ARBITRARY MATCHING TO SAMPLE

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November 12, 2025

ARBITRARY MATCHING TO SAMPLE (AMTS)

Primary Disciplinary Field(s): Experimental Psychology, **Behavior Analysis**, **Learning Theory**, **Cognitive Science**

1. Core Definition and Nomenclature

The **Arbitrary Matching to Sample** (AMTS) procedure is a fundamental experimental paradigm utilized extensively within the field of **behavior analysis** and learning theory to investigate how organisms acquire complex, non-topographical stimulus control. It is defined as a variation of the standard **Matching to Sample** (MTS) task in which the relationship between the sample stimulus presented and the correct comparison stimulus chosen is entirely arbitrary or symbolic, meaning it is dictated solely by the history of reinforcement and not by any inherent physical or logical similarity between the two stimuli. This procedure requires the subject to learn a specific, conditional discrimination where the consequence of a choice (reinforcement or punishment) is dependent on the specific sample presented at that moment. Unlike tasks involving physical identity, the subject must establish an entirely novel relationship between two otherwise unconnected elements, such as linking a specific color to a particular geometric shape, or associating a spoken word with a specific picture. The term **Symbolic Matching to Sample** is often used synonymously with AMTS, emphasizing the acquired symbolic function of the stimuli within the learned contingency.

The defining characteristic of AMTS is that the association cannot be derived through simple generalization or physical resemblance. For instance, if the sample stimulus is a picture of a blue telephone, the arbitrarily correct comparison stimulus might be a large red triangle. There is no physical reason inherent to the stimuli themselves that dictates this pairing; the rule (e.g., "If Blue Telephone, choose Red Triangle") exists purely as a behavioral contingency enforced by the experimenter. Successful performance on AMTS tasks demonstrates the organism's capacity for complex conditional learning, which is critical for understanding higher-order cognitive functions, especially the acquisition of language and symbolic thought. This procedure moves beyond the study of simple stimulus-response pairings by demanding that the subject attend not just to the stimuli themselves, but to the specific context created by the presence of the sample stimulus.

The complexity of AMTS lies in the conditional nature of the discrimination. The subject must learn not just that a stimulus is present, but that its presence signals the contingency for a specific, unrelated response. This requirement forms the operational basis for testing whether arbitrary stimuli can enter into **stimulus equivalence classes**, a concept crucial for understanding how humans learn abstract relations, such as those found in mathematics or linguistic syntax. The successful establishment of these arbitrary relations through AMTS is thus considered a prerequisite for demonstrating complex relational responding in both human and non-human

subjects.

2. Distinction from Identity Matching

To fully appreciate the scope of AMTS, it is essential to contrast it with its simpler predecessor, **Identity Matching to Sample** (IMTS). In IMTS, the subject is required to select the comparison stimulus that is physically identical (topographically similar) to the sample stimulus. For example, if the sample is a small circle, the correct choice among comparisons (e.g., small circle, large square, small triangle) is the small circle. This task primarily tests sensory discrimination and generalization based on physical properties, requiring minimal complex learning outside of attending to features such as shape, size, or color. IMTS behavior often develops quickly, sometimes requiring little direct reinforcement history if the organism possesses strong perceptual skills.

AMTS, conversely, demands a complete shift in the basis of discrimination. The subject must ignore physical similarity and instead respond solely according to the arbitrary rule established by the experimental contingency. While IMTS establishes control based on "sameness," AMTS establishes control based on "convention." This distinction is theoretically significant because AMTS procedures successfully model how stimuli acquire symbolic functions--the core process underlying language. A word (an arbitrary sound or graphic symbol) is not physically identical to the object it represents, yet humans learn to treat them as functionally equivalent through extensive arbitrary training. Therefore, AMTS is the experimental vehicle for analyzing the learning processes that bridge simple sensory input and complex symbolic behavior.

Furthermore, the procedural complexity involved in setting up and running AMTS tasks highlights this critical difference. IMTS requires merely presenting two identical stimuli alongside distractors. AMTS requires careful pairing of wholly disparate stimuli (e.g., auditory cue A with visual shape B; visual shape B with tactile texture C). The learning curve for AMTS is typically steeper and requires significantly more reinforced trials, reflecting the difficulty of overriding innate or previously learned physical generalization tendencies. The acquired behavior in AMTS is highly sensitive to changes in reinforcement schedules and experimental context, further reinforcing its status as a learned, conditional behavior rather than a simple perceptual response.

