Effects of Joint-Control Training on Producing Letter-Sound Bi-directionality in Children with Autism

Dissertation

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By

Cuong (Ken) Luu, M.S., BCBA

Graduate Program in College of Education and Human Ecology

The Ohio State University

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Dissertation Committee:

Dr. Moira Konrad, Advisor

Dr. Diane Sainato

Dr. Helen I. Cannella-Malone
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Abstract

The current investigation employed a multiple-baseline design to evaluate the effects of joint-control training as a method of phonics instruction. Three children with autism participated in this study, two males (ages 6 and 9) and a female (age 8). The participants were exposed to two types of instruction (i.e., tact training and joint-control training). In tact training, participants were presented with a sound card randomly until all four sound cards (Set 1) were presented 10 times in a given session (i.e., a total of 40 trials). In each trial, the experimenter presented a sound card to the participant and asked, “What sound?” If the participant emitted the correct sound, the experimenter delivered praise and a reinforcer. If the participant emitted the incorrect sound, the experimenter provided up to three additional prompts (i.e., “The sound is _____. What sound?”) before moving on to the subsequent trial. In joint-control training, participants were randomly presented a letter sound prior to being presented with a corresponding sound card randomly until all four sound cards (Set 2) were presented 10 times in a given session. The experimenter presented a letter sound and immediately after the participant imitated the sound, the experimenter presented the sound card to the participant and asked “What sound?” If the participant emitted the correct sound, the experimenter delivered praise and a reinforcer. Three additional prompts were provided if the participant did not imitate
the sound after the experimenter presented a letter sound and/or if the participant did not emit the correct sound after the experimenter presented a sound card and asked “What sound?” A probe session was conducted immediately after each tact and joint-control training session. Probe sessions were identical to the training sessions except that no additional prompts were given. Results showed that both tact training and joint-control training were effective in producing letter-sound bi-directionality, indicating that both methods may be used for phonics instruction for children with autism. Furthermore, teachers who completed the social validity questionnaires reported that the goals, procedures, and outcomes were acceptable and important.
Dedication

Dedicated to my parents. Thank you for teaching me the importance of hard work and perseverance in life. The greatest treasure is earned, not given.
Acknowledgements

“A journey of a thousand mile begins with a single step” - Lao Tzu

Thank you, Su Wong, for your never ending support. Without your encouragement to take the first “single step,” I would never stand where I am today. You always believed in me when no one else did.

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Vita

February 8, 1978.................................Saigon, Vietnam

2001..............................................B.S. Psychology, California State University, Los Angeles

2001-2002.................................Behavior Consultant
Behavior Management Program
Azusa, California

2002-2003.................................Behavior Coordinator
Behavior Management Program
Azusa, California

2002-2006.................................Behavior Specialist
Mommy and Me Program
Azusa, California

2003-2006.................................Assistant Director
Behavior Management Program
Azusa, California

2006..............................................M.S. in Applied Behavior Analysis,
California State University, Los Angeles

2007-2008.................................Behavior Analyst
Private Practice

2006-present.................................Graduate Teaching Associate,
The Ohio State University

Publications


Fields of Study

Major Field: Education
Table of Contents

Abstract...........................................................................................................................................................................ii

Dedication........................................................................................................................................................................iv

Acknowledgements..........................................................................................................................................................v

Vita..............................................................................................................................................................................vi

List of Tables.................................................................................................................................................................xi

List of Figures.................................................................................................................................................................xii

Chapters:

1. Introduction..............................................................................................................................................................1
   Children with Autism and Reading.........................................................3
   Going Beyond the Information Given.................................................4
   Reading and Other Skills.................................................................5
   Purposes of the Study........................................................................8
   Research Questions..........................................................................9

2. Literature Review.......................................................................................................................................................11
   What is Reading?................................................................................12
     Phonemic Awareness........................................................................12
     Phonics..............................................................................................12
     Fluency..............................................................................................13
     Vocabulary.......................................................................................13
     Comprehension...............................................................................13
   Reading and Individuals with Disabilities........................................14
     Reading Individuals with Intellectual Disabilities........................14
       Comprehension.............................................................................14
       Vocabulary...................................................................................17
       Fluency........................................................................................19
     Phonics and Phonemic Awareness................................................22
     Reading and Individuals with Autism............................................24
   Reading Intervention and Generalization....................................25
   Teaching Generatively....................................................................27

viii
Generalization Paradigms .......................................................... 29
Stimulus equivalence .............................................................. 31
Naming ................................................................................. 43
Joint (stimulus) control .......................................................... 53
Limitations of the paradigms ................................................... 62

3. Method .................................................................................. 76
Ethical Provisions ................................................................. 76
Participants .............................................................................. 77
Experimenter and Observer .................................................... 83
Setting .................................................................................. 83
Materials ................................................................................ 84
Definition and Measurement of the Dependent Variables ......... 85
Tact response ......................................................................... 85
Selection response ................................................................. 86
Data Collection ....................................................................... 86
Pre-Assessments .................................................................... 86
Preference assessment ............................................................ 86
Pre-baseline assessment .......................................................... 87
Baseline ................................................................................ 89
Probes .................................................................................. 90
Maintenance .......................................................................... 90
Interobserver agreement (IOA) ................................................ 90
Experimental Design ............................................................... 91
Decision Rules ........................................................................ 92
Transition from baseline to intervention condition ................. 92
Transition from intervention to maintenance condition .......... 92
Starting participants on subsequent tiers ............................... 92
Starting participants in the next experiment .......................... 92
Procedures ............................................................................ 93
Baseline ................................................................................. 93
Interventions ......................................................................... 94
Tact training (Experiment 1) ................................................... 94
Joint-control training (Experiment 2) ...................................... 95
Probes ................................................................................ 97
Maintenance ....................................................................... 97
Procedure Integrity ............................................................... 97
Social Validity ..................................................................... 98

