On stimulus equivalence

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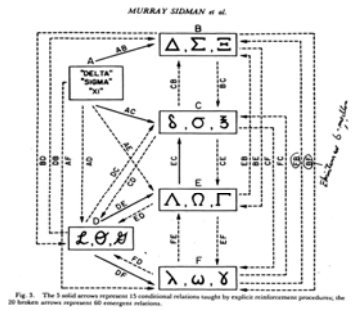


My interest in this research area has been fourth-fold:

- The emergence of new relations – not directly trained.
- Studying variables are influencing the emergence of equivalence relations.
- Complex repertoires (i.e., concepts, problem solving, language formation) are amenable to behavior analysis.
- Research on stimulus equivalence and the impact on the arrangement of effective conditional discrimination procedures in behavioral programs.

Three main reasons for the publicity on stimulus equivalence:

1. The findings that show that conditional discrimination procedures generate more relations than those which are established directly.
2. The findings show that stimulus equivalence is connected closely to complex behavior and verbal behavior in specific.
   (a) equivalence have been shown in humans with certain verbal capacity, but not in humans lacking this verbal capacity or in nonhumans.
   (b) if a child does not respond in accord with equivalence and then trained to naming the stimuli, they do respond in accord with equivalence on a new test.
   (c) equivalence procedures have shown to be effective in treatment of participants with language difficulties.
   (d) equivalence procedures have been used in behavior analysis in the understanding of symbolic meaning and the generative function within grammar.
3. Stimulus equivalence is of importance for the analytic unit.

Different terms

A - B - C

S^{K2} – S^{K} – **SD : R - SR**

SE (Setting events)

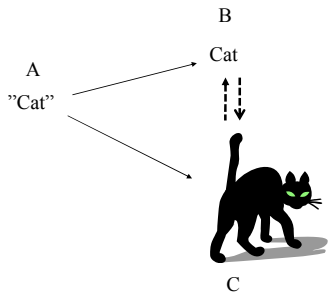
EO/MO (Establishing or motivational operations)

Stimulus equivalence

Stimulus equivalence is about the interchangeability of stimuli. Hence, we could say that the stimuli are in the same class. Reflexivity, symmetry, and transitivity are parts of the definition of equivalence.

(specific definitions will come later)

Example



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Emergent relations

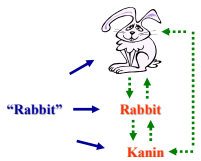

Figure 2 Shows the trained relations in the presence of an auditory stimulus. Six relations have emerged out of three trained relations.

The solid arrows show the direction of training and the broken arrows show the tested relations

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Some background information

- Early in the seventies Sidman (1971) described how reading skills can be established in the most efficient way.
- Reading is a skill which are under control of visual stimuli, words or written text, and one could even classify such reading relations and visual stimuli.
  - Reading aloud is such a category. In the presence of the textual stimulus ’football’, the child will say ”football”. This response could be emitted with and without understanding.
  - One can for example read a word in a foreign language without understanding the meaning. If the behavior is going to characterized as understanding, is dependent upon that a the written text occasion the choice of the relevant object. Specifically, this means that the child must choose the picture of the football in the presence of the written word ‘football’.
  - A third relation which is important is that the child has to choose the written word when the auditory stimulus football is presented, i.e., what we call receptive matching.

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From Sidman (1971)

One can read aloud without understanding, therefore:

- Reading aloud – a textual stimulus which emits a response.
- The written word must emit the choice of the object.
- An auditory stimulus must emit the choice of the written text (auditory receptive matching).

Different forms of matching

A. Identity matching
Written text – written text

B. Understanding
Dictatet word – picture

C. Picture naming
picture – say name aloud

D. Reading with understanding - reading
Dictated word – written text

E. Reading skills
Written text - picture

F. Talking - reading
Written text – say the name aloud

Fra Sidman (1971)

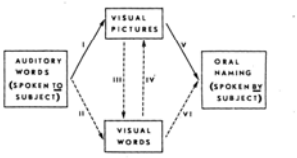


FIGURE 2. Schematic summary of the experiment. Of the stimulus equivalences, I-IV, the subject came to the experiment knowing I. Of the naming tasks, V and VI, he could do V. After being taught equivalence II, he could then do III, IV, and VI.

From Sidman (1971)

- The participant was a young man with mental retardation.
- Before the start of the study, the participant was not able to match written text to pictures or written text under control of auditory stimuli. On the other hand could he choose correct picture in the presence of most spoken words and he could name most of the pictures.

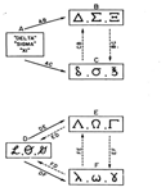
Emergence of new relations

- The results from this study showed the participants learned more than he was trained to do.
- "Emergent performances like these are critical components of language development." (O'Donnell & Saunders, 2003, p. 131)

Fra Sidman & Tailby (1982, p. 7-8):

"Previous studies using English language symbols had required extensive pretests to ensure that subjects could not already do the critical matching and naming. In order to eliminate both the time required for pretests and the problems created by giving children tasks they are unable to perform and to avoid the methodological dilemma of whether or not to reinforce correct responses during pretests, this experiment used Greek letters and letter names, stimuli that could be presumed unfamiliar to the subjects and therefore not requiring pretests at all."

Types of stimuli often used in equivalence research



Traditionally an area for cognitive psychology

Cognition is not a mental event, it is a behavioral event, and there is no reason that a psychology of cognition cannot be a behavioral psychology.

(Hayes, Barnes-Holmes og Roche 2001b, s. 145)

Equivalence explains one way in which symbols are established as referents to something and words can come to ”mean” something

“....one of the most fascinating observations is that when we often react to words and other symbols as if they *are* the things or events they refer to. Even though we do treat word and referent as equal in all respects, we attribute some of the same properties to both. This treatment of linguistic forms as equivalent to their referents permits us to listen and read with comprehension, to work out problems in their absence, to instruct others by means of speech or text, to plan a head, to store information for use in the future, and to think abstractly - all of these by means of words that are spoken, written, or thought in the absence of the things and events they refer to.”

