spontaneously in the situation. Only behavior E opens the box and provides access to the food outside the box. On later trials, the unsuccessful behaviors drop out or are "stamped out," and behavior E occurs sooner resulting in a shorter latency. Behavior E is said to be "stamped in".

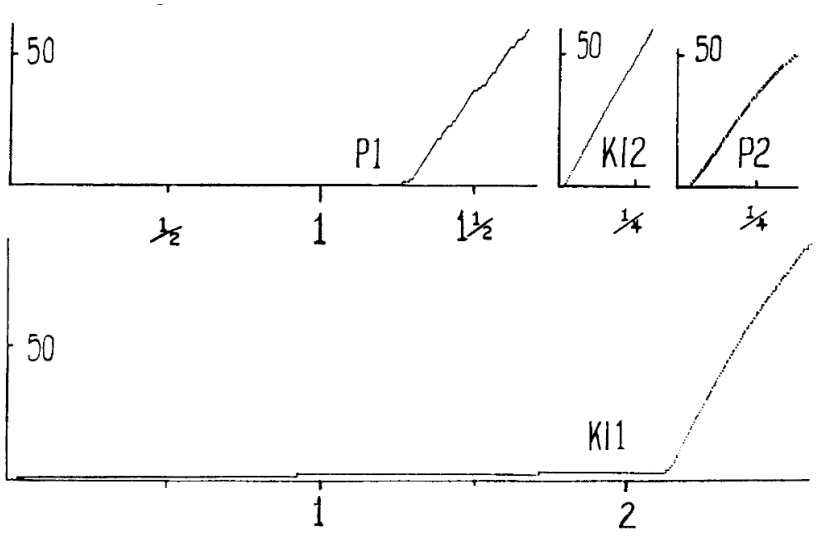


*Figure 2.* Cumulative records for four rats from Skinner's first experiment on operant conditioning of lever pressing. Time is shown in hours on the horizontal axis, and cumulative responses are shown on the vertical axis; each response on the lever moved the pen one step upward. Each press on the lever was reinforced with a single food pellet. Reprinted from "On the rate of formation of a conditioned reflex," by B. F. Skinner, 1932, *Journal of General Psychology*, 7, 274-285. Reprinted by permission from: Taylor & Francis LLC, (http://www.tandfonline.com).

the chamber. On the first session where the lever was in the upper position, the delivery of food was made contingent on the rat pressing the lever. The rats remained in the box after each reinforcement in contrast to Thorndike's experiments. Figure 2 shows the cumulative records of lever pressing for the four rats from this experiment. Time passes from left to right, and presses on lever cumulate vertically; a flat curve shows no responding, and a steep curve shows repeated pressing on the lever. Of four rats, two rats began to respond on the lever right after the first response produced the food pellet. A third rat responded equally fast after the second response was reinforced, and the fourth rat after its fourth response on the lever was reinforced. Skinner(1979) later related that "in carefully controlling my conditions I had eliminated all the unsuccessful behavior in Thorndike's "learning curve" *before conditioning took place*. There was nothing to be "stamped out". The successful response did not merely survive, it was conspicuously strengthened" (p. 88; emphasis by Skinner).

To pursue the finding that the conditioning took place so quickly, Skinner (1933) later arranged for the rats to obtain just a single reinforcement contingent on a single lever press. The first press produced one reinforcement and thereafter responses to the lever had no effect other than being recorded. Figure 3 shows the resulting curve with over 50 responses emitted by the rat after just one reinforcement; control conditions (labeled A and B in Figure 3) showed considerably less pressing on the lever. The experiment demonstrated that a single reinforcement is sufficient to change behavior instantaneously.

In his autobiography, Skinner (1979) summarized the impression from these early experiments in this way:

> The speed with which the behavior changed was surprising. Pavlov's "all-time record holder" was said to have needed seven reinforcements before making a conditioned response and Pavlovian conditioning had been criticized as too slow to explain most learning in daily life. My rats learned to press the lever in one trial and no learning could be

