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Vocal Training Procedures: A review of behavioral research

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Speech training
Where to start?

① **Establish preference**
For people
For voices

② **Train Verbal Skills**
(discriminated vocalizations)
Mand
Tact
Echoic
Intraverbal

Increase vocalizations
Frequency
Variability
Loudness (dB)

3

Pre-speech learners
Few vocalizations
No VB

◇ Need more vocals to work with

Early speech learners
Weak echoics
Weak vocal mands

◇ Reinforce current form as mand
◇ Improve form through echoic

Speakers
Speech under VB control
But articulation is unclear

◇ Improve form through echoic

Overview

- Shaping

(e.g., Lovaas et al., 1973; Sloane et al., 1968)

Have to wait for vocal responses to be emitted

Slow

- Time delay

(e.g., Charlop et al., 1985; Ingenmey & Van Houten, 1991; Matson et al., 1994)

- Echoic modeling & mand training

(e.g., Drash et al., 1999; Williams & Greer, 1993; see also Functional Communication Training)

Vocal responses have to be under echoic stimulus control

Echoic SC is often absent

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Overview

Focus of today's review

1. Stimulus-stimulus pairing **SSP**
2. Vocal variability training **VV**
3. Rapid motor imitation antecedent procedure **RMIA**

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How we speak

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Image

7

8

Video

8

9

MUSCLE MOVEMENT

Speech sounds produced

Observes sound

It sounds “right”

Reinforcing value of those speech sounds increases

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Stimulus-stimulus pairing (SSP)

Purpose

Increase vocalizations

(so these can then come under VB contingencies as mands, tacts, intraverbals, echoics, and others)

Indicators

Few vocalizations or little variation in vocalizations

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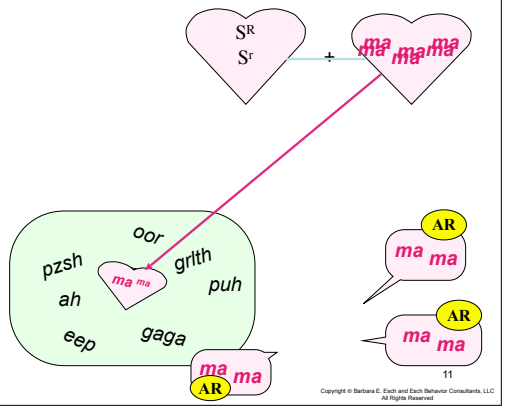
Stimulus Stimulus Pairing Procedure



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SSP

Rationale

- "…a two-stage conditioning history is necessary…" (Sundberg et al., 1996, p. 22)

1. Pair a (neutral) stimulus with an existing reinforcer (either conditioned or unconditioned). As a result, the previous 'N' stimulus acquires reinforcing value. (Birnbrauer, 1971; Haines, 1977; Steinman, 1968)
2. Any response that produces a stimulus that resembles the (previously paired/neutral) stimulus will be automatically reinforced. (Skinner, 1957; Vaughan & Michael, 1982)

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SSP

Procedure

- Pair a preferred stimulus with one that is less preferred (or the value is unknown)
- No response required

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Video

14

15

Video

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Vocalization Baseline

Not enough vocalizing overall

Rx training:
- SSP (pairing)
- Vocal variability
- Alternative comm mode

					mmmm~~				
		/a/							
					/a/				mmmm~~
	/ʌ/				/u/				
			mmmm~~						
							/ʌ/		

Vocalizations occurred in 8/60 intervals

Vocalization Baseline = 13%

Vowels	Frequency

Consonants	Frequency

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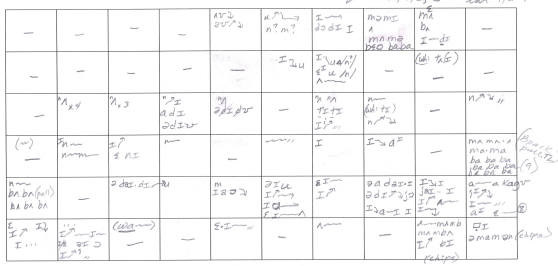
30 min free operant vocal play interval recording

Name _____

Record all speech vocalizations in each 30-sec cell
Mark + for each separate speech vocalization OR transcribe each phonetically

Vow: Easy/default: I, a, ʌ Cns: m, b
less freq: u, o/ɔ, ɛ dan t/d ?