(Sidman, 1994, p. 3).

Complex repertoires seem to be amenable to behavior analysis.

> "What distinguishes the studies of equivalence relations from most other areas of experimentation is the emergence in the laboratory of startling complex performances that have not been explicitly taught to the subjects."
>
> (Sidman, 1994, pp. 531-531)

Common word dog is occasioned by different stimuli

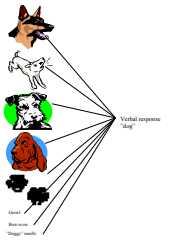


Figure 1 - the concept of "dog". Different examples of a specific stimulus class in which a common verbal response, "dog", is occasioned by a number of different stimuli. In spite of the difference in modality, occurrence of various breeds of dogs and sounds and odors emanating from dogs all of these responses could emit the same response "dog". Based on Donahoe and Palmer (1994).

Concept formation, thus, occurs when people learn to classify different objects as members of a single category (Donahoe & Palmer, 1994).

Keller and Schoenfeld (1950)

"Strictly speaking, one does not have a concept, just as one does not have extinction – rather, one demonstrates conceptual behavior, by acting in a certain way." (p. 154)

Keller and Schoenfeld (1950)

stated that "generalization within classes and discrimination between classes . . . is the essence of concepts" (p. 155).

Terms

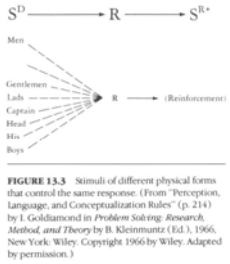


FIGURE 13.3 Stimuli of different physical forms that control the same response. (From "Perception, Language, and Conceptualization Rules" (p. 214) by I. Goldiamond in *Problem Solving: Research, Method, and Theory* by B. Kleinmuntz (Ed.), 1966, New York: Wiley. Copyright 1966 by Wiley. Adapted by permission.)

Stimulus control

- If social or non-social events precede operant behavior and in change the occurrence of that behavior, it's called controlling stimuli.
- A controlling stimulus (S) changes the probability of an operant in the sense that it is more or less probability for a response to occur when the stimulus is present.
- **Discriminative stimulus (S^D) –** an controlling stimulus "sets the occasion" for reinforcement of an operant.
- **S-delta (S^Δ) or an extinction stimulus** – an stimulus which "sets the occasion" for non-reinforcement or extinction.

Simple discrimination could be explained as:

S+	S-
Response	Response
↓	↓
Reinforcer	No reinforcer

Simple vs. Conditional discrimination

- The term stimulus control are used when operant behavior changes as a function of the presentation of either a discriminative stimulus S^D (S+) or S-delta S^a (S-).
- In simple discrimination is a response reinforced just in the presence of a specific stimulus or a response class produced by differential reinforcement. The arrangement of the differential reinforcement of characteristics of stimuli is called a discriminative operant (Catania, 2007).
- In conditional discrimination is simple discrimination brought under control of additional stimuli or conditional stimuli.

Conditional discrimination

- Conditional discriminations are instances in which the role of one stimulus is conditional upon on other stimuli that are present.

Differential reinforcement

- **Differential reinforcement** is the presentation of reinforcers dependent upon certain responses with certain response characteristics, and eventually in the presence of certain stimuli.

S^D vs. S^Δ

Et eksempel på positiv forsterkning

- S^D : → Respons → Forsterker

Andre barn i gata — Banning — Bifall fra de andre barna

Et eksempel på ekstinksjon

- S^Δ : → Respons → Ingen Forsterker

Bestemor og bestefar — Banning — (ikke noe positiv oppmerksomhet)

Stimulus control

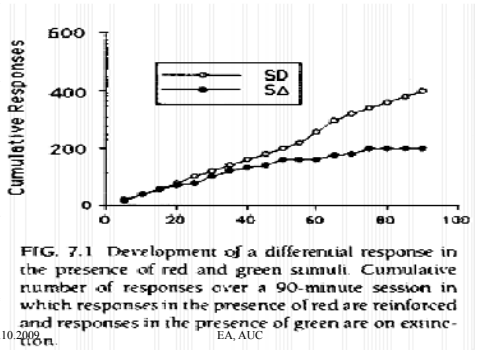


FIG. 7.1 Development of a differential response in the presence of red and green stimuli. Cumulative number of responses over a 90-minute session in which responses in the presence of red are reinforced and responses in the presence of green are on extinction.

The results from such a procedure

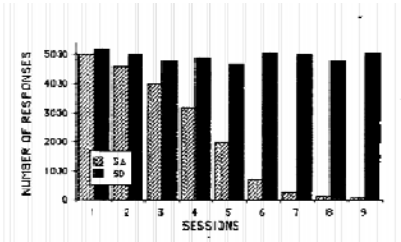


FIG. 7.3 Idealized results for a MULT VI 2-minute, EXT 1-minute schedule of reinforcement. Relative to the rest VI component, pecking declines over sessions to almost zero responses per minute in the green extinction phase.

Et eksempel på hvordan stimuluskontroll kan anvendes

- Et program hvor duer ble lært opp til å skille ut kapsler som var i orden fra de som var ødelagt.
- Duene klarte denne diskriminasjonen med over 90% nøyaktighet

Classes of stimuli

- A stimulus class could be defined as two or more stimuli controlling the same response class (e.g., Goldiamond, 1962; Skinner, 1938).
- Some stimulus classes are products of primary generalization. This means that two or more stimuli will control one response class because they have some physical characteristics in common.

- Primary stimulus generalization cannot explain how classes of stimuli are established when there are no physical similarity between the stimuli.
- Functional stimulus classes are known as classes of stimuli which have the same behavioral function even if stimuli do not have any physical similarity.
- Stimulus equivalence is synonymous with stimulus substitution. When a stimulus which is controlling some behavior may be replaced by another stimulus and the probability for the occurrence of the response is it possible to assume that that stimuli means the same for the organism.

