Translational Research on Token Reinforcement: Contiguity, Continuity, and Contingency

Iser G. DeLeon, PhD, BCBA-D
"I am not sure we need more preference assessment research...we are already very good at it"

Gary Pace, Ph.D.
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Gary Pace, Ph.D.
We are done.

Do we need more preference assessment research?
What’s Left to Do?

• Have we nailed it?
  – Development of methods
  – Matching methods to purpose & circumstance
  – Preference stability and its determinants
  – Effects of motivational operations

• Are we getting close?
  – Do we really need a hierarchy?
  – Verbal and pictorial preference assessments
  – Assessments that match real reinforcement parameters
  – Preference for learning arrangements

• Where’s the data?
  – Establishing stimuli as reinforcers and transferring control
  – Overjustification
  – But...does it enhance learning?
  – Determinants of reinforcer effectiveness & change
# Reinforcer Selection and Ecological Fit

**Table 2. Categories of Stimuli Most Frequently Delivered, by Certification Status**

<table>
<thead>
<tr>
<th>Category of Item Used</th>
<th>Percentage of All Responses</th>
<th>Percentage of Responses: BCBA/BCaBA</th>
<th>Percentage of Responses: Non-BCBA/BCaBA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social praise/attention (tickles, high-fives, etc.)</td>
<td>91.5</td>
<td>94.4</td>
<td>90.0</td>
</tr>
<tr>
<td>Tokens/Points</td>
<td>65.6</td>
<td>81.3</td>
<td>57.6</td>
</tr>
<tr>
<td>Breaks from work</td>
<td>65.0</td>
<td>77.6</td>
<td>58.6</td>
</tr>
<tr>
<td>Edibles</td>
<td>50.2</td>
<td>69.2</td>
<td>40.5</td>
</tr>
<tr>
<td>Toys</td>
<td>49.0</td>
<td>71.0</td>
<td>37.6</td>
</tr>
<tr>
<td>Independent free play</td>
<td>49.0</td>
<td>59.8</td>
<td>43.3</td>
</tr>
<tr>
<td>Access to physical activities (e.g., running, sports, playground)</td>
<td>37.5</td>
<td>42.1</td>
<td>35.6</td>
</tr>
<tr>
<td>Sensory items (e.g., theraband, theraputty, muscle massager, fan)</td>
<td>33.8</td>
<td>43.0</td>
<td>29.0</td>
</tr>
<tr>
<td>Community-based activities</td>
<td>19.2</td>
<td>21.5</td>
<td>18.1</td>
</tr>
</tbody>
</table>

Graff & Karsten, 2012, Behavior Analysis in Practice
Reinforcer Selection Flowchart

Evaluate social consequences as reinforcers

- Effective
  - Try establishing social reinforcers
    - Effective
      - Evaluate under more stringent conditions (e.g., intermittency)
        - Effective
          - Use social reinforcers
        - Ineffective
          - Ineffective
          - Ineffective
    - Ineffective
      - Ineffective
      - Ineffective

Determine preferred non-edible tangible items

- Effective
  - Evaluate under more stringent conditions
    - Effective
      - Evaluate tangible with token system
        - Effective
          - Use token system
        - Ineffective
          - Use distributed tangible
    - Ineffective
      - Ineffective
      - Ineffective

Determine preferred edible reinforcers

- Effective
  - Evaluate under more stringent conditions
    - Effective
      - Evaluate edible with token system
        - Effective
          - Use token system
        - Ineffective
          - Use distributed edible
    - Ineffective
      - Ineffective
      - Ineffective

Translational Research in BA

- Basic Research
- “Borrowed” Concepts
- “Found” Concepts

Demonstrate Generality in Clinical Population

Practical Implications & Utility

- Failures to Translate
- Partial Outcomes
- Procedural differences?

- Questions Raised in Application
- Use-Inspired Basic Research

Questions Raised in Application

Use-Inspired Basic Research
Contiguity

Delay to reinforcement: The temporal distance between response completion and the delivery of the reinforcer

- How do delays to reinforcer delivery impact the effectiveness of reinforcers in applied settings?