Vocalizations occurred in 36/60 intervals (60%)

Available vowels

Available consonants

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SSP
Research support

- Sundberg et al. (1996): *The Role of Automatic Reinforcement in Early Language Acquisition*
  - Premise: Auditory speech stimuli may not function as a reinforcing stimulus for some learners, as evidenced by few, weak, or inconsistent vocal responses that produce these (speech) auditory stimuli
  - Participants: 1 TD child, 4 preschoolers, severe-to-mod lang delays
  - Procedure: 15 pairings/min for a few minutes
  - Results:
    - All children emitted novel vocal responses (so, pairings increased vocalizations of children with strong speech skills and children with weak pre-intervention repertoires)
    - Temporary effects; vocalizations dissipated within minutes

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SSP
Research support

- 11 published SSP studies after Sundberg et al. (1996)
  - **8** showed **temporary increases** in target vocalizations
  - **3** showed **no SSP effects** on target vocalizations
  - Possible variables affecting outcomes
    - *Responder variables*: Pre-existing speech repertoire (frequency, topographies); difficulty of targets selected
    - *Conditioning variables*: presentation sequence of the S-S, # pairings overall, # syllables presented per trial, SPA method and items identified as high-preference

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SSP: Early studies

	Age (Number)	Pre-skills	Effects
Sundberg et al. (1996)	2-4 yr (5)	Normal (1) Mod-sev lang delay (4)	Effects with all skill levels
Yoon & Bennett (2000)	3-4 yr (3)	0-2 vocal play sounds, no VB; severe DD	Effects with all, but better for those with stronger pre skills
Miguel et al. (2002)	3-5 yr (3)	Minimal vocals, no VB Dx ASD	Effects with 2 of 3, but worse for those with stronger pre skills
	Temporary effects (~10 min); how to capture new vocalizations and bring them under contingencies of reinforcement as VB		
Esch et al. (2005)	6-8 yr (3)	No or minimal vocals, no VB; Dx ASD	Not able to establish ECH responses because no effects of SSP Could not replicate Miguel et al. (2002)

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SSP: Isolating procedural variables

What procedural variables might produce a more robust effect?
- Interspersed trials of S+ and S-
- Added a "look!" cue to observe/attend
- Added *motherese*

	Age (Number)	Pre-skills	Effects
Esch, Carr, & Grow (2009)	5-6 yr (3)	Minimal vocals No VB (2 partic) Dx ASD	Effects with all skill levels AR evident for only 1 of 3 participants; thus direct reinforcement may play greater role

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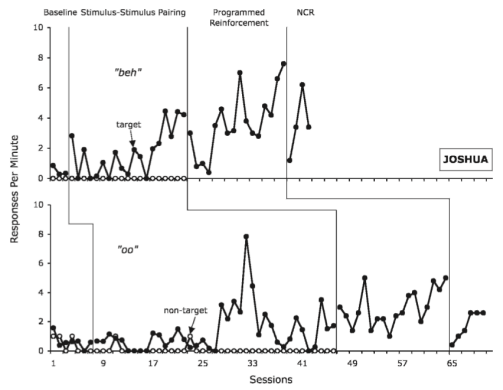

Esch et al. (2009)

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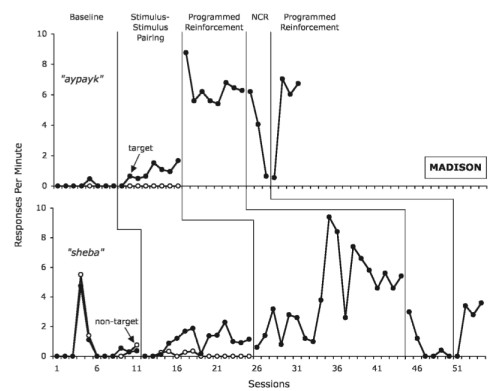

Esch et al. (2009)

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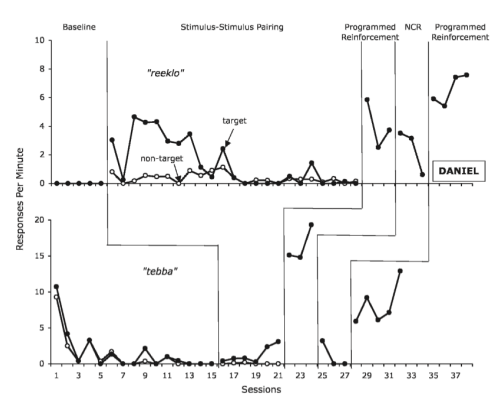

