

ARBITRARY MATCHING TO SAMPLE

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Introduction to Arbitrary Matching to Sample

The concept of **Arbitrary Matching to Sample** (AMTS) represents a foundational procedure within the experimental analysis of behavior, serving as a critical tool for studying complex cognitive processes such as stimulus equivalence, categorization, and derived relational responding. AMTS is defined as a specialized variation of the traditional **Matching to Sample** (MTS) task, distinguished by the non-identity relationship mandated between the sample stimulus presented and the correct comparison stimulus required for reinforcement. Unlike simpler matching tasks where the participant must select a comparison item identical in physical characteristics to the sample (identity matching), AMTS requires the participant to establish and demonstrate a learned, non-obvious, or **symbolic association** between disparate stimuli. This necessary arbitrary link challenges the organism, whether human or nonhuman, to move beyond simple perceptual similarity and engage in higher-order associative learning.

In a typical AMTS paradigm, the sample stimulus and the comparison stimuli are selected such that they possess no inherent, physical, or logical connection. For instance, if a visual sample of a specific color, such as **blue**, is presented, the correct response might be to select an entirely different modality or category, such as a specific geometric shape like a **large triangle**, when paired with incorrect choices like a small circle or a red square. The relationship established between the blue sample and the large triangle is entirely contingent upon the specific reinforcement history provided by the experimenter. This necessity to establish novel, arbitrary rules makes AMTS invaluable for investigating how associations are formed, maintained, and how they generalize across different contexts and stimuli, often revealing underlying mechanisms of human language and symbolic thought.

The significance of AMTS extends far beyond simple associative learning; it provides the procedural bedrock for understanding the formation of **stimulus classes**. When an organism successfully masters an arbitrary matching task, it demonstrates the ability to treat physically different stimuli as functionally equivalent under specific contextual control. This functional equivalence, often observed after multiple arbitrary relations are taught, is the core phenomenon that allows researchers to explore how complex systems of knowledge and categorization are built. Because the relationships are learned solely through differential reinforcement rather than innate or physical properties, AMTS allows for precise experimental control over the elements being linked, ensuring that derived responses observed later are truly novel and not merely reflections of pre-existing associations.

Historical Context and Theoretical Foundations

The methodological roots of the Matching to Sample procedure, from which AMTS is derived, lie deeply within the behavior analytic tradition, particularly the work stemming from B.F. Skinner's

analysis of discrimination and conditional discrimination. However, the specific focus on **arbitrary relations** gained prominence in the latter half of the 20th century as researchers sought methods to experimentally model complex human verbal behavior and symbolic reasoning in both human and nonhuman subjects. Early studies focused on demonstrating that organisms could learn relations that were not based on physical identity, paving the way for the exploration of phenomena like transitive inference and concept formation.

The formal establishment of AMTS as a major research tool coincided with the development of the theory of **Stimulus Equivalence**, pioneered primarily by Murray Sidman. Sidman's work argued that if several arbitrary conditional discriminations are trained (e.g., A leads to B, and B leads to C), then untrained relations such as B leading to A (Symmetry), A leading to C (Transitivity), and C leading to A (Equivalence) may emerge spontaneously. AMTS is the fundamental training procedure used to generate these initial conditional discriminations (A-B and B-C). Without the ability to arbitrarily link stimuli, the spontaneous emergence of these derived relations--a hallmark of human language and symbolic behavior--would be impossible to study systematically.

Furthermore, AMTS is central to **Relational Frame Theory** (RFT), a sophisticated behavior analytic account of human language and cognition. RFT posits that human beings learn to relate stimuli arbitrarily, not just based on identity or physical features, but based on social and verbal conventions (e.g., relating "larger than," "opposite," or "causes"). The AMTS procedure is seen as modeling the simplest form of derived relational responding: the formation of a coordination relation (or equivalence relation). By training a child or adult to arbitrarily match Stimulus A to Stimulus B, researchers are effectively training a basic relational frame that can later be expanded to include more complex and abstract relations, demonstrating the learned nature of symbolic reference.

Procedural Components of the AMTS Task

Executing an AMTS task requires strict control over three primary procedural components: the **Sample Stimulus**, the **Comparison Stimuli**, and the **Consequences** (reinforcement or correction). The procedure begins with the presentation of the sample stimulus, which is typically illuminated in a central location. This sample stimulus serves as the conditional cue, dictating which of the subsequent choices is correct. The duration of the sample presentation is carefully controlled, often terminated only when the participant makes an observing response, ensuring attention to the critical conditional cue.