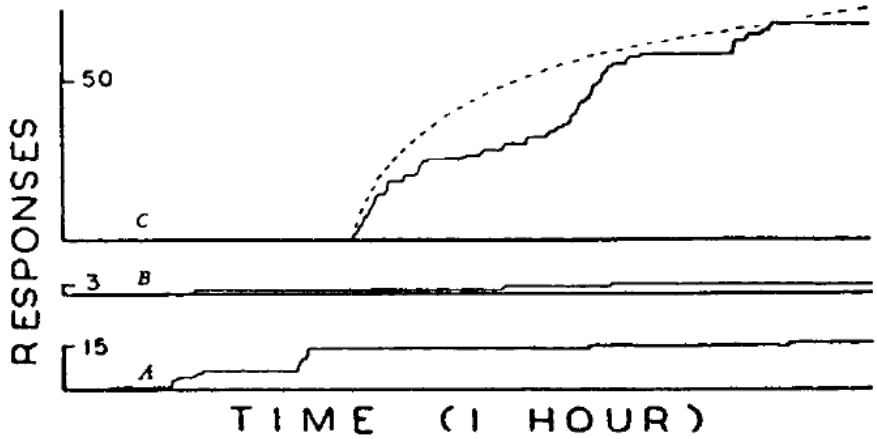


*Figure 3.* Cumulative record for one rat. A single lever press produced one reinforcement (three food pellets delivered very quickly) and subsequent lever presses had no effect other than being recorded. Time is shown in hours on the horizontal axis, and cumulative responses are shown on the vertical axis; each response on the lever moved the pen one step upward. Conditions A and B were control conditions with no reinforcement. Reprinted from ""Resistance to extinction" in the process of conditioning," by B. F. Skinner, 1933, *Journal of General Psychology*, 9, 420-429. Reprinted by permission from: Taylor & Francis LLC, (http://www.tandfonline.com).

> faster than that. … I had apparently found a process of conditioning that was different from Pavlov's and much more like most learning in daily life. I was soon writing to Fred [Keller] that I had a new theory of conditioning. (pp. 88-89)

These findings, together with other results, led to Skinner's (1937) formulation of two processes: respondent conditioning and operant conditioning. The one-trial conditioning effect was quite obviously a turning point for Skinner and an integral component of the development of operant conditioning.

That operant conditioning can occur at the level of a single reinforcement is not a curiosity of Skinner's early research. With proper experimental arrangements, this effect is easily demonstrated and can be recognized even by untrained observers. For example, with exposure to a so-called variable-time schedule where reinforcers are delivered independent of behavior, one can observe this effect repeatedly; for nearly every single reinforcer, the response that an animal happens to make right before that reinforcer is very likely to be repeated right after consumption of that individual reinforcer (e.g., Henton & Iversen, 1978). In addition, the effect can be isolated quite literally to a single reinforcement without prior magazine training in rats as when a single food pellet is placed in one of many holes on a vertical hole board and the rats can retrieve the pellet from inside the chamber. After pellet retrieval and consumption rats are highly likely to return to the prior location of the food pellet and to neighboring locations; this strengthening effect is instantaneous, like Skinner's early finding, and lasts a few minutes (Iversen & Mogensen, 1988). Skinner repeatedly emphasized the importance of the effect of a single reinforcement. For example, in *Beyond Freedom and Dignity*, Skinner (1971) writes, "A quick response to reinforcement must have had survival value, and many species have reached the point where a single reinforcement has a substantial effect" (p. 176).

The demonstration of an effect of a single reinforcement is essentially also a demonstration of extinction. In many experiments, Skinner demonstrated that when he withheld reinforcement, the conditioned response would continue for a long time before eventually extinguishing (e.g., Skinner, 1938). For Skinner, this was an essential finding because it demonstrated that behavior could occur without any kind of stimulation at the moment it occurred. The behavior was entirely a product of the prior conditioning history. Operant behavior occurs because it has been reinforced in the past, not because it will be reinforced in the future (i. e., operant behavior is not goal directed). Thus, in the target article, Skinner (1981) writes about purpose and intention: "Only past consequences figure in selection … The consequences of operant behavior are not what the behavior is now for; they are merely similar to the consequences which have shaped and maintained it" (p. 503). In perhaps simpler words, the extinction curves demonstrate that a rat does not press a lever to get a pellet now or in the near future, it presses the lever because presses in the past produced a pellet (e.g., Iversen, 1992).