Esch et al. (2009)

SSP: Isolating procedural variables

Purpose:
Replicate Esch et al. (2009) to demonstrate generality of the enhanced procedure

	Age (Number)	Pre-skills	Effects
Rader et al. (2014)	4-7 yr (3)	Low vocal play No echoics Dx ASD Chrom disorders (2)	Effects with 2 of 3 participants

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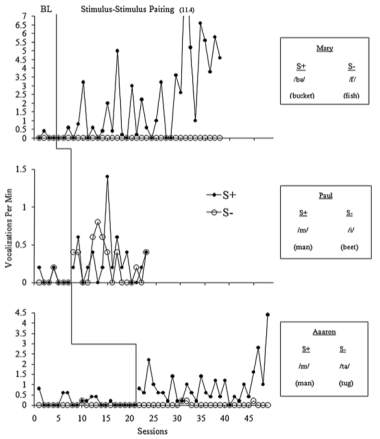

Rader et al. (2014)

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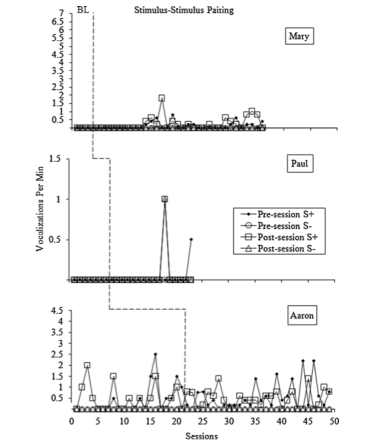

Rader et al. (2014)

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SSP: Isolating procedural variables

Purpose:
Separate responder variables, such as vocal repertoire, from conditioning variables that might influence conditioning voice as a reinforcer

- Frequent preference assessments
- Increase # of pairings
- Eliminate pre-exposure to target auditory stimulus
- Button press response instead of vocal response

	Age (Number)	Pre-skills	Effects
Petursdottir, Carp, Matthies, & Esch (2011)	3.5-4 yr (3)	Hi vocal play, strong echoic, mand, tact; echolalia (2) Lo vocal play, no VB (1) Dx ASD	(Phase 1) No effect of SSP on preference for voice produced via button press (Phase 2) • 1 Partic showed preference effects when given opportunity to select paired stimulus (not able to reverse, though) • 2 Partic showed preference effects under contingent variables

This study suggests:
When SSP fails to increase vocalizations, it may be a failure to condition auditory stimuli as reinforcing

But, it remains unclear which variables are responsible for this failure.
- Assess the value of auditory stimuli separate from their effect on vocalizations

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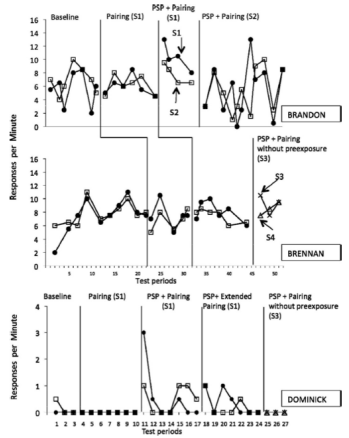

Petursdottir et al. (2011)

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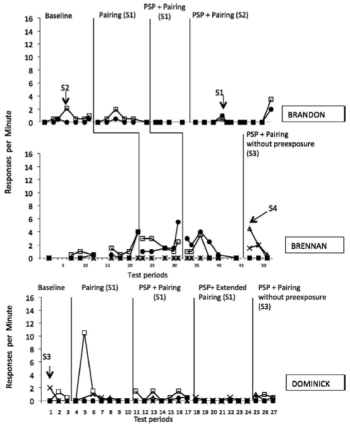

Petursdottir et al. (2011)

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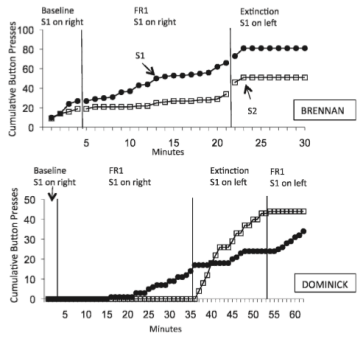

Petursdottir et al. (2011)