3. Procedural Framework and Components

The implementation of **Arbitrary Matching to Sample** follows a highly standardized experimental protocol rooted in operant research methodology. The task always consists of three primary phases: the sample presentation, the choice phase, and the consequence (reinforcement or correction). First, the **Sample Stimulus** (S1) is presented. This stimulus sets the context for the trial and determines which comparison stimulus will be reinforced. The sample may be visual (e.g.,

a letter, a photograph), auditory (e.g., a word, a tone), or tactile. The subject must usually engage with the sample (e.g., press a key, orient toward it) to initiate the next phase.

Following the sample presentation, the **Comparison Stimuli** are simultaneously presented (S2, S3, S4, etc.). Crucially, these comparison stimuli are arbitrary concerning the sample, having no topographical relation to it. The subject must select one of the comparisons. Only one comparison, designated the correct match (S2+), is reinforced, and this designation is entirely conditional upon the specific sample stimulus (S1) that initiated the trial. The remaining comparisons are distractors (S2-). For instance, if Sample A is presented, Comparison X is correct; if Sample B is presented, Comparison Y is correct. If the subject selects the correct comparison, a positive reinforcer is delivered (e.g., food, points, praise). If an incorrect comparison is selected, the trial is typically terminated without reinforcement or a correction procedure is initiated.

The core requirement of the AMTS procedure is the establishment of a robust **conditional discrimination**. This means the subject is not simply learning a relationship between S1 and S2+, but rather learning that S1 *signals* the contingency that makes S2+ the correct choice in that specific context. This framework allows researchers to rigorously define and test the boundaries of stimulus control. Furthermore, a typical AMTS experiment involves establishing several distinct arbitrary relations concurrently (e.g., A1-B1, A2-B2), often referred to as baseline training. Once these baseline relations are mastered, the stage is set for testing the emergence of untrained relations, which forms the basis of stimulus equivalence research.

4. Theoretical Underpinnings: Conditional Discrimination

The theoretical foundation of the **Arbitrary Matching to Sample** procedure lies in the concept of **Conditional Discrimination**, a sophisticated form of stimulus control first formalized within the framework of **Operant Conditioning**. Unlike simple discrimination, where a single stimulus signals the availability of reinforcement for a particular response (S-delta), conditional discrimination requires the presence of a second, contextual stimulus (the sample) to dictate which response will be reinforced among multiple available options. In essence, the sample stimulus serves as a conditional cue, modifying the discriminative function of the comparison stimuli.

The subject is not merely learning "press B," but rather learning the rule: "If A is present, then pressing B leads to reinforcement." This structure models the complex conditional rules that govern most human learning and social interaction. AMTS experiments demonstrate that organisms can learn these complex, rule-governed behaviors even when the stimuli themselves are completely unrelated in a physical sense. The learning process involves the development of strong stimulus control by the sample, ensuring that the subject selects the correct comparison stimulus only when the appropriate conditional context is present.

The success of AMTS in establishing conditional discrimination is critical because it challenges

simpler associationist accounts of learning. It shows that learning involves not just the creation of S-R links, but the formation of relationships *between* stimuli that are mediated by a learned rule enforced by the environment. This ability to form arbitrary, conditional relations is often considered a behavioral hallmark distinguishing advanced forms of cognition and symbolic processing from simpler associative learning mechanisms. Without the capacity for conditional discrimination established through AMTS, the development of complex language skills would be inexplicable from a purely behavioral standpoint.

5. The Role in Stimulus Equivalence

The primary significance of the **Arbitrary Matching to Sample** procedure lies in its indispensable role as the methodology for investigating **Stimulus Equivalence**. Stimulus equivalence refers to the phenomenon where, after training a limited set of conditional discriminations (the arbitrary links), subjects demonstrate the emergence of untrained, derived relations between those stimuli. This emergence is critical because it suggests that the learned stimuli are now treated as functionally interchangeable symbols, or members of an equivalence class.

To test for equivalence, an experimenter first establishes baseline arbitrary relations using AMTS, such as A1-B1 and B1-C1. Once the subject masters these trained relations, the subject is tested for three critical emergent properties without further training or reinforcement: **Symmetry** (If A1-B1 is trained, does B1-A1 emerge?), **Transitivity** (If A1-B1 and B1-C1 are trained, does A1-C1 emerge?), and the combination, **Equivalence** (Does C1-A1 emerge?). The emergence of these untrained relations suggests that the stimuli A1, B1, and C1 have formed an equivalence class and function as symbols for one another.