4. Results .................................................................................. 100
Preference Assessment ........................................................ 100
Pre-baseline Assessment ....................................................... 101
Alex ...................................................................................... 102
Charles ............................................................................... 102
Mandy ................................................................................. 104
Interobserver Agreement ................................................................. 104
Experimental Data ........................................................................ 104
Experiment 1 (Tact Training) ............................................................. 104
      Mandy .................................................................................. 104
      Charles ............................................................................... 106
      Alex .................................................................................. 107
Experiment 2 (Joint-control Training) .................................................. 113
      Charles ............................................................................... 113
      Alex .................................................................................. 114
      Mandy ............................................................................... 116
Procedural Integrity Data .................................................................. 121
Social Validity Data ......................................................................... 122

5. Discussion ................................................................................ 125
  Research Questions ..................................................................... 126
  Research Question 1 .................................................................... 126
  Research Question 2 .................................................................... 130
  Research Question 3 .................................................................... 134
  Research Question 4 .................................................................... 135
  Research Question 5 .................................................................... 137
  Limitation and Future Research ...................................................... 140
  Implications for Practice ................................................................. 145
  Conclusion ................................................................................ 148

References ..................................................................................... 151

Appendixes ................................................................................... 162
  Appendix A: Parental permission form .............................................. 162
  Appendix B: Teacher assent form .................................................... 167
  Appendix C: Training Stimuli .......................................................... 169
  Appendix D: Preference assessment form ........................................ 171
  Appendix E: Baseline data sheet ..................................................... 176
  Appendix F: Tact training procedural integrity form ....................... 178
  Appendix G: Joint-control procedural integrity form ...................... 180
  Appendix H: IOA data sheet .......................................................... 182
  Appendix I: Tact training data sheet ................................................. 184
  Appendix J: Joint-control training data sheet ................................ 186
  Appendix K: Social validity questionnaire ...................................... 188
List of Tables

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Definitions of principles and procedures</td>
<td>30</td>
</tr>
<tr>
<td>2.2</td>
<td>Definition and example of Skinner’s verbal operants</td>
<td>31</td>
</tr>
<tr>
<td>3.1</td>
<td>Participants’ characteristics</td>
<td>79</td>
</tr>
<tr>
<td>3.2</td>
<td>Participants’ reading skills and other services</td>
<td>82</td>
</tr>
<tr>
<td>3.3</td>
<td>Participants’ training stimuli of Sets 1 and 2</td>
<td>85</td>
</tr>
<tr>
<td>4.1</td>
<td>MSWO preference assessment results</td>
<td>101</td>
</tr>
<tr>
<td>4.2</td>
<td>Pre-baseline assessment results</td>
<td>103</td>
</tr>
<tr>
<td>4.3</td>
<td>Participants’ performance across experimental conditions of Experiment 1</td>
<td>110</td>
</tr>
<tr>
<td>4.4</td>
<td>Participants’ performance across experimental conditions of Experiment 2</td>
<td>118</td>
</tr>
<tr>
<td>4.5</td>
<td>Results of the questionnaire on importance of reading for children with ASD</td>
<td>123</td>
</tr>
<tr>
<td>4.6</td>
<td>Results of questionnaire on Tact and Joint-Control Training</td>
<td>124</td>
</tr>
</tbody>
</table>
## List of Figures

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>The stimulus equivalence paradigm</td>
<td>33</td>
</tr>
<tr>
<td>2.2</td>
<td>Standard conditional discrimination and outcome-specific procedures</td>
<td>36</td>
</tr>
<tr>
<td>2.3</td>
<td>Stimulus equivalence paradigm</td>
<td>39</td>
</tr>
<tr>
<td>2.4</td>
<td>Lowe and Beasty’s experimental paradigm</td>
<td>45</td>
</tr>
<tr>
<td>2.5</td>
<td>The circular relation in the naming account</td>
<td>48</td>
</tr>
<tr>
<td>2.6</td>
<td>A diagram explaining how naming is learned by a child</td>
<td>52</td>
</tr>
<tr>
<td>2.7</td>
<td>A schematic account of joint control</td>
<td>55</td>
</tr>
<tr>
<td>2.8</td>
<td>Schematic account of how joint control is developed</td>
<td>57</td>
</tr>
<tr>
<td>2.9</td>
<td>Identity and arbitrary matching-to-sample procedures</td>
<td>64</td>
</tr>
<tr>
<td>2.10</td>
<td>An example of identity and arbitrary matching-to-sample procedures</td>
<td>66</td>
</tr>
<tr>
<td>2.11</td>
<td>Joint-control paradigm</td>
<td>70</td>
</tr>
<tr>
<td>4.1</td>
<td>Participants’ experimental data for Experiment 1 (Tact Training)</td>
<td>111</td>
</tr>
<tr>
<td>4.2</td>
<td>Participants’ training responses in Experiment 1 (Tact Training)</td>
<td>112</td>
</tr>
<tr>
<td>4.3</td>
<td>Participants’ experimental data for Experiment 2 (Joint-Control Training)</td>
<td>119</td>
</tr>
<tr>
<td>4.4</td>
<td>Participants’ training responses in Experiment 2 (Joint-Control Training)</td>
<td>120</td>
</tr>
<tr>
<td>4.5</td>
<td>Mandy’s data showing only letters n and h across all conditions</td>
<td>121</td>
</tr>
</tbody>
</table>
Chapter 1

Introduction

Perie, Grigg, and Donahue (2005) estimated that 22% to 52% of fourth grade students read below the basic achievement level. Given that reading failure is a factor known to adversely affect children’s self-confidence, motivation to learn, and school outcomes (The National Institute for Literacy [NIFL], 2003), these numbers cannot be ignored. Children need to be taught basic reading skills and build competence in primary grades (e.g., kindergarten through third) in order to be successful learners as they progress through school (NIFL, 2007). Yet, national statistics indicate that one in six children experience difficulty learning to read in grade 1, with numerous students exhibiting reading failure in every school in the U.S. (Kame’enui, 1996).

