

CONCURRENT-CHAINS PROCEDURE

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1. Core Definition

The **Concurrent-Chains Procedure** is a specialized experimental paradigm utilized predominantly within the field of the Experimental Analysis of Behavior (EAB) to investigate how organisms, both human and animal, make choices between outcomes that differ not in the immediate reinforcement they provide, but in the subsequent schedules of reinforcement those choices initiate. This procedure is designed specifically to measure the relative value or preference for different delayed consequences or schedules of reinforcement themselves, rather than merely measuring preference for immediate primary reinforcers.

Unlike standard concurrent schedules, where two response options yield immediate, concurrent reinforcement, the concurrent-chains procedure introduces a temporal delay and a two-stage structure. An organism first engages in a choice phase, known as the **initial link**. A response during the initial link does not yield immediate reinforcement but instead transitions the subject into a second phase, termed the **terminal link**. The terminal link is a distinct, often non-choice, schedule of reinforcement, the completion of which finally delivers the primary reinforcer. Therefore, the choice made in the initial link is essentially a choice between two different future reinforcement environments or schedules.

This methodology is crucial because it allows researchers to separate the response that signifies preference (the initial choice) from the administration of the reinforcing outcome (the terminal schedule). The preference for a particular initial link is assumed to reflect the subject's assessment of the value or utility of the reinforcement schedule that follows it. It is an indispensable tool for studying complex decision-making processes, including those related to self-control, impulsivity, and delay discounting, where the value of a choice is determined by events occurring subsequent to the choice itself.

2. Theoretical Context: Studying Choice and Preference

The development of the Concurrent-Chains Procedure arose from the necessity to move beyond simple, immediate choice experiments to understand how behavioral processes operate over extended temporal intervals. Traditional concurrent schedules, which measure preference for two simultaneously available sources of immediate reinforcement, are excellent for demonstrating fundamental principles like the Matching Law. However, they fail to capture situations common in natural environments where a choice commits an organism to a specific path or sequence of

delayed consequences.

The procedure is rooted firmly in the principles of **Operant Conditioning**, particularly the concepts of conditioned reinforcement and stimulus control. The completion of the initial link, which leads to the terminal link, is viewed as a conditioned reinforcer because it grants access to a schedule that ultimately produces primary reinforcement. The experimental design therefore allows the conditioned reinforcing properties of the associated stimuli--the cues signaling which terminal schedule is available--to govern the initial choice behavior. This arrangement formalizes the study of how the characteristics of future rewards, such as their frequency, magnitude, or delay, influence current decisions.

By providing a structured environment where choice behavior is maintained solely by the differential access to future reinforcement schedules, the concurrent-chains procedure offers profound insights into how organisms allocate behavior in the face of varying long-term contingencies. This context is essential for understanding topics such as why an individual might choose a difficult, immediate task (initial link) if it guarantees a highly favorable long-term outcome (terminal link schedule) over an easier immediate alternative that leads to a less favorable long-term result.

3. Structural Components of the Procedure

The Concurrent-Chains Procedure is structurally defined by the sequential arrangement of two distinct phases: the **Initial Links** (or choice phase) and the **Terminal Links** (or outcome phase). This sequential structure is the hallmark that distinguishes it from other multiple or chained schedules in behavioral analysis.

The **Initial Links** typically consist of two simultaneously available, independent schedules of reinforcement, often designated as A and B, which are usually arranged as concurrent variable-interval (VI) schedules of equal value. Critically, responding in this phase does not produce primary reinforcement (e.g., food or water); rather, the first response on either schedule A or schedule B, after the required interval has timed out, terminates the choice phase and transitions the subject exclusively into the corresponding terminal link. For instance, if the subject responds on the key associated with Initial Link A, they are immediately transferred into Terminal Link A, and Initial Link B becomes unavailable until the next trial begins.

The **Terminal Links** constitute the second phase, following the choice made in the initial link. Each terminal link corresponds to the chosen initial link (Terminal Link A following Initial Link A, and Terminal Link B following Initial Link B). These links are typically non-choice schedules, meaning only one response option is available, and they differ fundamentally in their parameters--such as reinforcement frequency, magnitude, quality, or delay. The completion of the schedule specified by the terminal link results in the delivery of the primary reinforcer. Once the primary reinforcer is

delivered, the trial ends, and the organism is returned to the initial link phase to make a new choice, thus maintaining the chained nature of the procedure.

4. Mechanism of Operation: Initial and Terminal Links

The operational mechanism relies heavily on the principle of conditioned reinforcement and stimulus control. During the initial link phase, the stimuli associated with the two response options (e.g., colored lights on two separate keys) serve as **discriminative stimuli**. These stimuli gain their strength and control over behavior because they signal which subsequent terminal schedule is impending.