AMTS is the foundation of this research because identity matching cannot generate the arbitrary links necessary for the formation of abstract, symbolic equivalence classes. The capacity to derive these untrained relations following AMTS training is considered by many behavioral researchers to be the behavioral mechanism underlying human language, literacy, and abstract thought. For example, learning that the sound /dog/ (A) refers to the picture of a dog (B), and that the written word "DOG" (C) also refers to the picture (B), often leads subjects to immediately relate the sound (A) to the written word (C) without ever being directly taught that specific link. This phenomenon, observable only through AMTS-based procedures, is central to understanding the behavioral processes of complex human cognition.

6. Applications in Behavior Analysis and Education

Given its ability to model and establish complex conditional learning, the **Arbitrary Matching to Sample** procedure has profound applications, particularly in **Applied Behavior Analysis** (ABA) and educational settings. AMTS methodologies are routinely adapted to teach symbolic

communication, language skills, and academic concepts to individuals who struggle with traditional instructional methods, most notably children and adults diagnosed with **Autism Spectrum Disorder** and other developmental disabilities. The systematic, trial-based nature of AMTS allows educators to precisely control contingencies and reinforcement histories, ensuring that arbitrary associations are established effectively.

In educational contexts, AMTS is used to teach reading (arbitrarily linking the printed word, the spoken word, and the corresponding picture), mathematics (linking numerical symbols, sets of items, and specific quantity names), and foreign language vocabulary. For example, a learner might be trained on an AMTS task where the sample is the spoken word "casa," and the correct comparison is a picture of a house, thereby establishing an arbitrary foreign language-to-picture relation. Subsequent training might link the written word "CASA" to the picture. If equivalence emerges, the learner will automatically associate the written word with the spoken word, facilitating rapid and generalized learning.

The application of AMTS extends beyond didactic training into remediation and assessment. Researchers utilize AMTS performance to assess the prerequisite skills for symbolic behavior in individuals with cognitive deficits. Furthermore, variations of the task are employed to study concept formation and generalization, analyzing how subjects categorize novel stimuli based on the arbitrary rules learned during the training phase. The procedural rigor offered by AMTS ensures that observed learning outcomes are attributable directly to the established contingencies rather than extraneous variables, making it a powerful tool for both research and effective therapeutic intervention.

7. Methodological Challenges and Conceptual Debates

Despite its utility, the **Arbitrary Matching to Sample** procedure is not without its methodological challenges and conceptual debates. One primary challenge involves the technical difficulty of establishing robust stimulus control, especially in populations with severe learning deficits. Establishing multiple, non-identical, arbitrary relations requires extensive baseline training, and failures to acquire these initial conditional discriminations can halt the entire stimulus equivalence research process. Experimenters must rigorously control for factors such as stimulus salience, position biases, and reinforcement quality to ensure that the arbitrary contingency is truly governing the subject's behavior.

Conceptually, the major debate centers on the interpretation of the emergent relations observed following AMTS training--specifically, the phenomenon of stimulus equivalence. While behavior analysts view equivalence as a robust, learned behavioral phenomenon resulting from generalized conditional discriminations, some cognitive psychologists argue that the emergence of symmetry and transitivity necessarily implies underlying mediating cognitive processes, such as propositional

reasoning or rule following, that transcend simple reinforcement history. This debate often revolves around whether equivalence is truly "emergent" or if the untrained relations are merely complex, previously subtle, generalized components of the trained contingency.

Furthermore, questions persist regarding the necessity of language for the formation of equivalence classes. While most human subjects readily form equivalence classes following AMTS training, results with non-human animals have been highly inconsistent or limited, leading to hypotheses that certain verbal repertoires (e.g., naming, tracking one's own responses) may function as behavioral cusps essential for the reliable derivation of arbitrary relations. Understanding these limitations and the specific mechanisms that mediate AMTS success continues to drive advanced research in learning and cognitive science.

Further Reading

Matching to sample (Wikipedia)
Sidman, M. (1994). Equivalence relations and behavior: A research history. Boston: Authors Cooperative.
Conditional Discrimination in Psychology (ScienceDirect Topic Page)
Stimulus Equivalence (Wikipedia)