Functional equivalence

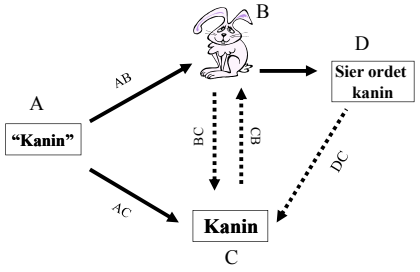
- If two stimuli are members of one class, then behavior in the presence of one the stimuli in the class will also occur in the presence of another stimuli in the class.
- Vaughan (1988) did an experiment with pigeons which were trained to discriminate between two set of slides. Pecking was reinforced only in the presence of one of stimuli in one of the sets, but not the other one. The reinforcement contingency was after a while switch. After a number of switching's of reinforcement contingencies the pigeons behavior changed after the presentation of the first slide in one of the stimulus sets. This means that the pigeons behavior changed for all stimuli in the set.

Terms

- Sample stimulus or ’utvalgsstimulus’. That is the first stimulus presented on the screen. A click on the sample stimulus is followed by presentation of two or more stimuli.
- Click on a comparison stimulus or ’sammenligningsstimulus’ is followed by some sort of programmed consequence.

forts.

- Simultaneous discrimination
- Successive discrimination
- Under conditional discrimination training will simple discriminations come under control of additional stimuli or so-called conditional stimuli.



Figur 1. Innenfor settet med A-stimuli er det presentasjon av auditive stimuli, innenfor settet med B-stimuli er det bilder som blir presentert, innenfor settet med C-stimuli er det ulike ordbilder som blir presentert, og til slutt er det navngivingsresponser. Denne figuren viser hvorledes ulike relasjoner blir trent. Seks relasjoner har framkommet på bakgrunn av tre relasjoner. Innenfor hvert av settene er det som regel tre ulike stimuli.
De fylte pilene indikerer hvilke relasjoner som er trente, mens de stiplete indikerer hvilke som framkommer uten direkte trening.

forts.

- In a typical conditional discrimination experiment, a minimum of two sample stimuli are presented successively, while a minimum of two comparison stimuli are presented simultaneously, e.g., the selection of B1 (the word 'rabbit') in the presence of A1 (a picture of a rabbit) and the selection of B2 (the word 'dog') in the presence of A2 (a picture of a dog). Mainly conditional discrimination procedures have been used in the study of stimulus equivalence.

Matching-to-sample

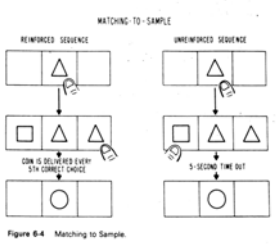
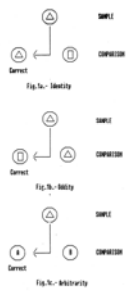


Figure 6-4 Matching to Sample.

In a conditional discrimination procedure the sample stimulus can either

(1) remain present after the presentation of comparison stimuli (simultaneous matching),
(2) disappear when the comparisons are presented (0 s delay), or
(3) be removed n seconds before the comparisons are presented (delayed matching).

Different types of matching



Kompleks stimuluskontrol

For eksempel ved Identity matching

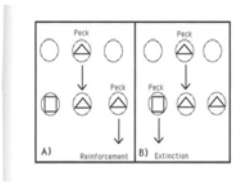
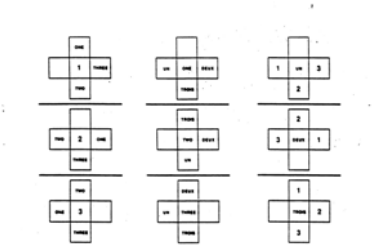


FIG. 8.11 Procedures used to train identity matching by a pigeon.

Eksempel på betinget diskriminasjonsprosedyre



It is not always true that equivalence relations occur even if that's what it is put forward

- "In humans, however, equivalence relations are easily generated."

(Catania, 1992, p. 154)

Matematisk modell

- Selv om ekvivalens er et matematisk begrep så ser det ut til å være slik at ekvivalens relasjonen kan beskrive atferd som kan observeres uansatt kontrollforhold.
- Begrepene refleksivitet, symmetri og transitivitet er brukt for å kunne avgjøre om en ekvivalens relasjon vil kunne dele opp et sett av stimuli, slik at det ikke blir noen overlapping.

Test for equivalence relations

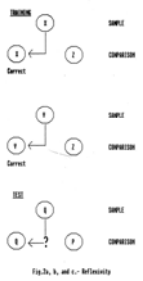
A possible test for equivalence after **a** *conditional discrimination training requires at least 2 three-member classes.*

Equivalence Relations must be:

1. Reflexive: Train **a** --> **a**, test **b** --> **b**
   If **a**R**a**, then **b**R**b**
2. Symmetric: Train **a** --> **b**, test **b** --> **a**
   If **a**R**b**, then **b**R**a**
3. Transitive: Train **a** --> **b** and **b** --> **c**, test **a** --> **c**
   If **a**R**b** and **b**R**c**, then **a**R**c**
4. Combined test: Train **a** --> **b** and **b** --> **c**. Test **c** --> **a**
   If **a**R**b** and **b**R**c**, then **c**R**a**

Basert på Sidman et al. (1982)

Reflexivity

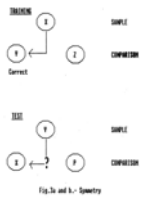


Atferdsmessige testene for å vurdere om en betinget relasjon er en ekvivalensrelasjon:

- Refleksivitet: Hver stimulus må ha en betinget relasjon til seg selv (for eksempel en sample stimulus A må være relatert til en comparison stimulus). Identitetsmatching vil kunne teste ut denne egenskapen.

Fortsetter

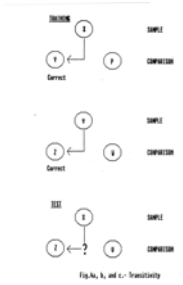
Symmetry



- Symmetri: En betinget relasjon må være bidireksjonal. Når en sample A har blitt relatert til en comparison B under baselinetrening (AB), må sample B være relatert til comparison A (BA) uten trening.