Unfortunately, the percentage of children reading below the basic achievement may be underestimated. The reported statistical estimation of children’s reading performance may mainly be comprised of children without disabilities. If the statistics also include reading performance of children with moderate to severe developmental disabilities, the estimation would likely increase by a great margin. The reason for such an increase might be that reading instruction for children with moderate to severe disabilities has historically been underemphasized (Browder, Wakeman, Spooner,
Lack of attention to reading instruction for this population may be the result of an assumption that teaching functional daily living skills is more important than teaching reading skills given that functional skills directly improve the social functioning of individuals with developmental disabilities (Browder et al., 2006). The inadequate emphasis on reading instruction may have excluded children with developmental disabilities from opportunities to learn reading and literacy skills in the classroom settings, and thus resulted in below-basic-level reading performance (NIFL, 2003).

Even though functional skills for daily activities are important, reading should be an instructional priority, because the ability to read plays a crucial role in improving the overall well-being of individuals with developmental disabilities (Browder et al., 2006). Without reading skills, the ability to encounter natural reinforcing contingencies is tremendously reduced for these children. For instance, they may have difficulty obtaining and keeping employment, engaging in leisure activities, and maintaining financial security (McCardle & Chhabra, 2004). Thus, reading is a critical life skill that individuals need to master in order to function efficiently in society.

Moreover, recent federal policies (e.g., Individual with Disabilities Education Act of 2004, No Child Left Behind Act) require schools to take full responsibility for teaching all students, including those with disabilities, to read (and other academic skills) at the “highest achievement standard possible” (Browder et al., 2006, p.393). Therefore, providing schools with information on evidence-based practices to improve reading of children with developmental disabilities is vital for schools to meet the national achievement standard. However, in their comprehensive review article, Browder et al.
found only 128 studies that focused on teaching reading to individuals with various
developmental disabilities within the last three decades. Of the studies included in their
review, only 19 included children with autism spectrum disorders and developmental
disabilities not specified. With such limited research on this population, it is clear that
more research is needed.

Children with Autism and Reading

One of the delays that children with autism spectrum disorder (ASD) tend to
exhibit is in language development (Nation, Clarke, Wright, & William, 2006).
Unfortunately, for this reason, many teachers assume that teaching these children to read
is unachievable given that they are “too cognitively impaired or are not ready” for
reading (Mirenda, 2003, p. 272). Although this assumption is incorrect, children with
ASD do display a certain characteristic that may impede them from learning to read
efficiently. For instance, these children demonstrate a predisposition for stimulus
overselectivity or “too rigid” stimulus control (Lovass, Schreibman, Koegel, & Rehm,
1971; Lovass & Schreibman, 1971). That is, children with ASD have the tendency to
perform only the behaviors that were taught, nothing more. As such, it seems that an
instructional program that promotes generalized responding, the ability to emit an
appropriate response in the presence of novel situation without direct training
(Lowenkron, 2006), is ideal for teaching children with ASD to read. Fienup, Covey, and
Critchfield (in press) call such an instructional program teaching “generatively” or “going
beyond the information given” (Bruner, 1957).
Going Beyond the Information Given

Certainly, one of the most important aspects of an instructional program is using technology to facilitate wide-spread behavioral change without additional instruction. Baer, Wolf, and Risley (1968) strongly emphasized this point in their seminal paper. They defined change of behavior without explicit instruction as *generality* because the learned behavior lasts over time, appears in a wide variety of possible environments, or spreads to different behaviors. To these researchers, an instructional program that has the technology to promote behavior generality is not only crucial to teaching generatively and effectively, but also has a tremendous impact on students’ lives.

Needless to say, the ability to generalize learned behavior across stimuli without explicitly being taught is invaluable to children with disabilities as it would not be feasible to acquire every novel behavior through explicit instruction in the natural environment (Baum, 2005). Specifically to children with developmental disabilities, enhancing their ability to respond appropriately under novel situations should further enable them to enjoy more healthy, happy, and productive lives (Baer, 1999; Cooper, Heron, & Heward, 2007). As Cooper et al. stated, “A behavior change–no matter how important initially–is of little value to the learner if it does not last over time, is not emitted in appropriate settings and situations, or occurs in restricted form when varied topographies are desired” (p. 653). Clearly, behavior generality is a crucial aspect of any behavior change programs (Baer, Wolf, & Risely, 1987) including reading. Numerous interventions with a generative component have successfully taught individuals with and without disabilities different skills such as nonverbal imitation (Koegel & Rincover, 1977), eating (Van den Pol et al., 1981), blockbuilding (Goetz & Baer, 1973),
conversation imitations (Hughes, Harmer, Killina, Niahois, 1995), and language (Goldstein, 1993).

Reading and Other Skills

While many reading interventions have produced great reading outcomes (Wanzek, Vaughn, Kim, & Cavanaugh, 2006), few interventions have shown the capability to promote untrained generalization (Chafouleas, Martens, Dobson, Weinstein, & Gardner, 2004; Eckert, Ardoin, Daly-III, & Martens, 2002; Hitchcock, Prater, & Dowrick, 2004; Kennedy & Flynn, 2003; Kourea, Cartledge, & Musti-Rao, 2007). Kennedy and Flynn, for instance, used a phonological awareness-based intervention program that focused on alliteration detection skills, or the repetition of the first consonant sound in a phrase (e.g., “Peter Piper picked a peck of pickled peppers”), rhyme detection skills, phoneme isolation, and spelling for children with developmental disabilities in an attempt to examine the effects on children’s ability to generalize the learned skills to other related skill areas such as phoneme segmentation and speech intelligibility. Although the results indicated that all children improved in the phonological awareness skills targeted in the intervention, none of the children exhibited any generalization to other related skills.