- Does the effect of delays differ for tokens vs. other sort of reinforcers?
Q: How often do teachers deliver reinforcers immediately following a correct response?

Descriptive assessment of integrity errors

- Observed 168 teaching trials
- Across 5 children with ASD attending EIBI clinics
- 9 teachers or paraprofessionals delivering instruction

Consequence delivered within 5-s of a correct response

Q: How do reinforcer delays impact reinforcer effectiveness during skill acquisition?

Effects of Reinforcer Delay on Acquisition

◆ Immediate SR+ (both praise and preferred item)

△ Immediate Praise; Delayed SR+ (10-s delay to preferred item)

□ Delayed SR+ (10-s delay to both praise and preferred item)

Result: Delays result in less rapid acquisition

Carroll, Kodak, & Adolf (2016) Journal of Applied Behavior Analysis
Q: How much delay is tolerable before detrimental effects are observed in acquisition?

- Parametric analysis of effects of delay to acquisition
- 3 children with ASD (2 shown)
- Discrete trials for mand acquisition
- Preferred edible + praise for correct responding with:
  - 0-second delay
  - 6-second delay
  - 12-second delay

Delay Discounting

- Delay discounting – the subjective value of money declines less steeply across delays than the subjective value of alcohol and food

![Temporal discounting functions for money, alcohol, and food. Points show median indifference points as a function of delay. Lines show best-fitting discount functions generated by the hyperbolic model (Eq. (1), see text).](image)

![Mean area under the curve for money, alcohol, and food. Vertical lines indicate one standard error above and below means. The means of conditions marked with the letter ‘a’ are significantly different from the means of conditions marked with the letter ‘b’; the means of conditions marked with the letter ‘b’ are not significantly different from each other.](image)

Odum & Rainaud (2003) Behavioral Processes
Q: Do reinforcer delays impact token reinforcers in a way that differs from other reinforcers?

- Children with ASD completing simple free-operant responses (max of 30)
- Increasing delays to reinforcement across phases
- Three reinforcement conditions:
  - Delayed food
  - Delayed token - exchangeable after session for the primary reinforcer
  - Delayed exchange - Immediate token with delayed exchange for the primary reinforcer (2 participants)
- Delays continue to increase until performance deteriorates relative to no-delay condition
Q: How do delays impact the effectiveness of primary reinforcers vs tokens?

- Token reinforcers lose their effectiveness at shorter delays
- But...
  - Not generalized tokens
  - Does the type of terminal reinforcer matter?
Continuity

• **Reinforcer accumulation:**
  “...reinforcers need not be consumed following each completion of a schedule requirement but rather can be accumulated, then collected and consumed later.”
  
  *McFarland & Lattal (2001) JEAB*

• We want kids to accumulate reinforcers
  – Does not interrupt ongoing behavior
  – Minimizes “handling costs”

• Usually involves a token system, thus an *inherent delay*
What promotes accumulation?

“Travel Costs”

- Rats pressing levers for food in an 8-foot long operant chamber
- Each lever press resulted in one food pellet delivered into a food cup
- Across conditions, the distance from the response lever to the food cup was manipulated, distances of 20 - 240 cm.
- The number of lever presses before collection increased monotonically with distance

Killeen (1974), The Psychological Record
What promotes accumulation?

Interest for savings?

Mendres, Borrero, Bullock, & DeLeon (unpublished manuscript)
What promotes accumulation?

Does the type of reinforcer matter?

“...unlike primary reinforcers, the reinforcing effectiveness of video depends at least partly on its continuity through time.”

*Hackenberg & Pietras (2000) EAHB Bulletin*
"Continuity?"

GB = Game Boy
CD = Compact Disc

Steinhilber & Johnson (2007), Journal of Applied Behavior Analysis
Continuity & Stimulus Value

Q: Is delayed accumulated reinforcement, mediated through tokens, just as effective as immediate reinforcement in supporting responding?