Fortsetter

Transitivity



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- Transitivitet: Hvis sample A står i en bestemt relasjon til comparison B og sample B i en bestemt relasjon til comparison C, så vil en kunne si at respondering er karakterisert ved transitivitet dersom sample A står i en bestemt relasjon til comparison C uten trening.

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Equivalence relation must be

1. Reflexive: **a**R**a**
2. Symmetrical: If **a**R**b**, so **b**R**a**
3. Transitive: If **a**R**b** and **b**R**c**, so **a**R**c**

Combined tests for symmetry and transitivity are:

a. Train **a**R**b** and **a**R**c**. Test **b**R**c** and **c**R**b**

b. Train **b**R**a** and **c**R**a**. Test **b**R**c** and **c**R**b**

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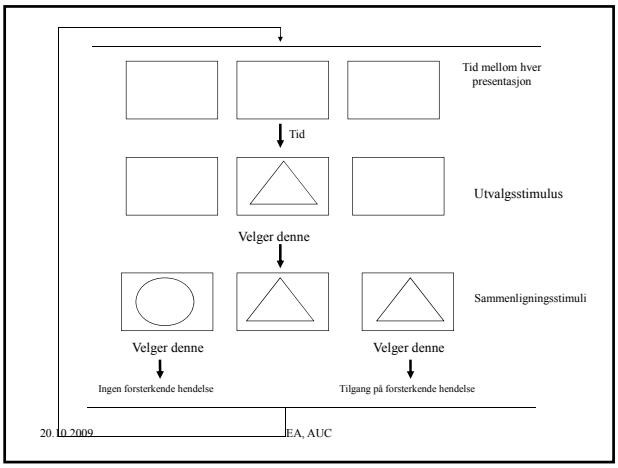

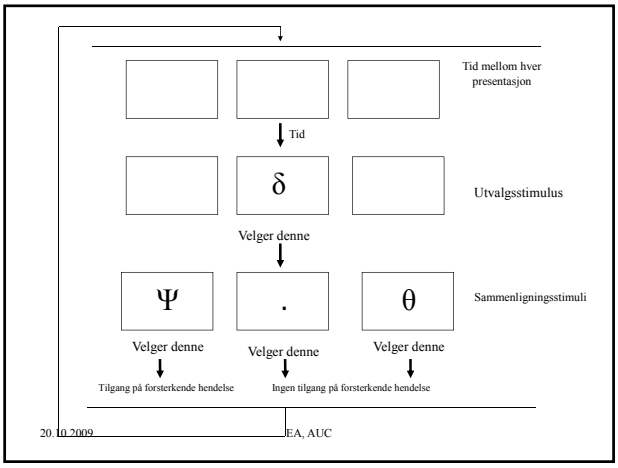

Praktisk eksempel #1

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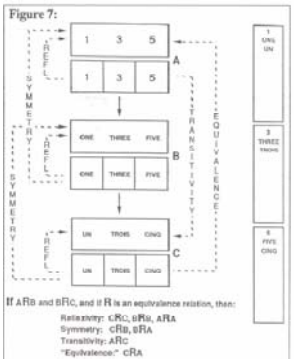
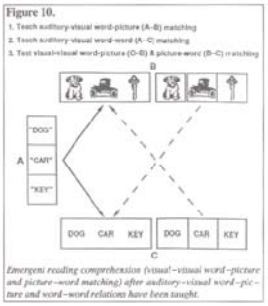
Praktisk eksempel #2

Examples of stimuli for auditory–visual word–picture (upper displays)and word–word (lower displays) matching.





Emergent reading comprehension (visual–visual word–picture and picture–word matching) after auditory–visual word–picture and word–word relations have been taught.

Consequences for the three-term contingency

- "Equivalence classes involve a type of stimulus control that is not encompassed by the three-term contingency."

(Catania, 1992, p. 152).

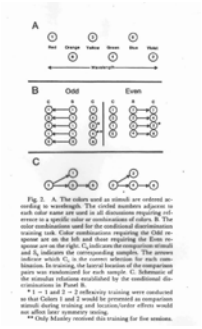
Verbal behavior and equivalence

- "Language and equivalences may be two aspects of a single behavioral competence"

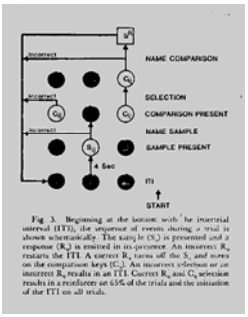
(Catania, 1992, p. 155)

Orginal set up from Sidman's experiments

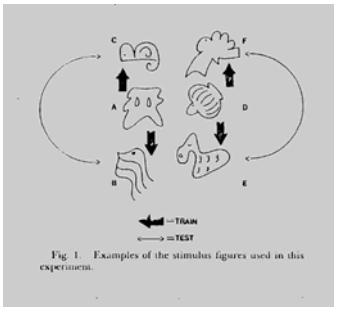
McIntire, Cleary, and Thompson (1987)



McIntire, Cleary, and Thompson (1987)



Fra Devany et al. (1986)

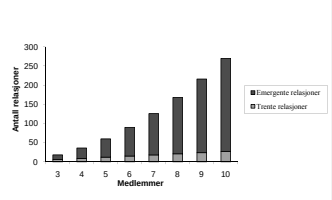


Trained vs. Emergent relations

Trained relations may be expressed as C(M-1) and emergent relations could be expressed as $C(M-1)^2$, where C is number classes and M is number of members.