The choice behavior observed in the initial link is maintained by the conditioned reinforcing property of the event of transitioning into the terminal link. Crucially, the relative strength of the choice (e.g., responding more frequently on Initial Link A than B) directly reflects the organism's valuation of the corresponding terminal schedule (Schedule A versus Schedule B). If Terminal Link A offers a higher rate of reinforcement or less delay than Terminal Link B, the stimulus associated with Initial Link A acquires a greater conditioned reinforcing value, leading to a higher frequency of choice responses for A.

To ensure that the preference demonstrated in the initial link is truly a measure of the value of the schedule and not simply the immediate response cost, the initial links are typically matched in terms of response effort and are often arranged as equal variable-interval schedules. This standardization ensures that the differential responding observed is primarily a function of the differences programmed into the terminal links. The entire procedure effectively transforms the study of long-term consequences into a study of immediate conditioned reinforcement controlled by the predictive stimuli.

5. Measurement and Quantification of Preference

The quantification of preference within the Concurrent-Chains Procedure is focused exclusively on the behavior exhibited during the **initial link** phase. Researchers track the relative frequency of choices made for each available option across many trials. The primary dependent measure is the **choice proportion**, calculated as the number of responses (or time spent) on one initial link divided by the total number of responses (or time spent) on both initial links.

For example, if an organism makes 80 choices for Initial Link A and 20 choices for Initial Link B over 100 trials, the preference ratio for A is 0.8. This ratio directly quantifies the subject's preference for the entire sequence starting with Initial Link A and culminating in the Terminal Link A schedule, relative to the competing sequence B. This allows for rigorous mathematical analysis, often aiming to determine whether the preference ratios align with predictions derived from theories such as generalized matching equations or specific models of delay discounting.

Furthermore, the procedure permits the systematic manipulation of parameters within the terminal links--such as varying the time required to complete the schedule (delay), the magnitude of the reward, or the probability of reinforcement--to generate quantifiable **preference functions**. By observing how the choice proportion shifts as these terminal parameters are adjusted, researchers can map out the functional value of reinforcement schedules. This data is essential for developing predictive models of choice behavior, particularly concerning how the subjective value of a reinforcer decreases as the delay to its delivery increases--a phenomenon known as **delay discounting**.

6. Applications in Behavioral Research

The versatility and precision of the Concurrent-Chains Procedure have made it a cornerstone in several key areas of behavioral research. One of its most significant applications is the experimental study of **self-control and impulsivity**. By presenting choices between a smaller, sooner reinforcement schedule and a larger, later reinforcement schedule in the terminal links, researchers can identify conditions that promote self-control (choosing the larger, later option) or impulsivity (choosing the smaller, sooner option).

The procedure is also widely used to investigate the psychological mechanisms underlying **delay discounting**. Researchers can systematically vary the temporal requirements of the terminal links and observe how the preference for the delayed outcome changes. This has led to the development and testing of hyperbolic and exponential models of discounting, offering critical insights into addictive behaviors, financial decision-making, and health choices, where immediate gratification often competes with long-term benefits.

A third major application involves the comparison of different types of reinforcement schedules themselves, irrespective of delay. For example, researchers can use concurrent chains to determine an organism's preference for a Variable Interval (VI) schedule versus a Fixed Ratio (FR) schedule, allowing them to assess which schedule generates greater overall utility or motivational value when approached sequentially. This application informs our understanding of optimal foraging strategies and the inherent motivating properties of various environmental contingencies.

7. Significance in Understanding Complex Decision-Making

The Concurrent-Chains Procedure represents a crucial methodological advancement because it allows for the empirical measurement of choice for abstract stimuli--namely, the schedules of reinforcement themselves--rather than just concrete, immediate reinforcers. This capability elevates the analysis of behavior to address complex, higher-order decision processes that characterize human and animal interactions with structured environments.

By forcing the subject to commit to a sequence of events before receiving primary reinforcement,

the procedure models real-world situations involving sequential steps, planning, and commitment. This has profound implications for understanding psychological phenomena such as commitment devices, planning errors, and the impact of cognitive biases on long-term goal pursuit. The procedure provides an objective, behavioral yardstick for measuring subjective value, utility, and cost-benefit analysis in scenarios where the rewards are not immediate.

Ultimately, the concurrent-chains methodology has provided rigorous, quantitative data necessary to test and refine theories regarding the temporal organization of behavior. Its robust design ensures that observed preferences are attributable to the programmed differences in the outcomes (terminal links) and not confounding variables in the decision process (initial links), cementing its legacy as one of the most powerful tools in the experimental analysis of choice behavior.

8. Further Reading

[Operant Conditioning \(Wikipedia\)](#)

[Concurrent Chain Schedules in Psychology \(ScienceDirect\)](#)

[Choice in Psychology \(Wikipedia\)](#)

[A Review of Research on Concurrent-Chains Procedures \(Journal of the Experimental Analysis of Behavior\)](#)