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SSP
Discussion

- SSP-induced vocalizations may indicate that sound-making is (at least somewhat) automatically reinforced
  - AR vocalizations are acquired early (thus, perhaps easier [Rader et al., 2014]); that is, infants emit AR vocalizations before they acquire complex VB
  - We may be susceptible to AR provided through parity with vocalizations of our verbal community (Palmer, 1996)

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SSP
Research support - Summary

- SSP is aimed at increasing the available pool of speech vocalizations.
- SSP is a **preliminary** procedure. Presumably,
  - First, pairing establishes some sounds as preferred stimuli.
  - Then, when those stimuli are randomly produced, their higher value results in those responses (that produced those preferred stimuli) being selected into the repertoire (AR).
- When this happens, these vocalizations will have to be brought under COR as functional verbal operants (e.g., mands, tacts, echoics, intraverbals).
- Timing of teaching mands, tacts, etc is critical, because SSP effects are temporary.
- SSP is not yet a reliable procedure, so its clinical value is questionable. It may be that other procedures (e.g., VV, RMIA) would yield faster, more robust clinical results.

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Vocal Variability (VV)

Purpose
Increase topographies of vocalizations

Indicators
Little or no variation in vocalizations

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Vocalization Baseline

Lots of vocalizing but…

- no vowels
- low variability

Rx training:
- SSP (pairing)
- Vocal variability
- Alternative comm mode

mmmm~~			mmmm~~	mmmm~~	mmmm~~	mmmm~~			
		mmmm~~	mmmm~~			mmmm~~	mmmm~~		
	mmmm~~	mmmm~~			mmmm~~		mmmm~~	mmmm~~	mmmm~~
mmmm~~	mmmm~~	mmmm~~	mmmm~~	mmmm~~	mmmm~~				
						mmmm~~	mmmm~~	mmmm~~	mmmm~~
	mmmm~~	mmmm~~			mmmm~~	mmmm~~	mmmm~~	mmmm~~	

Vocalizations occurred in 31/60 intervals

Vocalization Baseline = 52%

Vowels	Frequency

Consonants	Frequency

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Vocal variability
Rationale

- Many children with developmental delays (e.g., ASD) emit infrequent and/or repetitive (i.e., invariant) speech sounds.
- Variability is an operant that can, and does, come under COR. (But note upcoming: Peleg, Martin, & Holth, EABA, Sept 2014)
- Lag schedules of reinforcement provide COR for variable responding and have been shown to evoke varied verbal responses in children with a diagnosis of autism. (See Lee et al., 2002; Susa & Schlinger, 2012)

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Response Class Variability

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Invariant (one member of response class)			Random (any member of response class)
Goodbye	Goodbye	Goodbye	Goodbye
Goodbye	See you later	See you later	Bye Bye
Goodbye	See you later	Bye Bye	Ciao
Goodbye	Goodbye	Goodbye	See you later
Goodbye	Goodbye	Bye Bye	Bye Bye
Goodbye	See you later	Bye Bye	Bye Bye
Goodbye	Goodbye	See you later	Hasta luego
Goodbye	See you later	Catch ya' later	So long
Goodbye	See you later	So long	Later
			Catch ya' later

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Teaching and Operant Variability

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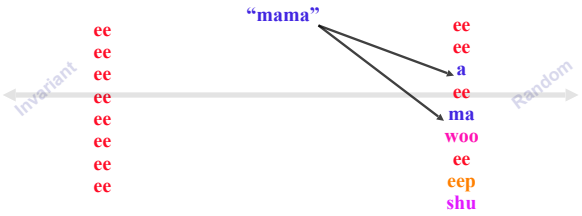

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Vocal variability

General procedure

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Lag 1 schedule

Trials	Response	Reinforce?
Base	Initial	(Y)
1	Same	N
2	Diff	Y
3	Same	N
4	Diff	Y
5	Diff	Y
6	Same	N
7	Diff	Y
8	Diff	Y
9	Diff	Y
10	Diff	Y

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Vocal variability
Research support - Non-vocal/verbal responding

Differential reinforcement of

- Novel movements by porpoises (Pryor, Haag, & O'Reilly, 1969)
- Novel block-building forms (Goetz & Baer, 1973)
- Novel button press sequences (Miller & Neuringer, 2000)
- Variable block-building play responses (Napolitano et al., 2010, extending Goetz & Baer, 1973)

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Vocal variability
Research support - Lag Schedules