Following the sample presentation, the participant is immediately presented with two or more comparison stimuli, usually arranged horizontally or vertically. Critically, in the AMTS procedure, none of these comparison stimuli physically resemble the sample; their relationship is purely arbitrary and based on the pre-established training criterion. For instance, if the sample was an auditory tone, the comparison stimuli might be three distinct visual icons. Only one comparison

stimulus is designated as correct relative to the sample (the S+); the others are designated as incorrect (S-). The spatial location of the S+ is varied randomly across trials to prevent the participant from learning a positional bias rather than the stimulus-stimulus relationship.

The third component involves the consequence delivered immediately following the participant's choice. If the participant selects the S+ (the correct arbitrary match), they receive **reinforcement**, which could be a primary reinforcer (e.g., food for an animal, tokens for a human) or social praise, depending on the subject population. If the participant selects an S- or fails to respond within a time limit, a correction procedure or time-out may be implemented. The systematic pairing of the sample and the correct arbitrary comparison, coupled with differential reinforcement, is what establishes the necessary conditional discrimination. Over repeated trials, the participant learns the rule: "When Sample A is present, select Comparison B, regardless of their physical dissimilarity."

Distinction Between Arbitrary and Identity Matching

Understanding the utility of AMTS requires a clear differentiation from its simpler counterpart, **Identity Matching to Sample** (IMTS). While both procedures utilize the fundamental structure of conditional discrimination, the nature of the relationship required for a correct response fundamentally separates them and dictates the cognitive level being assessed. In IMTS, the correct comparison stimulus shares the exact physical properties, or **formal identity**, with the sample stimulus. If the sample is a picture of a red square, the correct choice among comparisons must also be a red square. This task primarily assesses perceptual discrimination, attention, and immediate visual memory.

In contrast, AMTS fundamentally moves beyond mere physical comparison. In AMTS, the relationship is **functional**, not formal. The participant is not required to match based on "sameness" of appearance, but on a learned, functional equivalence established by the history of reinforcement. The sample stimulus serves as a **symbolic cue** for the correct comparison. For example, matching the auditory stimulus "DOG" to the visual image of a dog is an arbitrary match, even though the relationship seems obvious to a fluent speaker, because the sound waves forming the word "DOG" do not physically resemble the animal. This type of arbitrary relationship requires a far more complex level of learning and memory formation.

The critical theoretical distinction lies in what the successful completion of the task implies about the learner's behavior. Success in IMTS demonstrates the ability to perceive and respond to physical similarities ($A=A$). Success in AMTS demonstrates the ability to form a **conditional discrimination** (If A, then B; If C, then D), where B and D are physically distinct from A and C, respectively. This ability to link disparate stimuli based on arbitrary rules is the mechanism that generates complex stimulus classes and is essential for studying derived relational responding and linguistic capabilities. Therefore, AMTS serves as the benchmark procedure for investigating truly

symbolic or representational learning, whereas IMTS serves as a control or a baseline measure of basic perceptual capabilities.

Role in Stimulus Equivalence and Derived Relations

The primary theoretical importance of the AMTS procedure resides in its unparalleled capacity to establish the necessary prerequisite conditional discriminations required for the emergence of **Stimulus Equivalence**. Stimulus equivalence is demonstrated when, after training a limited set of arbitrary conditional relations, the learner exhibits untrained, derived relations among the stimuli, demonstrating that the stimuli now form an interchangeable class. The AMTS procedure is the tool used to teach the initial "legs" of this relational network.

To demonstrate equivalence, a researcher might train two sets of arbitrary relations using AMTS. First, a relation between Stimulus A and Stimulus B ($A \rightarrow B$) is trained (e.g., Sample A1 leads to Comparison B1). Second, a relation between Stimulus B and Stimulus C ($B \rightarrow C$) is trained (e.g., Sample B1 leads to Comparison C1). If these arbitrary relations are successfully established, the participant is then tested for derived, untrained relations. The critical test for transitivity involves presenting A as the sample and C as the correct comparison ($A \rightarrow C$), and the test for symmetry involves presenting B as the sample and A as the correct comparison ($B \rightarrow A$). The successful completion of these derived tests confirms that A, B, and C have become **functionally equivalent** stimuli.

The emergence of these derived relations following AMTS training is highly significant because it cannot be accounted for by traditional models of simple association or contiguity. The participant has never been explicitly reinforced for matching A to C or B to A; these responses are generated spontaneously, suggesting that the learner has established a higher-order relational rule. This derived equivalence, which is commonly observed in verbally fluent humans but often difficult to achieve in non-verbal animals, is widely considered a key experimental model for understanding symbolic function, meaning, and the mechanism by which human language generates vast networks of interconnected concepts based on arbitrary conventions.