(Arntzen, 1999)

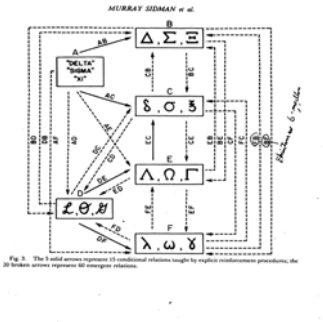
Relationship between trained and emergent relations



N-terms

Contingencies	Relations	Behavioral processes
1-terms	R	Stimulus functions
2-terms	$R \rightarrow S^R$	Reinforcement
3-terms	$S^D \rightarrow R \rightarrow S^R$	Discrimination and conditioned reinforcement
4-terms	$S^K \rightarrow S^D \rightarrow R \rightarrow S^R$	Conditioned discrimination and stimulus equivalence

From Sidman et al. (1986)



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Sidman, 1986

Table 4: A Balanced Four-Term Contingency (Conditional Discrimination)
R = Response; C = Consequence; S = Stimulus

S3 (green)	S1 (square)	R1 (press) ---> C1 (coin)
		R2 (other) -/-> C1 (coin)
	S2 (circle)	R1 (press) -/-> C1 (coin)
		R2 (other) -/-> C1 (coin)
S4 (red)	S1 (square)	R1 (press) -/-> C1 (coin)
		R2 (other) -/-> C1 (coin)
	S2 (circle)	R1 (press) ---> C1 (coin)
		R2 (other) -/-> C1 (coin)

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Test for respondering i henhold til refleksivitet

Table 5: A Test for Reflexivity of the Conditional Relations in Table 4.
R = Response; C = Consequence; S = Stimulus.

S3 (square)	S1 (square)	R1 (press) ---> C1 (coin)*
		R2 (other) -/-> C1 (coin)
	S2 (circle)	R1 (press) -/-> C1 (coin)
		R2 (other) -/-> C1 (coin)
S4 (circle)	S1 (square)	R1 (press) -/-> C1 (coin)
		R2 (other) -/-> C1 (coin)
	S2 (circle)	R1 (press) ---> C1 (coin)*
		R2 (other) -/-> C1 (coin)
S3 (green)	S1 (green)	R1 (press) ---> C1 (coin)*
		R2 (other) -/-> C1 (coin)
	S2 (red)	R1 (press) -/-> C1 (coin)
		R2 (other) -/-> C1 (coin)
S4 (red)	S1 (green)	R1 (press) -/-> C1 (coin)
		R2 (other) -/-> C1 (coin)
	S2 (red)	R1 (press) ---> C1 (coin)*
		R2 (other) -/-> C1 (coin)

*During reflexivity test, no coins are actually delivered.

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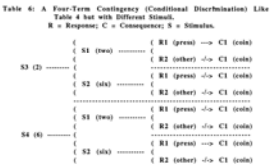
Fire terms kontingens med ulike stimuli



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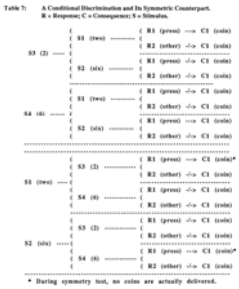
Test for respondering i henhold til symmetri



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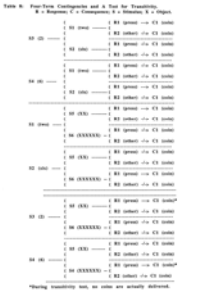
Test for respondering i henhold til transitivitet



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Fem terms kontingens

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Stimulus equivalence and verbal behavior

- Stimulus equivalence → verbal behavior
- Verbal behavior → stimulus equivalence
- ? → stimulus equivalence

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Three models can account for equivalence

- Sidman and basic behavioral process
- Horne & Lowe and naming
- Hayes and relational frame theory

The view that equivalence relations represent a basic behavioral process (Sidman, 1990; Sidman, 1994; Sidman, 1997) differs from the relational frame theory (e.g., Hayes, 1991) and the naming hypothesis (Horne & Lowe, 1996) that both require a behavioral history for the emergence of stimulus equivalence.

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Sidman – fundamental stimulus function

" … I am left with the suspicion that the formation of equivalence relations, like reinforcement, discrimination, and other stimulus function, may be a product of evolution, and not derivable from more basic behavioral processes."

Sidman, 1994, p. 567)

Hvor kommer ekvivalens fra?

"An equivalence relation, therefore, has no existence as a *thing*; it is not actually *established*, *formed*, or *created*. It does not *exist*, either in theory or in reality. It is defined by the emergence of new - and predictable - analytic units of behavior from previously demonstrated units."

(Sidman, 1994, pp. 388-389)

"Naming"

- Ved "naming" hypotesen (Horne & Lowe, 1996) er den grunnleggende enheten av verbal atferd "name" relasjonen. "Name" relasjonen er lært og vil senere kunne symbolisere objekter og hendelser ute i verden. Gjennom å lære lytteatferd og senere ekkoisk respondering, dvs. atferd som involverer produsering og høre sine egne ytringer, så lærer barnet toveis (bidirectional) relasjoner mellom klasser av objekter og hendelser og hans eller hennes egen snakker-lytter atferd. Resultatet er at barnet erverver "naming". Relasjoner som snakker-lytter relasjoner kan forklare for en rekke atferd som "oppstår" inklusive ekvivalens.

Lytteratferd

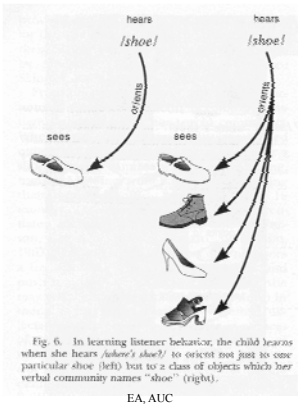

Fig. 6. In learning listener behavior, the child learns when she hears */shoe's shoe?/* to orient not just to one particular shoe (left) but to a class of objects which her verbal community names "shoe" (right).

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”Echoic”

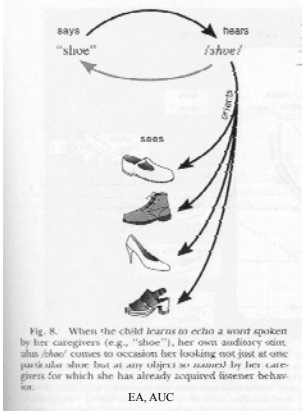

Fig. 8. When the child learns to echo a word spoken by her caregivers (e.g., "shoe"), her own auditory stimulus */shoe/* comes to occasion her looking not just at one particular shoe but at any object so named by her caregivers for which she has already acquired listener behavior.