Variability of complex language

- Novel verbal responses to questions (Lee et al., 2002, 2006)
  What do you like to do? How are you?
- Extension (Susa & Schlinger, 2012)
  - 2 methodological improvements
    - SPA instead of parent report of reinforcers
    - Eliminated Q "what do you like to do" b/c visible stimuli could evoke responses

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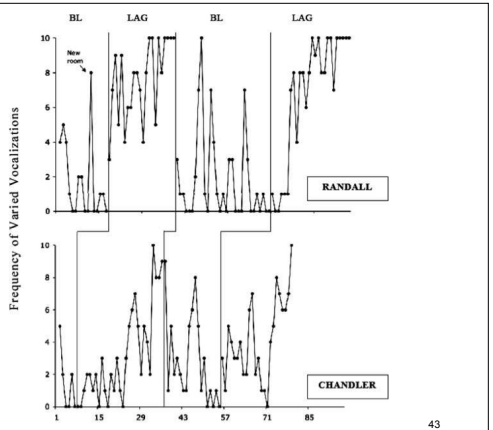
Vocal variability
Research support - Lag Schedules

Vocal variability (in early speech learners with weak vocal skills)

- Novel vocalizations by low-vocal, non-verbal children with autism (Esch et al., 2009)
  - Variability defined as different topography or different sequence



Esch, Esch, & Love (2009)

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Results

- Variable vocalizations increased
- Overall frequency of vocalizations increased
- No increase in novel phonemes

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Vocal variability
Procedure

May have inadvertently constrained variability b/c phonemes are too few, even though variability (sequence differences) was reinforced

Lag 1 schedule

Trials	Response	Reinforce?
Base	ah	(Y)
1	ah	N
2	buh	Y
3	uh	Y
4	bah	Y
5	baba	Y
6	baba	N
7	abba	Y
8	baba	Y
9	ah	Y
10	buh	Y

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Vocal variability
Research support - Lag Schedules

"One caveat suggested by this study is the importance of developing a socially significant definition of vocal variability. We defined vocal variability as any vocalization whose phonemes differed in topography (*lee*, *mop*) or in sequence (*ub*, *buh*) from those uttered in the previous trial. For both children, vocal responses tended to vary within a phonemic class whose response members required little tongue repositioning (e.g., *uh*, *ah*, *buh*, *muh*). Hence, defining and reinforcing variability solely on the basis of phonemic sequence may have inadvertently constrained other aspects of variability that are needed for further speech learning. That is, although speech variations were strengthened, they were atypical of those required for fluent speech in which rapid tongue, lip, jaw, and laryngeal movements must necessarily occur to produce a variety of different phonemes in coordinated sequences."

(Esch, Esch, & Love, 2009, p. 77)

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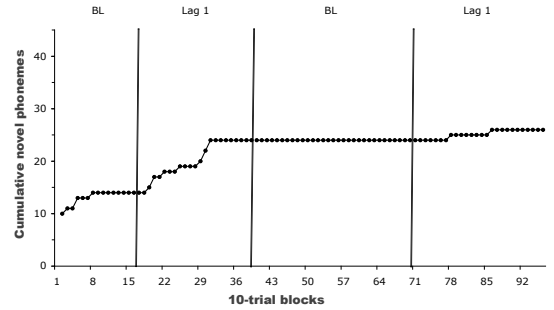
Novel phonemes

Randall



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Esch, Esch, & Love (2009)

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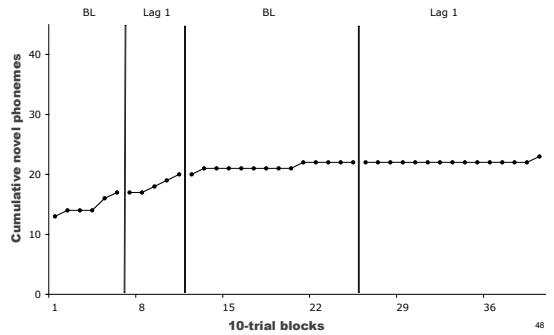
Novel phonemes

Dennis



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Esch, Esch, & Love (2009)

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Vocal variability
Research support - Lag Schedules

- VV extension (Koehler-Platten et al., 2013)
  - Novel phonemes evoked with 2 of 3 low-vocal children with autism with little to no echoic repertoire
  - Programmed COR for *novel* phonemes, not just for varied phonemes
    - "…increasing variability without expanding the repertoire of phonemes does not prepare the participant for further vocal training." (p. 81)

