Sidman’s Theory of Stimulus Equivalence: Current Status and Future Directions

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Progress in the inductive sciences

• Theoretical progress
  • A sufficient amount of data (leads to)
  • A conceptual organization based on broad orderly patterns (leading to)
  • Novel predictions and programs of research.

• Good theories
  • Specify their domains precisely
  • Create the conditions for their modification and development.
Goals and outline

• Section 1: Sidman’s thinking about Stimulus Equivalence
  Sidman 1986; 1994; 2000

• Section 2: Evaluation of the supporting and discrepant empirical evidence
  Sidman’s (2000) Theory

• Section 3: Some implications
Stimulus Equivalence

• Refers to the observation that training a few overlapping conditional discriminations gives rise to a number of other conditional discriminations without instruction or reinforcement
  • Directly training  $A \rightarrow B; B \rightarrow C$
  • Results in  $A-A, B-B, C-C, B-A, C-B, A-C, C-A$

• Emergent conditional discriminations are described as reflexivity, symmetry, transitivity, and equivalence.
### Detailed Description of Training and Testing

<table>
<thead>
<tr>
<th>Trained Relations</th>
<th>Symmetry Tests</th>
<th>Transitivity and Equivalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>A2 – B2 B1 B3</td>
<td>B2 – A2 A1 A3</td>
<td>A2 – C2 C1 C3</td>
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<td>A3 – B3 B1 B2</td>
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* Reflexivity tests not shown
The origins of equivalence relations

- The tests documented the complete substitutability of within-class stimuli in the context of conditional discrimination procedures.
- Sidman (1986)
  - Suggested that equivalence grew out of four-term contingencies of reinforcement
  - “Just as adding a third term to the analytic unit makes conditioned reinforcement possible, adding a fourth term also generates a new process” (1994, p. 338-339)
  - Equivalence was said to emerge as a by-product of the stimulus-stimulus relations established in 4-term contingencies of reinforcement
Some discrepant data

• The equivalence relation could include the reinforcing stimulus as well as the conditional and discriminative stimuli
  • Dube, McIlvane, Mackay, & Stoddard, 1987
  • Dube, McIlvane, Maguire, Mackay, & Stoddard, 1989
  • Dube, Rocco, & McIlvane, 1989
  • McIlvane, Dube, Kledaras, deRose, & Stoddard, 1992
- Two developmentally delayed subjects (14 & 20 years; 3.8 & 4.1 age-equivalent scores on PPVT)
Both subjects’ choices on the first set of probes indicated the development of equivalence [ABC].

Subjects’ choices on the second set of probes indicated that the D stimuli were also class members.

Common reinforcers led to the addition of the D stimuli to the existing class.
Schenk (1994, Exp. 2)

- 8 preschool children (mean age 5.5 years)
- Subjects trained on 8 identity matching trials with class specific reinforcers
  - A1 – A1 – rfp1 – rfp1
  - B1 – B1 – rfp1 – rfp1
  - C1 – C1 – rfp1 – rfp1
  - D1 – D1 – rfp1 – rfp1
  - A2 – A2 – rfp1 – rfp2
  - B2 – B2 – rfp1 – rfp2
  - C2 – C2 – rfp1 – rfp2
  - D2 – D2 – rfp1 – rfp2
- No history of arbitrary matching (i.e., A-B) was established
Schenk (1994, Exp. 2)

<table>
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<tr>
<th>S</th>
<th>AB</th>
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For six of the eight children, identity matching with class-consistent reinforcers was sufficient to produce equivalence.
Some more discrepant data

- Three term contingencies were found to be sufficient to establish the pre-requisites for equivalence relations
  - Barnes & Keenan, 1993
  - deRose, McIlvane, Dube, Galpin, & Stoddard, 1988
  - deRose, McIlvane, Dube, & Stoddard, 1988
  - Vaughn, 1988
  - Hayes, Devany, Kohlenberg, Brownstein, & Shelby, 1987
• Will exposure to three-term contingencies with common responses and reinforcers be sufficient to produce equivalence relations among stimuli?