These findings led the authors to propose that explicit training that targets grapheme-phoneme (i.e., printed letter–sound) connections is needed to promote generalization. Likewise, Eckert et al. (2002) found similar outcomes, the lack of generalized responding, even though their study emphasized oral reading fluency. They also noted that the improvements in their participants’ reading fluency was the product of
explicit training during treatment, but little or no generalized improvement was observed when generalization tests were given.

In teaching behaviors other than reading, similar results were also obtained using an explicit training approach. For instance, many behavioral researchers have successfully used discrete-trial techniques and tact training (e.g., point to object when its name is presented or say an object’s name when that object is presented; Sundberg & Michael, 2001) to teach individuals specific linguistic skills such as receptive and expressive vocabulary acquisition, naming, and even the use of appropriate grammatical forms such as plurals and word-order combinations (Goldstein, 1983; Guess, Sailor, Rutherford, & Baer, 1968; McEachin, Smith, & Lovass, 1993; Lovaas, 1987). However, under only discrete-trial training and tact training, individuals may become prompt-dependent and lack the ability to generalize the trained behaviors to novel situations unless extra training is provided (Carr et al., 1997; Carr & Felce, 2002; Sundberg & Michael, 2001). Specifically, the trained behaviors only occur under the same antecedent stimuli used during training. Thus, many training trials are needed to teach an individual a behavior across settings or stimuli.

Collectively, these studies suggest that although explicit instruction does play an important role in teaching children to read and engage in other behaviors, it does not seem to prompt untrained generalization. So, in other words, explicit instruction is effective in that individuals learn the targeted behaviors, but does not, in and of itself, teach generatively in that the learned targeted behaviors do not always generalize to other stimuli or settings. Furthermore, the explicit instruction approach may actually hinder the generalized responding of children with ASD given that these children have a tendency
for overselectivity, as previously mentioned. In particular, a stimulus may gain strong and rigid stimulus control over a particular response, and consequently, that response may not be emitted under similar stimuli. Consequently, it is necessary to find an instructional approach that teaches explicitly and generatively. Such an approach would be extremely useful for children with developmental disabilities, and in particular, children with ASD.

Joint-control as an Explicit and Generative Instructional Method

Lowenkron (1998) defined joint control as “a discrete event, a change in stimulus control that occurs when a response topography, evoked by one stimulus and preserved by rehearsal, is emitted under the additional (and thus joint) control of a second stimulus” (p. 332). Joint-control training generally occurs within an A-B conditional relation training where the sample stimulus is a spoken word (e.g., “cup”) and the correct comparison stimulus is an object (e.g., cup). Starting with the sample stimulus, in response to hearing the word (e.g., “cup”) from a teacher, a student repeats the word and continues to rehearse the word. While the student rehearses the word, seeing the target object among other objects would evoke saying the word (e.g., “cup”) and thus the spoken word is controlled by both the audible and visual stimuli (called the joint control event). In essence, the joint control model assumes that to demonstrate generalized responding, an individual must already respond under multiple sources of control. Further, when an individual learned to respond under joint-control, generalization would occur spontaneously when only the name of a new stimulus is given.

Taking the information provided thus far, the next logic step is to use joint-control training as a reading instructional method given that it is research-based, it provides explicit and generative instruction, and it is suitable as a reading program for teaching
children with ASD. Nevertheless, there is one disadvantage using this training model. Only one study (Tu, 2006) has examined this approach in an applied setting with children with ASD as compared to other generative instruction approaches (e.g., matrix, stimulus equivalence, and naming training), which have been studied more frequently examining this population of children across different behaviors (Goldstein, 1981; Sidman, 1994; Horne & Lowe, 1996) and settings.

On the other hand, the limited studies available on joint-control training may only indicate that joint-control model is a fairly new concept (Lowenkron, 1998) and that many researchers are unaware of it. For this reason, more research is needed to better understand the effects of such a paradigm. Furthermore, some technical limitations (e.g., research design, instructional procedures, etc.) revealed in Tu (2006) need to be addressed to extend the literature on joint-control training. Although only one study has demonstrated the positive effects of joint-control training on children with ASD, children with severe mental retardation have benefited from this training (Lowenkron, 1988). Given its potential as an effective generative instruction, more research is needed to determine if joint-control training can be a generative reading intervention for children with ASD.

Purposes of the Study

This study has three purposes. The first purpose was to evaluate the effects of a joint-control model as a phonics intervention for children with ASD. The intervention consisted of teaching children with ASD to verbally name and rehearse the presented materials (i.e., printed letters) simultaneously.
The second purpose was to assess the validity of the joint-control perspective. Specifically, this study was to examine the accuracy of two aforementioned assumptions: (a) to achieve generalized responding, an individual must have already acquired the repertoire to respond under multiple sources of control; and (b) once an individual has acquired the repertoire to respond under joint control, generalization can be achieved with novel stimuli by simply teaching their names.

The third purpose was to extend and address the limitations of a study (Tu, 2006) in which participants with ASD were taught to label pictures. There were a few differences between the current study and Tu’s. First, the current study was intended to teach children with ASD the letter-sound relations instead of teaching children with ASD the picture-sound or picture-hand sign relations. Second, the current study used a multiple-baseline design to evaluate the effects of joint control training instead of an A-B design. Finally, the current study used a consistent mastery criterion for each stimulus relation rather than using various criteria.