Experimental Applications and Research Utility

The versatility and precision offered by the AMTS task have made it an indispensable methodology across various fields of psychological research, ranging from behavioral neuroscience to developmental psychology. One primary application involves the study of concept formation and categorization. By training participants to arbitrarily match a large set of novel stimuli into two or more distinct classes, researchers can investigate the parameters under which new concepts are learned, how flexible those concepts are, and how they interact with existing knowledge structures. This is particularly useful in studying the formation of abstract concepts that lack clear physical

definitions.

Furthermore, AMTS is widely employed in comparative psychology to explore the cognitive capacities of nonhuman species. Researchers utilize AMTS to determine whether different species, such as primates, marine mammals, or even birds, possess the ability to form arbitrary conditional discriminations and, crucially, whether they can demonstrate the subsequent derived relations that signify stimulus equivalence. The failure of most nonhuman species to reliably demonstrate full stimulus equivalence, even after rigorous AMTS training, highlights the unique symbolic learning capabilities that emerge with human verbal behavior.

In clinical and educational settings, AMTS procedures are adapted for assessing and remediating learning deficits. The systematic teaching of arbitrary relations is a core component of interventions for individuals with developmental disabilities, autism spectrum disorder, and language delays. By breaking down complex symbolic systems (like reading or arithmetic) into manageable arbitrary matching tasks, educators can systematically build foundational relational repertoires. For example, teaching a child to arbitrarily match the written word "CAT" (Sample A) to the spoken word "cat" (Comparison B), and then matching the spoken word "cat" (Sample B) to the picture of a cat (Comparison C), leverages the AMTS structure to facilitate the eventual derived understanding that the written word and the picture are equivalent symbols.

Challenges and Methodological Considerations

While the AMTS procedure is powerful, its effective implementation requires careful attention to numerous methodological challenges that can influence the validity and reliability of the results. One critical consideration is the selection of stimuli. To ensure the relationship is truly arbitrary, stimuli must be chosen to minimize any pre-existing biases, similarities, or known associations that the participant might bring to the task. If, for example, the sample and comparison share a similar texture or hue, the resulting match might be based partially on identity rather than the learned arbitrary rule, contaminating the assessment of conditional discrimination.

Another significant challenge involves the **reinforcement schedule** and the training protocol. AMTS training often requires hundreds or even thousands of reinforced trials to establish reliable responding, especially for subjects learning complex, multi-element relations (e.g., A-B, B-C, C-D). Researchers must implement robust error correction procedures and maintain high-quality reinforcers to ensure the participant remains motivated and focused throughout the extensive training phase. Failure to adequately reinforce the specific conditional discrimination can lead to inconsistent responding or the emergence of unwanted side effects, such as positional biases or stereotyped responses.

Finally, measuring the emergence of derived relations in the AMTS context requires stringent testing protocols. When testing for symmetry or transitivity, it is paramount that the test trials are

conducted without explicit reinforcement for the derived response. The presentation of derived relations must be interspersed with reinforced baseline trials to maintain motivation, but the derived test trials themselves must be non-reinforced to ensure that the observed response is truly spontaneous and not merely a new, trained arbitrary relation. Methodological rigor in controlling reinforcement and stimulus variables is essential for drawing accurate conclusions about the formation of arbitrary symbolic relationships.

Clinical and Educational Implications

The principles derived from research utilizing **Arbitrary Matching to Sample** have profound implications for clinical psychology, especially in areas dealing with cognitive deficits and the acquisition of verbal behavior. The systematic teaching structure of AMTS provides a template for breaking down complex learning goals into discrete, teachable units based on conditional discrimination. For individuals struggling with abstract concepts, AMTS allows clinicians to establish the foundational relational repertoires necessary for subsequent mastery of academic and social skills.

In the treatment of language-related disorders, the AMTS framework is used extensively to teach symbolic behavior. For example, teaching the functional use of currency involves establishing arbitrary relations: the visual appearance of a coin (Sample A) must be arbitrarily matched to its numerical value (Comparison B), and then that numerical value (Sample B) must be arbitrarily matched to the quantity of goods it can purchase (Comparison C). This sequencing, derived directly from the AMTS procedure, ensures that the abstract concept of value is systematically integrated into an equivalence class, facilitating functional understanding and generalization outside the training environment.

Ultimately, AMTS is not merely an academic procedure; it serves as a powerful model for understanding how humans learn to create and manipulate symbols. By elucidating the necessary steps--from establishing a simple, trained arbitrary link to the spontaneous emergence of complex, derived relations--the AMTS task provides clinicians and educators with evidence-based strategies to promote meaningful communication, conceptual thinking, and academic proficiency across diverse populations. The ability to arbitrarily link stimuli is fundamentally what allows for the expansion of vocabulary, the understanding of metaphor, and the mastery of culturally mandated symbolic systems.