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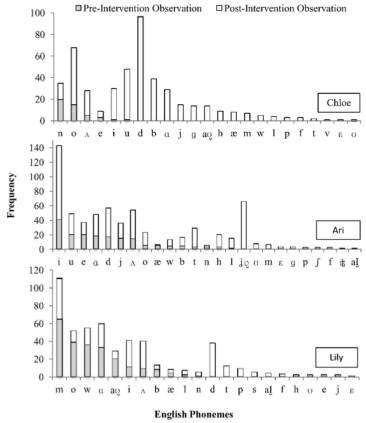

Koehler-Platten et al. (2013)

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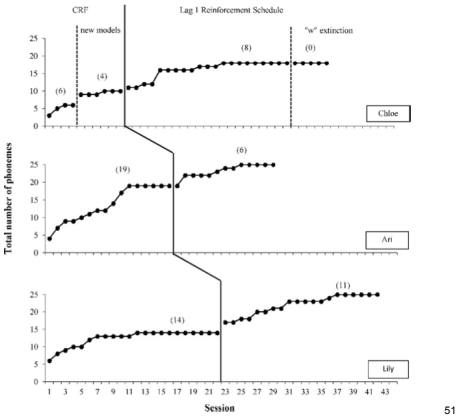

Koehler-Platten et al. (2013)

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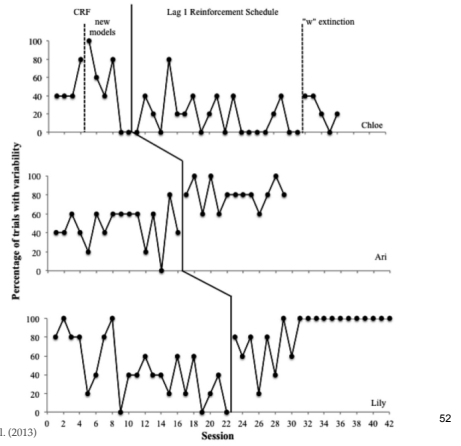

Koehler-Platten et al. (2013)

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Vocal variability
Research support - Summary

- Operant variability may be altered
- Lag schedules can increase **variability** and **novelty** of speech syllables

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Rapid motor imitation antecedent (RMIA)

Purpose
Evoke echoic responses

Indicators
Echoics are weak (inconsistent, inaccurate, delayed); i.e., not under strong control of an echoic stimulus.

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RMIA
Rationale

- *Behavioral momentum:* Low probability responses (e.g., vocal imitations) can be evoked when preceded by higher probability responses (e.g., non-vocal imitations)
  (Mace & Belfiore, 1990; Mace et al., 1988; Nevin, 1983)
- Generalized imitation is a functional response class, so unreinforced responses in the class can be maintained if *some* responses in the class are reinforced
  (Baer et al., 1967; Lovaas et al., 1966)

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RMIA
Rationale

- But…generalized imitation may be confined within topographic subclasses (e.g., gross motor, fine motor, short vocal, long vocal); further, generalized imitation training, without mand contingencies, hasn't automatically resulted in *vocal* imitation
  (Garcia et al., 1971; Poulson et al., 1993; Ross & Greer, 2003; Young et al., 1994)
- Echoic responses are imitative responses (Skinner, 1957) and, as such, should be susceptible to COR that evoke and maintain other imitative responses

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RMIA
Rationale

- *Reinforcement*
  - Infant vocalizations and motor & vocal imitations **increased with contingent attention** (e.g., tickles, smiles) from parents compared to fixed-time (i.e., NCR) attention [that was provided] during baseline conditions
    (Poulson & Kymissis, 1988)
  - RMIA includes a mand contingency; it's vocal imitation training where vocal responses are preceded by non-vocal imitation responses, and are followed by the opportunity to emit a vocal mand (programmed for reinforcement)

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RMIA
Procedure

- Prerequisite skills (Taught before starting RMIA procedure; Ross & Greer, 2003)
  - Sit still
  - Make eye contact
  - Follow simple directions
  - Imitate non-vocal motor movements

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RMIA
Procedure

- Present a series of rapid *non-vocal* imitation models, ending with the target *vocal* imitation model

Typically,
3 GM
3 FM

Do this →	Motor imit
Do this →	Motor imit
Do this →	Motor imit
Do this →	Motor imit
echoic model →	**Vocal** imit

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Video

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RMIA
Procedure

- "…we think that the procedure acts to join the different afferent and efferent responses of see and do to hear and say and functions as a new higher order operant."