Research Questions
1. What is the effect(s) of joint-control training on the production of letter-sound bi-directionality in children with ASD?
2. To what extent will the effect(s) differ between the tact and joint-control training in producing letter-sound bi-directionality in children with ASD?
3. How will the joint-control training function as phonics instruction for children with ASD?
4. To what extent will the assumptions of joint-control accurately predict letter-sound bi-directionality performance of children with ASD?
5. How will the participants’ teachers rate the acceptability of the study’s goals, procedures, and outcomes?
Chapter 2

Literature Review

One of the main challenges the educational system in the United States faces is teaching children with and without developmental disabilities to become proficient readers. Undeniably, there is a significant positive relationship between reading and other important outcomes (Kliwer & Landis, 1999). About 35% of children (with and without disabilities) come to school having no knowledge of reading and will never learn to read unless intensive reading interventions are provided (Bursuck & Damer, 2007). However, many educators and administrators still assume that children with intellectual disabilities can never learn to read because of their cognitive deficits (Mirenda, 2003). As a result, educators tend to focus on daily living skills and spend little instructional time on teaching children with developmental disabilities to read (Hodges, 1980).

Thus, the purpose of this chapter is to present findings of selected studies investigating the effects of reading instruction on reading skills of children with disabilities and to identify and provide a discussion for various generative instructional methods. In what follows, the chapter first focuses on defining reading, then provides a brief overview of the literature in the form of reading instruction on the five core skills of reading in children with disabilities, and ends with discussion of the generative instructional methods. Due to the limited number of reading studies that targeted children
with ASD, studies that included other populations of students with disabilities were used as a reference.

What is Reading?

Reading is a complex skill that requires an individual to master a combination of subskills to become proficient (Mueller, Olmi, & Saunders, 2000; Nation, Clarke, Wright, & William, 2006). The National Institute for Literacy (NIFL; 2003) identified five vital reading components as phonemic awareness, phonics, fluency, vocabulary, and text comprehension. Bursuck and Damer (2007) defined these subskills as the ability to (a) hear and manipulate the smallest sound units in spoken language (phonemic awareness); (b) recognize that there is a systematic and predictable relationship between written letters and spoken sounds (phonics or alphabetic principle); (c) read text quickly, accurately, and with expression (fluency); (d) understand the meaning of spoken and written words receptively and expressively (vocabulary); and (e) recognize the meaning of information presented in print (comprehension).

Phonemic Awareness

When an individual has mastered phonemic awareness, the person is able to recognize the same sound (/c/) in different spoken words (“cat, cake, catch”), isolate the first and last sounds in a spoken word (/c/ or /t/ in cat), blend sounds (/c/, /a/, /t/) into a word (cat), and segment a word (map) into its separate sounds (/m/, /a/, /p/).

Phonics

To demonstrate phonics or alphabetic principle skills, an individual can decode written words or exhibit the ability to make out a written word using letter-sound relationships such as seeing the written word dog to saying “dog.” Moreover, “once
children learn that *phone* is spelled this way rather than *foan*, their memory helps them to read, spell, and recognize the word instantly and more accurately than they could read *foan*” (NIFL, 2003, p.18). Recognizing the relationships between written letters and spoken sounds allow children to familiarize written words accurately and to decode new words (NIFL, 2003).

*Fluency*

When children demonstrate reading fluency, their reading sounds natural, effortless, with expression, and as if they are speaking (NIFL, 2003). For instance, children who lack fluency may read a line from Three Little Pigs and the Big Bad Wolf by James Orchard Halliwell-Phillipps in the following manner: “Not (pause) by the hair (pause) of my chinny (pause) chin chin.” A fluent reader may read the same line as: “Not by the hair of my chinny chin chin.” However, children’s fluency changes depending on the familiarity of words being read as well as the amount of practice with reading the text (NIFL).

*Vocabulary*

Clearly, understanding the meaning of words plays a vital role in learning to read. Suppose a child reads a passage and comes to a sentence “I want to deliver the cake now!” but has no knowledge of the word *deliver*. It is likely that the child would not be able to make sense of the sentence. On the other hand, if a child recognizes the meaning of *deliver* is to hand over to, then the sentence would make sense.

*Comprehension*

To demonstrate comprehension, children need to make sense of the content read through their experiences, knowledge of their surrounding environments, knowledge of
vocabulary, and knowledge of reading strategies (NIFL, 2003). The reading strategies may include using graphic and semantic organizers and looking back and forward in the text for information that might help explain the difficulty.

Reading and Individuals with Disabilities

Reading Individuals with Intellectual Disabilities

Comprehension

The ultimate goal of teaching children to read is to help them achieve the ability to comprehend text. The NIFL (2003) identified six effective procedures for teaching comprehension: (a) monitoring comprehension, (b) using graphic organizers, (c) answering questions, (d) generating questions, (e) recognizing story structure, and (f) summarizing. Although children without disabilities may benefit from these strategies, it may be difficult for children with cognitive disabilities to apply these strategies, given that many of these children lack fundamental skills, such as decoding, receptive language, and oral reading fluency (NRP, 2000). Studies on comprehension tend to fall under procedure (c) answering questions (information must be inferred from different stimuli). Specifically, teaching individuals with disabilities comprehension by reading sight words in the context of functional activities (Browder & Minarovic, 2000; Mechling & Gast, 2003) and by matching words to pictures (Driscoll & Kemp, 1996; Mechling, Gast, & Langone, 2002; Rehfeldt, Latimore, & Stromer, 2003) are examples of this procedure.

For example, although participants in Mechling and Gast (2003) were not children, results suggested that individuals with mild to moderate intellectual disabilities can be taught to comprehend text using the question-answering approach as the NIFL
(2003) suggested. For instance, Mechling and Gast taught three participants to locate grocery items by reading words on aisle signs using computer-based instruction. Comprehension was measured by participants’ ability to locate grocery items based on reading the aisle signs. For instance, during training, the word coffee was paired with the word pudding. To demonstrate text comprehension, participants proceeded to find the pudding in the coffee aisle subsequent to seeing the aisle sign “coffee.” In other words, participants recognized that pudding belongs in the same aisle as coffee. Likewise, Browder and Minarovic (2000) taught non-reader adults with moderate mental retardation to use sight words to self-initiate job tasks. These researchers taught participants to read a list of job-related words using flashcards and taught comprehension of the words by having participants say a word and take the participants to the designated location. After mastering these steps, participants were taught to read words on a list instead of flashcards and eventually use the list to initiate job tasks by reading from the task list and completing the tasks.