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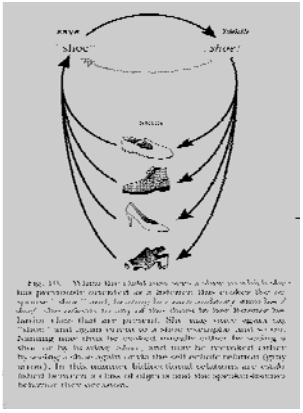
”Naming”



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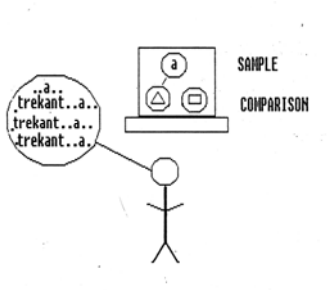
”Names”

> “... names can be said to refer to, represent, stand for, substitute for, specify, and recall classes of arbitrary but conventionally related objects and events. In that sense naming is symbolic behavior”. (Horne & Lowe, 1996, p. 215).

Heterogen mediering



Relational Frame Theory

- I motsetning til både Sidmans (1994) og Horne og Lowes (1996) teorier, som fokuserer på hvordan stimulusklasser dannes, er deriverte stimulusrelasjoner sentralt i Relational Frame Theory (RFT). Med deriverte stimulusrelasjoner menes stimulusrelasjoner som framkommer uten å være direkte trent.
- RFT er et moderne atferdsanalytisk bidrag til forståelse av språk og kognisjon.
- En grunnleggende antagelse innenfor RFT er at det å relatere stimuli til andre stimuli er lært atferd.
- Relasjonell respondering er en type generalisert operant som kommer som et resultat av eksponering for multiple eksemplarer, som innebærer stimulussituasjoner som ligner hverandre uten å være helt like, og der konsekvensene av respondering i nærvær av disse stimulussituasjonene er avhengig av nærvær av andre stimuli.

RFT presentation

Variables that could influence responding in accord with equivalence

- Different protocols
- Different training structures
- Node
- Number of relations trained
- Generalized equivalence classes
- Familiar stimuli
- Some stimuli have shown not be possible to include in a stimulus class.
- Transfer of function/transformation of function

Different protocols:

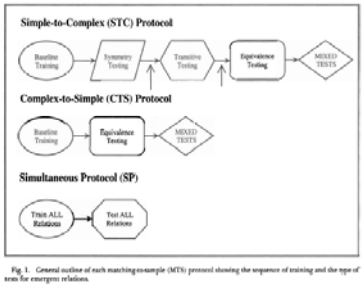
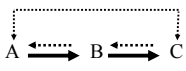


Fig. 1. General outline of each matching-to-sample (MTS) protocol showing the sequence of training and the type of tests for emergent relations.

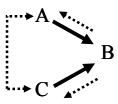
Imam (2006)

Training structures
to test for "equivalence"

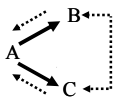
Linear-series



Many-to-one/
Comparison-as-node



One-to-many/
Sample-as-node



Solid arrows indicate trained relations, dashed-line arrows indicate tests for responding in accord, symmetry, transitivity and equivalence.

I en LS treningsstruktur

Typer av trials under trening

Sample	C+	C-	C-	Sample	C+	C-	C-
A1	B1	B2	B3	B1	C1	C2	C3
A1	B1	B3	B2	B1	C1	C3	C2
A2	B2	B1	B3	B2	C2	C1	C3
A2	B2	B3	B1	B2	C2	C3	C1
A3	B3	B1	B2	B3	C3	C1	C2
A3	B3	B2	B1	B3	C3	C2	C1

I en LS treningsstruktur

Typer av testtrials: SYMMETRI

Sample	C+	C-	C-	Sample	C+	C-	C-
B1	A1	A2	A3	C1	B1	B2	B3
B1	A1	A3	A2	C1	B1	B3	B2
B2	A2	A1	A3	C2	B2	B1	B3
B2	A2	A3	A1	C2	B2	B3	B1
B3	A3	A1	A2	C3	B3	B1	B2
B3	A3	A2	A1	C3	B3	B2	B1

I en LS treningsstruktur

Typer av testtrials

	Transitivitet				Ekvivalens		
Sample	C+	C-	C-	Sample	C+	C-	C-
A1	C1	C2	C3	C1	A1	A2	A3
A1	C1	C3	C2	C1	A1	A3	A2
A2	C2	C1	C3	C2	A2	A1	A3
A2	C2	C3	C1	C2	A2	A3	A1
A3	C3	C1	C2	C3	A3	A1	A2
A3	C3	C2	C1	C3	A3	A2	A1

I en MTO treningsstruktur

Typer av trials

Sample	C+	C-	C-	Sample	C+	C-	C-
A1	B1	B2	B3	C1	B1	B2	B3
A1	B1	B3	B2	C1	B1	B3	B2
A2	B2	B1	B3	C2	B2	B1	B3
A2	B2	B3	B1	C2	B2	B3	B1
A3	B3	B1	B2	C3	B3	B1	B2
A3	B3	B2	B1	C3	B3	B2	B1

I en MTO treningsstruktur

Typer av testtrials: SYMMETRI

Sample	C+	C-	C-	Sample	C+	C-	C-
B1	A1	A2	A3	B1	C1	C2	C3
B1	A1	A3	A2	B1	C1	C3	C2
B2	A2	A1	A3	B2	C2	C1	C3
B2	A2	A3	A1	B2	C2	C3	C1
B3	A3	A1	A2	B3	C3	C1	C2
B3	A3	A2	A1	B3	C3	C2	C1