(Greer, personal communication, July 24, 2014)

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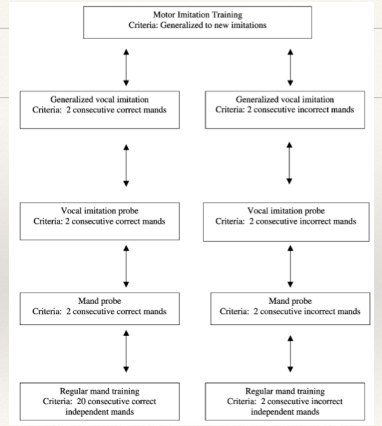
RMIA
Procedure



RMIA Procedure Flowchart (Ross & Greer, 2003)

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RMIA
Research support

- Ross & Greer (2003)
  - Echoics were evoked, following a series of rapid motor imitations
  - The "run-up" imitation models were faded; echoics then occurred under echoic-only control
  - Then, echoic-to-mand transfers were taught, resulting in unprompted vocal mands
  - Mands were maintained at 3-month follow up probe

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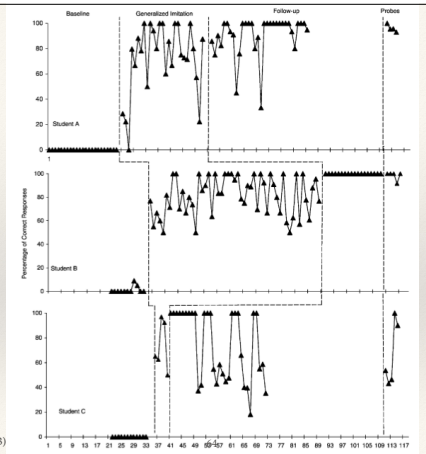

Ross & Greer (2003)

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Image

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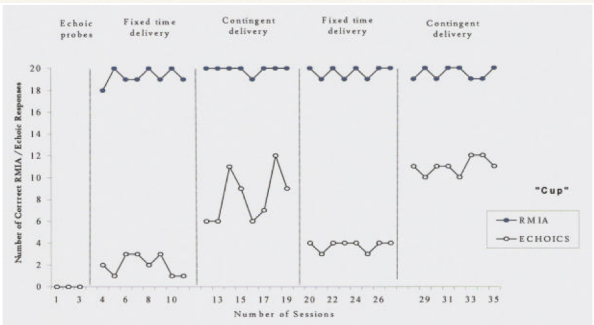
Participant A



Tsiouri & Greer (2007)

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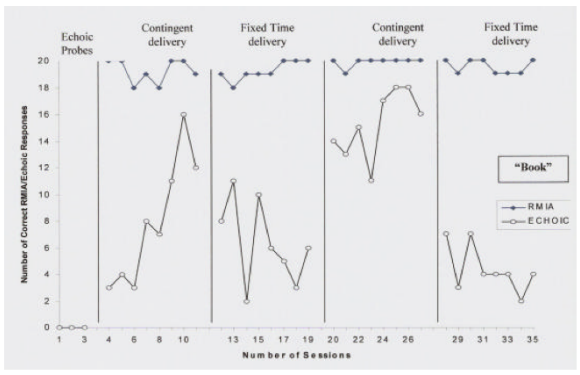
Participant A



Tsiouri & Greer (2007)

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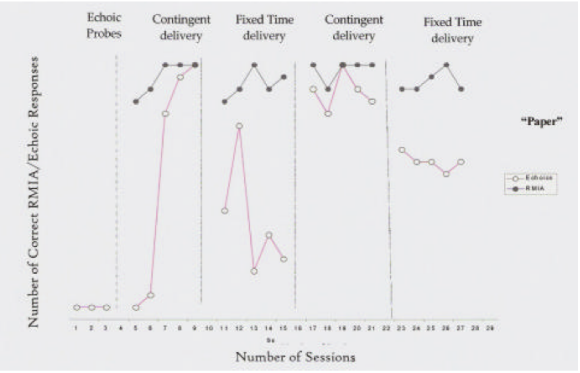
Participant B



Tsiouri & Greer (2007)