In a similar manner, children with moderate intellectual disabilities were indirectly taught comprehension of written words and pictures as well as comprehension of pictures and oral words (Driscoll & Kemp, 1996) using a stimulus equivalence model (Sidman, 1971). In the first instructional method, Driscoll and Kemp instructed participants to orally read the words that corresponded to the written words and pictures. Once participants mastered the mentioned relations, comprehension was measured by having participants match written words to pictures. In the second instructional method, participants were instructed to read the sounds that corresponded to written words and to match written words to picture. Comprehension was measured in an identical fashion as
in the first method except that instead of matching written words to pictures, participants were saying the words that corresponded to pictures.

Using the same model of instruction (stimulus equivalence), another group of researchers taught text comprehension to both adults and children with mild to moderate intellectual disabilities (Rehfeldt, Latimore, & Stromer, 2003). During training, participants were trained on two relations: (a) dictated words and their corresponding printed words and (b) the same dictated words with their corresponding pictures. After training, participants’ performances on four untrained relations (i.e., printed words to dictated words, pictures to dictated words, pictures to printed words, and printed words to pictures) were measured. Results from this study were identical to Driscoll and Kemp (1996). All untrained relations increased drastically during post-training probes. Participants comprehended the presented text by demonstrating the ability to dictate words to its respective printed words and pictures and to match the corresponding pictures to its printed words and vice versa.

Although stimulus equivalence methods may have some degree of effectiveness in instructing text comprehension to individuals with disabilities, there are a few concerns that need to be considered. First, instructional methods that emphasize solely sight words may produce minimal generalization of reading skills to unfamiliar or novel words. This is because participants trained with such interventions may lack the necessary decoding skills to do so (Barudin & Hourcade, 1990). Second, as each sight word requires numerous trials to master, it might not be beneficial to children with disabilities given that learning all of the functional sight words, if even possible, would require extensive time and effort. Thus, it seems illogical to implement interventions that require such
extensive time and effort especially when many of these children are already far behind in their academic achievement, which Stanovich (1986) described as the “Matthew Effect” wherein the gap grows over time (i.e., the rich get richer and the poor get poorer). As such, it may be more efficient to focus on teaching these children rudimentary reading skills that may produce better generalization to reading novel words.

**Vocabulary**

Stanovich (2000) pointed out that reading ability (especially comprehension) and vocabulary are related even though the casual relation has not been scientifically proven. While a causal link has not been determined, it is not difficult to imagine that many readers with and without disabilities cannot understand what they read without knowing the meaning of most words in the content they read. NIFL (2003) revealed that children learn vocabulary through (a) indirectly through engaging in daily oral language, listening to adults read to them, and reading on their own; and (b) directly through explicit instruction.

Indirect learning of vocabulary might not be appropriate or efficient for children with disabilities for a few reasons. First, some of these children may not have adequate oral language skills to even engage in daily oral language (Nation, 2005; Nation et al. 2006). Second, there is an assumption still held by many educators and parents that children with severe disabilities can never learn how to read due to their cognitive deficits (Barudin & Hourcade, 1990). With this expectation, educators tend to not read to children with disabilities (Mirenda, 2003). Third, a common characteristic of children with disabilities, including those with high-incidence disabilities such as learning disabilities, is difficulty with incidental learning (Browder et al., 2006; Lovass, Schreibman, Koegel, 2003).
& Rehm, 1971; Lovass & Schreibman, 1971). For these reasons, recent research on teaching individuals with disabilities to read has focused primarily on using explicit instruction procedures to teach sight word vocabulary.

Mastropieri, Scruggs, and Fulk (1990), for example, used stimulus control procedures to teach difficult words (e.g., vituperation, oxalis, etc.) to 25 students with learning disabilities. These 25 participants were assigned to either a keyword mnemonic instruction group or the common approach instruction group. In both instructional conditions, students were presented with a stimulus (i.e., a word on an index card) and a prompt such as “This word means… What does this word mean?” Students then received feedback for their answers. The difference between the mnemonic instruction and the common approach instruction was that in the mnemonic instruction, the index cards also contained a keyword and picture associated with the vocabulary word instead of containing only the vocabulary word and its definition. Interestingly, although both conditions included explicit instruction, a simple modification to the training materials produced better student performance. These researchers found that participants in the mnemonic instruction group showed higher levels of recall and comprehension than the common approach method.

In a similar study, Barudin and Hourcade (1990) compared the effects of four instructional procedures (sight word, fading, tactile-kinesthetic, control group) on recall and transfer skills of 32 students with moderate to severe mental retardation. The sight word procedure was identical to the common approach instruction in Mastropieri et al. (1990). That is, participants were provided with the correct response when they incorrectly responded to the presented stimulus. The fading condition was similar to the
mnemonic instruction used by Mastropieri et al. in that pictures associated with the vocabulary words were used as cues. However, in this study, pictures were gradually faded as participants responded correctly to the presented stimuli. In the tactile-kinesthetic condition, the presented stimuli (printed words) were represented by sandpaper letters. In this condition, participants simultaneously said the sound of a presented word and traced the sandpaper word with his/her index finger. In the control condition, no instruction was delivered. The researchers participated in board and card games with participants.

Results from this study were consistent with Mastropieri et al.’s (1990) findings. Barudin and Hourcade (1990) found that, although all the three instructional conditions produced better performance in both recall and transfer skills than the control condition, participants in the fading condition outperformed other conditions after four days of instruction. Even though some transfer skill (i.e., ability to read untaught words) was recorded, it was insignificant. In other words, not enough generalization was recorded to indicate that any of these instructional methods were effective in facilitating generalization from taught to untaught vocabulary word. In sum, these two studies indicated that incorporating pictures into vocabulary instructional methods can be more effective in promoting better student learning.