The instantaneous behavior changes that are a hallmark of operant conditioning are well documented (e.g., Iversen, 1991). Yet, historical changes after Skinner's early research have led to a different and growing focus on so-called "steady-states" of continuously maintained behavior under fixed conditions where behavior is not presented at the moment-to-moment level, as on cumulative records of responding, but instead in the form of averages over sessions, and the focus of the research is on how steady states relate to environmental variables. Skinner (1976) lamented the gradual disappearance of cumulative records from the pages *of Journal of the Experimental Analysis of Behavior* in a piece entitled "Farewell, My Lovely!" Skinner explained that he would miss the kinds of experiments that featured orderly changes in behavior on small time scales because they

" … suggested a really extraordinary degree of control over an individual organism as it lived its life from moment to moment" (p. 218). Skinner also emphasized that "These "molecular" changes in probability of responding are most immediately relevant to our own daily lives" (p. 218). Thus, Skinner's emphases on moment to moment effects and behavior changes within short periods of time have their roots in his research and are germane to and an essential aspect of the process of operant conditioning. From his early research Skinner came to the conclusion that evolution has selected living organisms that are reacting to consequences of their behavior even to the point that a single consequence is sufficient to select behavior instantaneously.

Another side to selection by consequences that is not addressed directly in the target article is what I here call *selection by context*. Skinner's early research also involved several experiments on development of what is now called the discriminated operant or the three-term contingency (e.g., Skinner, 1938). The essence of this research is that several sessions of discrimination training enable a context within which the operant behavior occurs instantaneously upon exposure to that context. For example, when reinforcement is presented contingent on emitting a response only when a light is present and not when the light is absent, the light eventually will evoke emission of the response with a very short latency (in the order of seconds). Figure 4 presents a schematic of the discriminated operant. An animal is continuously engaging in different behaviors ("Other responses" 1-6 in Figure 4). When the stimulus is presented, the subject instantaneously stops what it is doing and switches to the target response that in the past has produced reinforcement in the presence of the stimulus. Such instantaneous selection of behavior by stimulus context is very important in daily life and is generally covered under the term "stimulus control". However, the selective aspect of the stimulus or context is not often appreciated in discourse regarding operant conditioning. Behavior can be selected by consequences that happen *after* the behavior is emitted, where the effect of strengthening

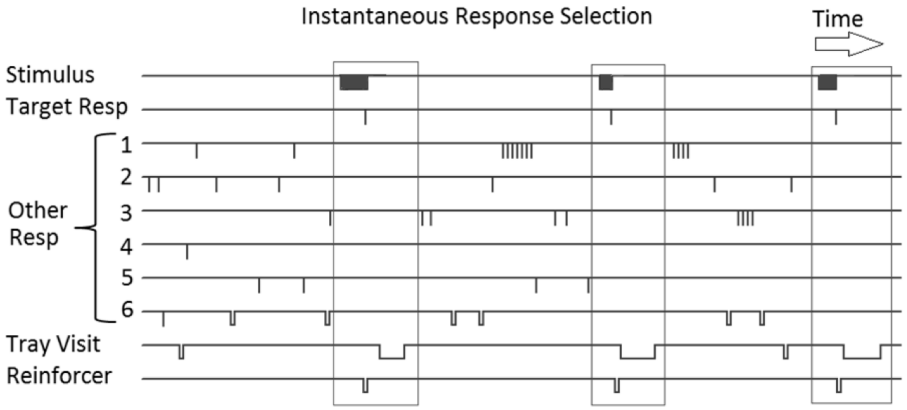


*Figure 4.* Schematic of the flow of events once a discriminated operant has been established. A stimulus, say a light, turns on once in a while (top line). When the target response occurs in the presence of the stimulus, the response is reinforced (lowest line), and the animal visits the food tray to collect the reinforcer; a three-term contingency. Presenting the stimulus enables an instantaneous selection of the target behavior over several other behaviors that are possible in the same situation or context, as illustrated by the other responses 1-6. The vertical rectangles are added for emphasis of the three-term contingency; after discrimination training, the target response occurs only during the stimulus, the context.

of the response may be seen instantaneously. When such selection is arranged to occur only in a specific context (e.g., discrimination training), the outcome is that behavior can also be selected by a context that starts *before* the behavior occurs and which may enable an instantaneous selection of a specific behavior that previously was reinforced in that context.

In summary, selection by consequences means that the behavior will be influenced by the consequence that follows the behavior, whereas selection by context means the behavior will be influenced by the context that precedes the behavior.

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