• Tasks:
  • Directly trained simple successive discriminations
  • Probes for derived conditional discriminations in extinction.

• 9 simple discrimination trials alternated with 18 conditional discrimination trials (15 times per session).
Trained Relations

Set 1
(A, B, C)

Set 2
(A, B, C)

Set 3
(A, B, C)

Tested Relations

A1
A2
A3

B1
B2
B3

C1
C2
C3
### Training performance by position

![Training performance chart](chart1.png)

### Test performance by position (1st 3 columns) and by stimulus selection (4th column)

![Test performance chart](chart2.png)

#### Session 1

- Blocks 1-12

#### Session 2

- Blocks 13-24

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**Set 1 - go left**

**Set 2 - go middle**

**Set 3 - go right**
Correlations between Training and Test Performances

Set 1 - go left
Set 2 - go middle
Set 3 - go right

% allocation for all sample stimuli from the set

Training (position) - solid line
Test (position) - dashed line
Test (stimulus set) - dotted line

sets of 3 blocks
Vaidya & Eilifsen

• Will exposure to three-term contingencies with common vocal responses be sufficient to produce equivalence relations among stimuli?

• Tasks:
  • Directly trained successive discriminations involving vocalizations
  • Probes for derived conditional discriminations in extinction.

• 9 simple discrimination trials alternated with 18 conditional discrimination trials (15 times per session).
The origins of equivalence relations

- Sidman (1994, 2000)
  - Presents a considerably expanded view of equivalence and a simple theory about the origins of equivalence relations
  - “The notion is that a reinforcement contingency produces at least two types of outcome: analytic units and equivalence relations” (2000, p. 128)
  - “These [equivalence relations] consist of ordered pairs of all positive elements that participate in the contingency” (2000, p. 128)
The origins of equivalence relations

- The expanded formulation of equivalence removes the constraints of Sidman’s (1986) account
  
  - “The theory that the reinforcement contingency generates the equivalence relation places no lower limit on the complexity of the contingency” (Sidman, 2000, p. 137).
  
  - “…when two or more discriminative stimuli control the same two-term contingency (the same defined response and reinforcer), those stimuli can be shown to be related via equivalence. That is to say, three-term contingencies can establish the prerequisites for an equivalence relation” (emphasis in original, Sidman, 1994, p. 375).
Sidman’s theory of equivalence

- Sidman (2000)
  - “The notion is that a reinforcement contingency produces at least two types of outcome: analytic units and equivalence relations” (p. 128).
  - **Analytic units:**
    - 2-term: Operant Reinforcement; Operant Punishment
    - 3-term: Simple Discriminations; Conditioned Reinforcement
    - 4-term: Conditional Discriminations; etc.
  - **Equivalence relations:**
    - Ordered pairs of all positive elements participating in the contingency
Sidman’s theory of equivalence

• Sidman (2000)
  • “These [equivalence relations] consist of ordered pairs of all positive elements that participate in the contingency” (p. 128).

A1 -- B1 -- rsp1 -- rft
B2 -- rspx -- no reinforcement

(A1,A1); (B1,B1); (rsp1, rsp1); (rft1,rft1); (A1,B1); (B1,A1); (A1,rsp1);
(rsp1,A1); (A1,rft1); (rft1,A1); (B1,rsp1); (rsp1,B1); (B1,rft1);
(rft1,B1); (rsp1,rft1); (rft1,rsp1)
Sidman’s theory of equivalence

\[
\begin{align*}
A1 & \rightarrow B1 \rightarrow \text{rsp1} \rightarrow \text{rft1} \\
B2 & \rightarrow \text{rpx} \rightarrow \text{no reinforcement} \\
B1 & \rightarrow C1 \rightarrow \text{rsp1} \rightarrow \text{rft1} \\
C2 & \rightarrow \text{rpx} \rightarrow \text{no reinforcement}
\end{align*}
\]