Fluency

Despite the important relationship between comprehension and vocabulary, recognizing vocabulary words without fluency or automaticity will likely not contribute to reading comprehension (Shinn, 1992). Chall (1996) stressed that when children recognize words quickly and automatically (i.e., fluently), it allows them to comprehend
the read information instead of using their effort to recognize words, which may interfere
with comprehension. To put it another way, when children read with fluency, they can
focus their energy on the ideas read and those read ideas with personal background
knowledge, which then increases their chance of understanding what they are reading
(Bursuck & Damer, 2007).

A few studies (Falk, Band, & McLaughlin, 2003; Printz, McLaughlin, & Band,
2006; Rinaldi, Sells, & McLaughlin, 1997) used a reading racetrack and flashcard
formats to teach sight word and fluency to children with mild disabilities. For instance,
Printz et al. improved a student’s reading fluency by requiring him to complete a
racetrack drill for 1-minute and engage in an error-drill. During the racetrack drill, the
participant read the sight words printed on the racetrack and continued until time expired.
Immediately after the racetrack drill, the words to which the participant responded
incorrectly were printed on flashcards and the flashcard drill began. In the flashcard drill,
the participant was provided with the correct response and practiced until mastery.
Although these instructional methods showed promising data, children in these studies
appeared to be at risk for reading failure rather than children identified with
developmental disabilities.

Browder et al. (2006) found that most fluency studies did not teach the fluency
component but simply measured error rate and counting words read correctly from
passages (e.g., Farmer, Gast, Wolery, & Winterling, 1991; Singh & Singh, 1984, 1985;
Worsdel, Iwata, Dozier, Johnson, Neidert, & Thomason, 2005). In other words, fluency
was used as a dependent variable rather than an independent variable. This was perhaps
due to the limited word recognition in many of these children’s repertoire. For instance,
Singh and Singh (1984) compared the effects of two training conditions (i.e., preview of target text and preview of unrelated text) and a no-training condition. In all three conditions, reading error rates and self-correction rates of children with moderate mental retardation were recorded. In the no-training condition, participants were required to read a 100-word passage without any assistance from the teacher. Further, when participants requested for help, all requests were ignored, and participants were prompted to continue reading. In the preview of target text condition, the teacher discussed the title and background of the story by looking at pictures that accompanied the story and orally introduced new words and phrases without identifying them in the text. The preview with target text condition and the preview with unrelated text condition were identical except that in the latter condition, the materials used were unrelated to the target text. The results of this study showed that children’s oral reading errors decreased and self-corrections increased in the preview of target text.

In a follow-up study, Singh and Singh (1985) compared the effects of two error-correction procedures (word supply and word analysis) and a no-training control condition for children with moderate mental retardation and Down syndrome. The no-training control condition was identical to the previous study (Singh & Singh, 1984). However, in the word-supply condition, the experimenter supplied a correct word whenever participants incorrectly read a word in the text. In the word-analysis condition, the experimenter directed participants’ attention to various phonetic elements of the error word, requested participants to imitate the sounds and have participants read the whole word. Results showed that both error-correction procedures were more effective than the no-training condition. Moreover, of the two conditions, the word-analysis condition was
more effective than word-supply condition in decreasing errors and increasing self-corrections. These findings suggest that phonological skills may play a major role in helping children with disabilities decrease their reading errors and increase their self-corrections.

**Phonics and Phonemic Awareness**

Comprehension is the ultimate goal in teaching children to read. Unfortunately, without phonemic awareness and phonics proficiency, children with disabilities are unlikely to achieve that goal. Not only are these two skills essential for children to become skilled readers (Ehri, 2004), but they also prepare children to write words and remember correct spelling patterns (Griffith, 1991; National Institute of Child Health and Human Development, 2000).

More importantly, Barudin and Hourcade (1990) noted, without phonemic awareness and phonics, generalization of reading novel words would likely be minimal. Barudin and Hourcade further suggested that although phonics and phonemic awareness have limited daily utility, these skills are essential for acquisition of general functional academic skills. Furthermore, phonics and phonemic awareness can serve as the two best school-entry predictors of how well children will perform in reading during the first two years of instruction (Share, Jorm, Maclean, & Matthews, 1984).

Interestingly, although phonics and phonemic awareness play an essential role in teaching children to become skilled readers, a comprehensive review by Browder et al. (2006) found only a 14% of 128 reading studies conducted with individuals with cognitive disabilities included phonics (13) or phonemic awareness (5). Even more concerning, when these 18 studies were filtered through Horner et al.’s (2005) and
Gersten et al.’s (2005) indicators of quality research or evidence-based practices, only one phonics study and no phonemic awareness study met all quality indicators.

The one phonics study (Hoogeven, Smeets, & van der Houven, 1987) that met all quality indicators targeted letter-sound correspondences in children with moderate to severe mental retardation. Basically, pictorial cues were used as prompts and gradually faded as children mastered the targeted letter-sound correspondences. The targeted letter-sound correspondences were taught to participants in two phases. In the first phase, distinctive and accentuated features of common objects were used as pictorial cues. These pictures were selected based on the sounds associated with actions of these objects (e.g., the hissing sound /s/ of a snake). Moreover, these pictures were embedded with grapheme features (e.g., the picture of a snake was positioned in an S posture). With these pictures, participants were taught to emit the corresponding sounds. Once participants responded correctly to all the picture-sound correspondences, the second phase of the study began.