ABAB Reinforcer Assessment

• A = no reinforcement BL
• B = Multielement comparison of accumulated vs distributed reinforcement conditions

Measure: Rates of simple free-operant responses
Distributed Reinforcement

10 task completions and 10 reinforcers earned (30 s each) = 300 s total

Access is immediate for each response requirement, but interrupted
Accumulated Reinforcement

10 task completions and 10 reinforcers earned (30 s each) = 300 s total

Access is delayed until all work completed, but continuous
Continuity & Stimulus Value: Efficacy

DeLeon, Chase, Frank-Crawford et al. (2014), Journal of Applied Behavior Analysis
The highest mean rates of responding were observed in the accumulated reinforcement conditions for all participants. May be added value in arranging accumulated reinforcement? “Handling Costs”?

<table>
<thead>
<tr>
<th>Condition</th>
<th>Evan</th>
<th>Alice</th>
<th>Jillian</th>
<th>Sam</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>0.04</td>
<td>0.00</td>
<td>1.49</td>
<td>N/A</td>
</tr>
<tr>
<td>Distributed</td>
<td>0.84</td>
<td>0.73</td>
<td>1.37</td>
<td>N/A</td>
</tr>
<tr>
<td>Accumulated</td>
<td>1.27</td>
<td>1.56</td>
<td>1.83</td>
<td>N/A</td>
</tr>
</tbody>
</table>

DeLeon, Chase, Frank-Crawford et al. (2014), Journal of Applied Behavior Analysis
Continuity & Stimulus Value: Preference

Q: Does the delay inherent in accumulated reinforcement render it less preferred than distributed reinforcement? Does the kind of reinforcer matter?

Concurrent-chain reinforcer assessment
• Initial link – choose accumulated or distributed

“Choose one.”

• Terminal link – complete 10 tasks under chosen arrangement
• 5 choice trials per session

Measure
• Cumulative choices
• Food and non-food conditions
DeLeon, Chase, Frank-Crawford et al. (2014), Journal of Applied Behavior Analysis
DeLeon, Chase, Frank-Crawford et al. (2014), Journal of Applied Behavior Analysis
Continuity & Value Interim Summary

• Accumulated reinforcement seems preferred by learners with IDD despite the inherent delay

• Accumulated reinforcement mediated by tokens supports higher rates of free-operant responding despite the inherent delay

• But…
  – Is response rate really the most relevant measure?
  – Is “amount” of behavior supported by the stimulus more relevant?
Q: Is demand for delayed, accumulated access more or less elastic as an equal amount of immediate, but distributed access?

2 Concurrent-schedule demand curves

First series:
- Test stimulus: Increasing FR across Phases (FR1, FR2, FR5, FR10, FR20, etc.)
- Second stimulus, constant FR1

Second series:
- Token later exchangeable for test stimulus: Increasing FR across Phases (FR1, FR2, FR5, FR10, FR20, etc.)
- Second stimulus, constant FR1
- 30s of Activity A = constant FR1 or
- Token exchangeable for 30s of Activity B = increasing price

Bullock, DeLeon, Chastain, & Frank-Crawford, in preparation
Bullock, DeLeon, Chastain, & Frank-Crawford, in preparation
Contingency

The relation between the amount of work required to earn a reinforcer and the subsequent value of that reinforcer

- How does simply arranging a response-reinforcer contingency influence subsequent “value”
- How does the amount of work required to earn a reinforcer influence subsequent value
- Not: The Law of Least Effort
Contingency: Cost and Subsequent Value

- **Possibility 1**
  - Stimuli historically associated with greater effort, by virtue of being paired with an aversive event (i.e. greater effort), lose value over time and experience
  - A negative relation between “how much one has to work” for a reinforcer and how it is subsequently valued

- **Possibility 2**
  - Stimuli historically associated with greater effort, once current effort is equated, are “on sale.”
  - A positive relation between “how much one has to work” for a reinforcer and how it is subsequently valued
Contingency: Cost and Subsequent Value

“..such are the Tempers and dispossessions of Seamen in general that **whatever you give them out of the common way**, altho it be ever so much for their good yet it will not go down with them and you will hear nothing but murmurrings gainest the man that first invented it; **but the Moment they see their superiors set a Value upon it**, it becomes the finest stuff in the World and the inventor an honest fellow.”

Captain James Cook, *Diaries*, 1769

"The harder the conflict, the more glorious the triumph. What we obtain too cheap, we esteem too lightly."