\[
(A1, A1); (B1, B1); (\text{rsp1}, \text{rsp1}); (\text{rft1}, \text{rft1}); (A1, B1); (B1, A1); (A1, \text{rsp1}); (\text{rsp1}, A1); (A1, \text{rft1}); (\text{rft1}, A1); (B1, \text{rsp1}); (\text{rsp1}, B1); (B1, \text{rft1}); (\text{rft1}, B1); (\text{rft1}, \text{rft1}); (\text{rft1}, \text{rsp1})
\]

\[
(C1, C1); (B1, C1); (C1, B1); (A1, C1); (C1, A1); (C1, \text{rsp1}); (\text{rsp1}, C1); (C1, \text{rft1}); (\text{rft1}, C1);
\]
Sidman’s theory of equivalence

- Sidman (2000)

  A1 -- B1 -- rsp1 – rft1
  B2 – rsp2/rspx – no reinforcement
  A2 -- B2 – rsp2 – rft2
  B1 – rsp1/rspx – no reinforcement

  (A1,A1); (B1,B1); (rsp1, rsp1); (rft1,rft1);
  (A1, rsp1); (rsp1, A1); (A1, rft1); (rft1, A1);
  (B1, rsp1); (rsp1, B1); (B1, rft1); (rft1, B1);
  (rsp1, rft1); (rft1, rsp1);
  (A1, B1); (B1, A1);

  (A2,A2); (B2,B2); (rsp2, rsp2); (rft2,rft2);
  (A2, rsp2); (rsp2, A2); (A2, rft2); (rft2, A2);
  (B2, rsp2); (rsp2, B2); (B2, rft2); (rft2, B2);
  (rsp2, rft2); (rft2, rsp2);
  (A2, B2); (B2, A2);
Sidman’s theory of equivalence

- If two contingencies contain a common element then all elements of the contingencies become equivalent

\[ A_1 \rightarrow B_1 \rightarrow \text{rsp1} \rightarrow \text{rft1} \]
\[ A_2 \rightarrow B_2 \rightarrow \text{rsp1} \rightarrow \text{rft1} \]

\[(A_1,A_1); (B_1,B_1); (\text{rsp1}, \text{rsp1}); (\text{rft1}, \text{rft1}); (A_1,B_1); (B_1,A_1); (A_1,\text{rsp1}); (\text{rft1},A_1); (A_1,B_1); (B_1,B_1); (A_1,\text{rft1}); (\text{rft1},A_1); (B_1,\text{rft1}); (\text{rft1},B_1); (\text{rft1},\text{rft1}); (\text{rft1},\text{rft1});
\]
\[(A_2,A_2); (B_2,B_2); (A_2,B_2); (B_2,A_2); (A_2,\text{rsp1}); (\text{rft1},A_2); (A_2,\text{rft1}); (\text{rft1},A_2); (B_2,\text{rsp1});
\]
\[(\text{rsp1},B_2); (B_2,\text{rft1}); (\text{rft1},B_2);
\]
\[(A_1,B_2); (B_2,A_1); (A_2,B_1); (B_1,\text{A2});\]
Sidman’s theory of equivalence

A1 \rightarrow B1 \rightarrow \text{rsp1} \rightarrow \text{rft1}
A2 \rightarrow B2 \rightarrow \text{rsp1} \rightarrow \text{rft1}

• Since contingencies like this are typically effective, the theory requires that the common elements must selectively drop out of the equivalence relation.
Sidman (1994, 2000) - summarized

- Reinforcement contingencies produce analytic units and equivalence relations

- All positive elements of a contingency enter into equivalence relations

- Common elements that conflict with the development of analytic units drop out of the equivalence relation
Summing up …

- Sidman’s theory appears to organize a number of empirical observations from laboratory preparations
  - Reinforcers are included in the equivalence relation
    - Dube & McIlvane (1995); Dube, McIlvane, Mackay, & Stoddard (1987); Dube, McIlvane, Maguire, Mackay, & Stoddard (1989); Goyos (2000); Schenk (1994)
  - Three-term contingencies are sufficient in producing the pre-requisites of equivalence relations
    - Barnes & Keenan (1993); deRose, McIlvane, Dube, Galpin, & Stoddard (1988); Sidman, Wynne, Maguire, & Barnes (1989); Vaughn, 1988
    - Studies by McAllister, Maciver, Elifsen in our lab at UNT.
Summing up …

- Sidman’s theory also makes a number of specific predictions
  
  - Common elements should drop out of the equivalence relation
  - Acquisition and maintenance of performances should be unaffected by training structures
  - Nodal distance effects should not be a systematic feature
  - There should be an interaction between the development of analytic units and equivalence relations
Do common elements drop out of the equivalence relation?