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Video

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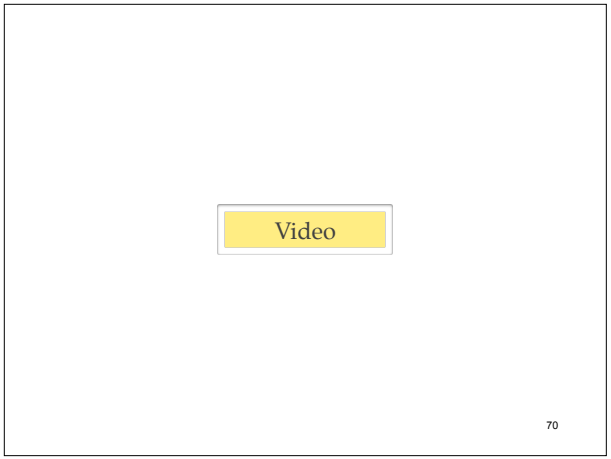

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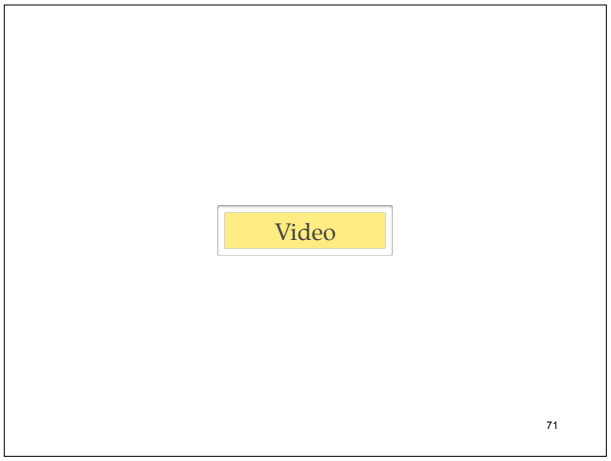

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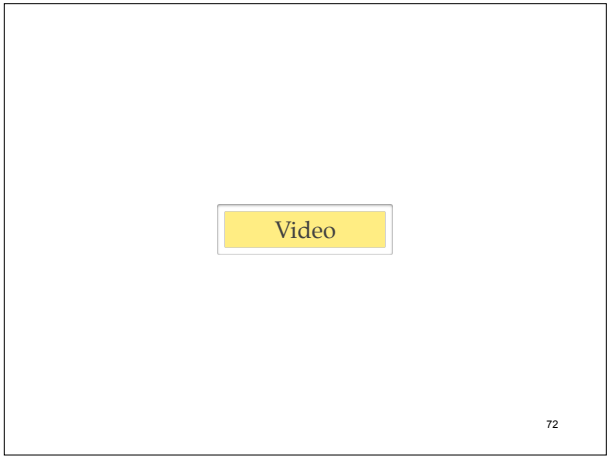

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RMIA studies

	Age (Number)	Pre-skills	Effects
Ross & Greer (2003) Ech-to-mand	5-7 yr (5)	No spontaneous speech No echoic VB No gen'zd imitation Dx ASD	• All acquired generalized vocal imitations • 4 of 5 participants maintained mand VB at follow up & at 3-mo probes
Tsiouri & Greer (2003) Extended Ross & Greer (2003) to tacts	3-5 yr (2)	No vocal comm skills No or weak echoic VB Gen'zd imit skills	*(Experiment 1 results)* • Mand & tact forms acquired during RMIA and were maintained at 1-mo follow up • Both echoic/indep tacts required fewer trials to mastery than mands (but tact COR not restricted to gen'zd rfcr only)
Tsiouri & Greer (2007)	4-5 yr (2)	No functional comm No or weak echoic VB Gen'zd imit skills Dx PDD	• Echoics evoked during RMIA procedure • Contingent social rfmt produced greater echoic effects than a FT schedule • Motor imit high in both rfmt conditions

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RMIA

Research support - Summary

- Echoics, mands, and tacts have been produced during the RMIA procedure
- Further research is needed to:
  - Replicate and extend the (few) studies available
  - Investigate some of the concerns identified in these studies
    - Influence on echoic acquisition by mand vs tact contingencies during training
    - Prerequisite skills: e.g., how strong must the generalized imitation repertoire be for RMIA benefit to occur
    - Methodology:
      - Separate various treatment components
      - # training trials
      - Would rapid LR vs imitation produce similar results

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