I en MTO treningsstruktur

Typer av testtrials: EKVIVALENS

Sample	C+	C-	C-	Sample	C+	C-	C-
A1	C1	C2	C3	C1	A1	A2	A3
A1	C1	C3	C2	C1	A1	A3	A2
A2	C2	C1	C3	C2	A2	A1	A3
A2	C2	C3	C1	C2	A2	A3	A1
A3	C3	C1	C2	C3	A3	A1	A2
A3	C3	C2	C1	C3	A3	A2	A1

I en OTM treningsstruktur

Typer av trials

Sample	C+	C-	C-	Sample	C+	C-	C-
A1	B1	B2	B3	A1	C1	C2	C3
A1	B1	B3	B2	A1	C1	C3	C2
A2	B2	B1	B3	A2	C2	C1	C3
A2	B2	B3	B1	A2	C2	C3	C1
A3	B3	B1	B2	A3	C3	C1	C2
A3	B3	B2	B1	A3	C3	C2	C1

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I en OTM treningsstruktur

Typer av testtrials: SYMMETRI

Sample	C+	C-	C-	Sample	C+	C-	C-
B1	C1	C2	C3	C1	A1	A2	A3
B1	C1	C3	C2	C1	A1	A3	A2
B2	C2	C1	C3	C2	A2	A1	A3
B2	C2	C3	C1	C2	A2	A3	A1
B3	C3	C1	C2	C3	A3	A1	A2
B3	C3	C2	C1	C3	A3	A2	A1

20.10.2009 EA, AUC

I en OTM treningsstruktur

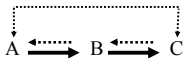
Typer av testtrials: EQUIVALENCE

Sample	C+	C-	C-	Sample	C+	C-	C-
B1	C1	C2	C3	C1	B1	B2	B3
B1	C1	C3	C2	C1	B1	B3	B2
B2	C2	C1	C3	C2	B2	B1	B3
B2	C2	C3	C1	C2	B2	B3	B1
B3	C3	C1	C2	C3	B3	B1	B2
B3	C3	C2	C1	C3	B3	B2	B1

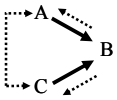
20.10.2009 EA, AUC

Training structures
to test for "equivalence"

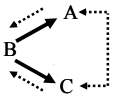
Linear-series



Many-to-one/
Comparison-as-node



One-to-many/
Sample-as-node



Solid arrows indicate trained relations, dashed-line arrows indicate tests for responding in accord, symmetry, transitivity and equivalence.

Various class structures based on nodes

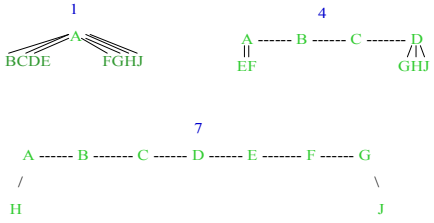


Figure 4. Variations of class structure in a 9-member stimulus class. Members are indicated by the different letters in the spider diagram and the number of nodes are indicated by digits. Adapted from Fields et al (1993b).

No. of classes →

Members	1	2	3	4	5	6
A	Kanin	Katt	Hund	Marsvin	Hest	Høne
B	Rabbit	Cat	Dog	Guinea pig	Horse	Hen
C	Kaninchen	Katze	Hund	Meerschweinchen	Pferd	Huhn
D	Konijn	Kat	Hond			
E	Lapin	Chat	Chien			
F	Coelho	Gato	Cão			

The first study: Training structure

Probability of stimulus equivalence as a function of training design

The Psychological Record, 1997, 47, 309-320

20.10.2009 EA, AUC

The Second study: Familiar stimuli

Stimulus familiarity and the delayed emergence of stimulus equivalence or consistent nonequivalence

The Psychological Record, 1998, 48, 81-110

20.10.2009 EA, AUC

The Third study: Expanding

Probability of stimulus equivalence as a function of class size vs. number of classes

The Psychological Record, 2000, 50, 79-104

20.10.2009 EA, AUC

The fourth study: Training structure

Equivalence outcome in single subjects as a function of training structure

The Psychological Record, 2000, 50, 603-628

An example with a three 3-member training structure.

	A1	A2	A3	B1	B2	B3	C1	C2	C3
A1		B	B	W	B	B	W	B	B
A2	B		B	B	W	B	B	W	B
A3	B	B		B	B	W	B	B	W
B1	W	B	B		B	B	W	B	B
B2	B	W	B	B		B	B	W	B
B3	B	B	W	B	B		B	B	W
C1	W	B	B	W	B	B		B	B
C2	B	W	B	B	W	B	B		B
C3	B	B	W	B	B	W	B	B	

W = Within stimulus class discriminations
B = Between stimulus class discriminations

Equation for calculating number of Grand total discriminations which fits the number in the discrimination analysis of Saunders and Green (1999):

$$\frac{(CXM)^2 - CXM}{2} \qquad \frac{(3X3)^2 - 3X3}{2} = 36$$

C = Class
M= Member

According to the analysis of Saunders and Green (1999), in the MTO training structure all samples (B-stimuli) are successively discriminated and the comparisons (A- and C-stimuli) are simultaneously discriminated, which:
"... establishes all of the simple discriminations required for consistently positive outcomes for the properties of equivalence".
On the other hand, according to Saunders and Green (1999), in the OTM training the subjects need to discriminate successively the samples (B-stimuli) and the A comparison from another, and the C comparison from another. The training contingencies do not require discrimination of each A stimulus from each C stimulus. This will give the subjects:
"... the opportunity to acquire on only a fraction of the simple discriminations that make up the conditional discriminations they will encounter on the tests ... does not prepare subjects very well for tests".

It is not obvious:
- ★ what in the procedures which require within stimulus class discriminations (A1/C1 and A2/C2)?
- ★ why only between stimulus class discriminations (A1/C2 and A2/C1) occur in MTO and not in OTM?