Thomas Paine, *The Crisis*, 1776

“The more you suffer, the more it shows you really care.”

The Offspring, *Self-Esteem*, 1995
Fig. 1. Experimental design and behavioral results. (A) Time course for a typical trial. (B) Reported pleasantness and intensity rating scales. (C) Reported pleasantness for the wines during the cued price trials. (D) Taste intensity ratings for the wines during the cued price trials. (E) Reported pleasantness for the wines obtained during a postexperimental session without price cues.
Contingency: Cost and Subsequent Value

- Clement et al. (2000)
  - Pigeons exposed to chain schedules
  - Training: Two types of trials

Q: Does the amount of work required to earn a reinforcer alter the value of that reinforcer?

- Children with ASD (n = 8)

- Pre-test:
  - Preference assessment
  - Progressive-ratio schedule for 4 moderately preferred items

- Middle 4 items assigned to one condition for 4 weeks:
  - FR1 delivery for academic tasks
  - Escalating (FR1 → FR10) delivery for academic tasks
  - Yoked noncontingent delivery
  - Restricted

- Post-test: Preference assessment and PR schedule analysis
Contingency: Cost and Subsequent Value

- Earned reinforcers retained their value to a greater extent than free reinforcers.
- Are interventions that involve contingent reinforcers more durable than interventions that involve noncontingent reinforcers?
- Is the loss of earned reinforcers more potent than the loss of free reinforcers?

Contingency: Cost and Subsequent Value

Q: If effort is positively correlated with subsequent value, is it more aversive to lose reinforcers that require greater effort to earn?

• College students (n=28)

• Token Accumulation
  – Contingent delivery (CD) group (n = 14):
    • Completes task to earn 20 tokens, later exchanged for $
  – Noncontingent deliver (NCD) group (n = 14)
    • 20 tokens delivered freely on schedule yoked to earner

• Test of sensitivity to loss
Do you see PTLE less than 3 times in the list? If so, press 'P'

You have EARNED a token! You now have a total of 1 token.

When you are ready, press the SPACE BAR to continue.
Free Group

Miller, DeLeon, Toole, Lieving, & Allman (2016), The Psychological Record
Contingency: Cost and Subsequent Value

Test of Sensitivity to Loss

• Variation of the “Miami Door-Opening Task” (Daugherty & Quay, 1991)
• 2 responses:
  – Response “D”: Open the chest – produces either:
    • Another token
    • Loss of one token; ratio of gains to losses decreases across blocks of 10 trials
  – Response “K”: Cash out
• Primary D.V.: How many D responses before cashing out?
Press 'D' to open the chest. Press 'K' to end your session and cash out your tokens!

You can now receive more tokens by opening the chest. Each time that you open it, there is a chance to GAIN or LOSE a token.

You have GAINED a token!

When you are ready, press the SPACE BAR to continue.
Fig. 1  Number of trials gambled (left panel) and net tokens (right panel) for contingent delivery (CD) and noncontingent delivery (NCD) participants in Phase 2. Each circle represents a value for one participant; the bars represent the group mean.
Contingency: Cost and Subsequent Value

• Earners were more sensitive to token loss

• Same effects obtained across all manipulations of effort and value – a robust effect
  – Differences in token value
  – Differences in level of effort

• Sensitivity in college students; less in children with IDD?
  – Discrepancy related to earned vs. lost reinforcers?
  – Effects dependent on ability to form rules?
Final Comments

• Token reinforcement systems are ubiquitous in applied settings, especially for kids with IDD

• We know less about tokens systems than we think we do

• “Value” is not an inherent property of the stimulus, it depends critically on context.
Group Demand Curve

Proportion of Participants that Completed the Schedule

Price (Schedule Value)

Goldberg, Allman, Hagopian, Triggs, Frank-Crawford, Mostofsky, Denckla, & DeLeon (2016), Autism
Goldberg, Allman, Hagopian, Triggs, Frank-Crawford, Mostofsky, Denckla, & DeLeon (2016), Autism

**Group Demand Curve**

![Graph showing the demand curve for videogames with two curves: Solitary Play (squares) and Activity Embedded in Social Context (circles).](image-url)