• The provision that all positive elements of a contingency become equivalent predicts that contingencies with common elements should be ineffective in organizing behavior.

• Since contingencies are effective, the theory requires that the common elements must selectively drop out of the equivalence relation.
Minster, Jones, Elliffe, & Muthukumarswamy (2006)
Minster, Jones, Elliffe, & Muthukumaraswamy (2006)
Do common elements drop out of the equivalence relation?

- Minster ‘s et al. (2006) data suggest that the answer is no – subjects’ choices indicated that R3 remained a part of both Set 3 and Set 4 equivalence classes.

- Minster et al. (2006) also found that baseline responding was not disrupted.

  - This study needs to be replicated.
  - A response was required on every trial and that requirement may have produced a different set of controlling variables on the trials in which reinforcer inclusion was assayed.
Training structures

- Research by R. Saunders and colleagues and Erik Arntzen and Per Holth has suggested that different baseline training structures (OTM, MTO, and LS) are differentially effective in establishing equivalence relations.

- There are, however, a couple of instances (one within-subjects comparison in our lab), in which researchers have failed to find any influence of training structure on the likelihood of equivalence.

- These findings, then, need to be followed up.
Nodal distance

• Sidman’s theory does not predict any effects of nodal distance on accuracy or any other dimensions of the subject’s responses.

• Early research by Fields and colleagues, however, suggested that accuracy and speed of responding were inversely related to the nodal distance established during training.

• Recent work by Imam (2001, 2003, 2006), however, suggests that the observed nodal distance effects may derive from unequal histories of reinforcement inadvertently arranged in certain training procedures (like LS).

• Continued research in this area is needed to test the theory’s predictions.
Interactions b/w analytic units and equivalence relations
Vaidya & Brackney (2014)

Part 1
Successive discrimination training
Measured acquisition

Part 2
Document 2, 3-member equivalence classes

Part 3
Successive discrimination training within and across equivalence classes.
Measured acquisition

Asked whether equivalence-class membership conferred any advantage in the acquisition of simple discriminations

2 adult human participants

Part 1 measured the development of simple discriminations

Part 2 trained the pre-requisites for 2 sets of 3, 3-member equivalence classes and documented them via tests

Part 3 compared the development of simple discriminations with stimuli within and across equivalence classes.
Vaidya & Brackney (2014)

<table>
<thead>
<tr>
<th>Set 1</th>
<th>Part 1</th>
<th>Part 2</th>
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<tbody>
<tr>
<td></td>
<td>A1 B1 C1</td>
<td>A1---B1---C1</td>
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<td>A2 B2 C2</td>
<td>A2---B2---C2</td>
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<td>A3 B3 C3</td>
<td>A3---B3---C3</td>
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<td>Set 2</td>
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<td>A5---B5---C5</td>
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<td>A6 B6 C6</td>
<td>A6---B6---C6</td>
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Graphs showing responses over trial blocks for Part 1 and Part 2.
Conclusions

• Sidman’s theory also appears to be able to handle a great deal of the nonhuman data on stimulus class formation
  • Urciolli (2008)
  • Wasserman (2005)
  • Wasserman, Devolder, & Coppage (19xx)
  • Zentall’s work on common sample and comparison coding
Conclusions

• In the inductive sciences, the utility of a theory derives from its ability to drive research.

• New questions and new preparations allow for novel interactions with the subject matter which are useful in identifying the limits of the phenomena and its particular character.

• By that standard, Sidman’s theory already has been immensely successful.