The following equation could be set up for between stimulus class discriminations:

$$\frac{(CXM)^2 - CXM}{2} - CXM \qquad \frac{(3X3)^2 - 3X3}{2} - 3X3 = 27$$

The fifth study: Training structure

Arntzen, E. (2004). Probability of Equivalence Formation: Familiar Stimuli and Training Sequence

The Psychological Record, 54, 275-291

CONCLUSIONS:

1. Rates of equivalence class formation increases when some of the stimuli are "familiar" or readily nameable pictures.

2. Rates of equivalence class formation may increase most when the "familiar" stimuli are introduced in the first task then when introduced later.

3. Reaction times to comparison stimuli are higher initially during tests for emergent relations than during training - which may indicate 'precurrent' behavior as in problem solving before equivalence or non-equivalence 'emerge'.

4. Higher rates of equivalence formation are correlated with lower increases in mean reaction times initially during training, and with lower mean number of training trials to criterion.

It is not clear wether the facilitating effect of "familiar" stimuli on equivalence class formation depends on regular naming or some other kinds of preestablished differential responding to the stimuli.

The sixth study: Delayed matching to sample

Arntzen, E. (2006). Delayed matching to sample and stimulus equivalence: Probability of Responding in Accord with Equivalence as a Function of Different Delays. *The Psychological Record, 56,* 135-168

The seventh study: Training structure and children, youths and adults

Establishing equivalence classes in children, youths and adults with
one-to-many and many-to-one training structures

Erik Arntzen
Akershus University College

Submitted for publication

"A magician pulls rabbits out of hats. An experimental psychologist pulls habits out of rats."

The eight study: Rehearsal

"Rehearsal" in delayed matching to sample and stimulus equivalence

Erik Arntzen[1]
Akershus University College

Submitted for publication

[1] Presented as a paper at the ABA convention in Boston 2004. Please address requests for printouts and other correspondence about this presentation to Erik Arntzen, Akershus University College PO Box 423, 2001 Lillestrøm, Norway. E-Mail: Erik.Arntzen@equivalence.net

The research so far has shown that:

1) Conditional discrimination procedures generate considerably more relations than those relations directly trained (e.g., Sidman, Kirk, & Willson-Morris, 1985).

2) Several researchers have suggested a close relationship between stimulus equivalence and verbal relations (e.g., Barnes, McCullagh, & Keenan, 1990; Catania, 1992; Devany, Hayes, & Nelson, 1986)

a) Responding in accord with equivalence has been shown in language-able subjects, but not in language-disabled subjects (e.g., Barnes, McCullagh, & Keenan, 1990; Devany, Hayes, & Nelson, 1986).

Continues

b) Naming of the stimuli used in stimulus-equivalence experiments results in responding in accord with equivalence during a new test (Eikeseth & Smith, 1992; Dugdale & Lowe, 1990). In spite of the results indicating that naming is neither necessary nor sufficient to produce responding in accord with equivalence (Sidman & Tailby, 1982), there is ample evidence that naming may facilitate responding in accord with equivalence (Lowe & Horne, 1996; Sidman, 1994).

c) Procedures used to produce responding in accord with equivalence are effective in treating language problems (Barnes, McCullagh, & Keenan, 1990).

d) Equivalence relations have been used in explaining the meaning of symbols, categorization, and the generative process of grammar (e.g., Lane, Clow, & Critchfield, 1998; Sidman, 1994).

e) Results from experiments with nonhumans are controversial: researcher have proposed that there has not yet been presented any trustworthy evidence that nonverbal animals can pass tests of stimulus equivalence (e.g., Horne & Lowe, 1996), while other researchers argues that the same data are indicative of the emergence of equivalence classes in nonhumans (e.g., Fields, 1996).

f) Equivalence have shown to be influenced by the familiarity of stimuli (e.g., Arntzen & Holth, 2000; Holth & Arntzen, 1998; Mandell & Sheen, 1994)

3) Stimulus equivalence could be of theoretical importance for determining the behavioral unit of analysis, i.e., expanding from three-term contingencies to four- and five-term contingencies (Sidman, 1986).

4) Many-to-one is superior to one-to-many in producing positive equivalence outcome (Barnes 1992 as cited in Barnes, 1994; Saunders, Saunders, Williams, & Spradlin, 1993; Saunders, Wachter, & Spradlin, 1988; Spradlin & Saunders, 1986) in to contrast to studies of Arntzen & Holth (1997, 2000)

5) A predicted is made that there is an inverse relation between number of nodes and measures of response strength (accuracy and speed), and that the number of nodes may differentially effect the order in which derived relations come to exert stimulus control (Fields, Verhave, & Fath, 1984). Fields and coworkers have shown that class formation is influenced by the training protocols (e.g., Adams, Fields, & Verhave, 1993b; Fields, Reeve, Adams, & Verhave, 1991), the structure of the class as governed by the relations trained as the prerequisites for the classes (e.g., Fields, Landon-Jimenez, Buffington, & Adams, 1995), the familiarity of stimuli that are members of the potential classes (e.g., Buffington, Fields, & Adams, 1997), and the nodal structure of the class (e.g., Buffington, Fields, & Adams, 1997; Fields, Adams, & Verhave, 1993a; Fields, Adams, & Verhave, 1993b; Fields, Reeve, Rosen et al., 1997). Finally, the likelihood of forming new equivalence classes is a direct function of the size and number of nodes in previously established equivalence classes (Buffington, Fields, & Adams, 1997; Fields, Hobbie, Adams, & Reeve, 1999). The current experiments have extended these findings, showing that the emergence of stimulus equivalence was more disturbed by number of nodes than both class size and number of stimulus classes. The results indicate that an increasing number of nodes, and not just increasing class size, inhibits an equivalence outcome to a greater extent than does an expanding number of classes (Arntzen & Holth, 2000).

20.10.2009 EA, AUC

Praktiske råd: Den mest effektive måten å fremme stimulusekvivalens på er å:

1. benytte en one-to-many procedure.
2. bruke bilder som node.
3. anvende en simple-to-complex trening- og testprotokoll.
4. sette oop forsøket muligens med 2 s delayed matching.

20.10.2009 EA, AUC