In the second phase, participants were taught to emit the same response to graphemes instead of the pictures (i.e., transferring stimulus control from pictures to graphemes). This was achieved by gradually fading out the pictorial elements while keeping the embedded graphemes. For example, the head of a snake was faded first, then the body, and eventually only a written S was presented. Results on 14-day maintenance probes indicated that participants’ mean percentage of correct responses was 99.8, and the mean percentage on 100-day maintenance probes was 84.6. These findings indicated that even children with moderate to severe disabilities can be taught letter-sound correspondences.
Unfortunately, this is the only known high-quality study that specifically emphasized teaching phonics (without any of the other components of reading) to children with moderate to severe disabilities. Clearly, more research is needed in the area of teaching phonics and phonemic awareness to children with disabilities, especially given the vital function these skills play in improving children’s reading ability. Specifically, research should focus on finding the most effective and efficient methods to teach phonics (Joseph & Seery, 2004) and phonemic awareness to children with disabilities.

Reading and Individuals with Autism

Another need also exists for research in teaching reading to children with autism spectrum disorder (ASD). The availability of literature on this population is even more scarce. Of the 1,123 participants found across 30 years of research studies, only 6% or 62 participants were identified with ASD (Browder et al., 2006). Specific to the phonics studies found by Browder et al., it was difficult to determine participants’ diagnoses. The participants were either labeled as unspecified or dually diagnosed with ASD and mental retardation. In a more recent review, Whalon, Al Otaiba, and Delano (2009) found only 11 studies from 1976 to 2008 that included participants with ASD. Studies that were excluded from this study (a) lacked a formal research design, (b) provided only sight word instruction, and (c) included an intervention targeting a skill other than reading even if reading was measured. Of the 11 studies, 4 targeted code-focused skills (e.g., word identification, sentence reading, letters reading, etc.), 5 targeted meaning-focused skills (e.g., sentence creation using vocabulary terms, comprehension and vocabulary answering, etc.), and the remaining 2 targeted both code- and meaning-focused skills.
Similar to other findings on children with other disabilities, Nation et al. (2006) also found that when comparing children with and without ASD, children with ASD performed poorly with decoding non-words. These children were performing at least two standard deviations below the population norm. This suggests that children with ASD might lack an essential reading subskill that may enable them to read: phonics (Joseph & Seery, 2004). Layng, Twyman, and Stikeleather (2003) also noted that in order for a reader to decode words instantaneously, the reader must be fluent in the sound-letter and letter-sounds relations. That is, learning phonics enables the reader to associate sounds to letters and to associate written language to combinations of letters. Children who do not receive systematic phonics instruction tend to have educational difficulty in years to come, if not corrected by the end of third grade (Layng et al.). Thus, phonics should be systematically taught to young children, particularly those with disabilities.

Reading Intervention and Generalization

Whereas many interventions have produced great reading outcomes (Wanzek, Vaughn, Kim, & Cavanaugh, 2006), few interventions have shown the capability to promote untrained generalization (Chafouleas, Martens, Dobson, Weinstein, & Gardner, 2004; Eckert, Ardoin, Daly-III, & Martens, 2002; Hitchcock, Prater, & Dowrick, 2004; Kennedy & Flynn, 2003; Kourea, Cartledge, & Musti-Rao, 2007). Kennedy and Flynn, for instance, employed a phonological-awareness-based intervention program that focused on alliteration detection skills, or the repetition of the first consonant sound in a phrase (e.g., “Peter Piper picked a peck of pickled peppers”), rhyme detection skills, phoneme isolation, and spelling for children with disabilities in an attempt to examine the
effect on the children’s ability to generalize the learned skills to other related skill areas such as phoneme segmentation and speech intelligibility.

Although the results indicated that all children improved in the phonological awareness skills targeted in the intervention, none of the children exhibited any generalization to other related skills. These findings led the authors to propose that explicit training that targets grapheme-phoneme (i.e., printed letter– sound) connections is needed to promote generalization. Eckert et al. (2002) found similar outcomes (i.e., the lack of generalized responding), although their study emphasized oral reading fluency. They noted that improvements in participants’ reading fluency was the product of explicit training during treatment, but little or no generalized improvement was observed when generalization tests were given.

On a similar note, even if an intervention was demonstrated to be effective in promoting generalization, a closer analysis revealed that additional training was necessary. Kourea et al. (2007), for example, used a peer-mediated intervention to teach academic skills, such as sight-word acquisition and maintenance to children at-risk for reading failure. Results indicated that in addition to the 80% of the children who made significant improvements in their sight-word acquisition and maintenance, all children’s reading fluency and comprehension scores were higher when compared to baseline. That is, these children demonstrated untrained generalization. Nevertheless, a closer look at the peer-mediated intervention revealed that there were many components of the intervention that may have facilitated generalized skills demonstrated by the children and that these children were able to read and understand what they read during baseline but at a lower rate. Of the numerous components of the intervention, one component that
seemed to play a vital part was the tutor huddle in which the children were provided with many opportunities to learn and practice the words across different persons. This component may have promoted the generalization through multiple exemplars and training loosely (Stokes & Baer, 1977). Furthermore, these children already demonstrated reading fluency and comprehension during baseline, and thus no new behavior was acquired except the improvement in the same skills.

These studies do not provide ample evidence that reading interventions are effective in producing untrained generalization; however, they do suggest that there are limitations in many reading interventions that researchers need to understand in order to find interventions that promote untrained generalization without explicit training.

*Teaching Generatively*

Lowenkron (2004a) defined generalization as the involvement of at least two types of responding, the generalized abstract and the generalized identity. According to Lowenkron (2004b), abstract responding is the ability to respond to different dimensions of stimulus relations, such as size (large or small), shape (square or triangle), color (green or red), or form (spoken or printed word), instead of responding to concert identical features (e.g., a particular color, shape, or shape) like in identity responding. In abstract responding, for example, when a participant sees a lower-case letter (e.g., a) she picks an upper-case letter (e.g., A), and when she sees a printed letter A she says /a/. On the other hand, in identity responding, when a participant sees a lower-case letter (e.g., c) she picks the same lower-case letter, and when she sees a letter written in red she picks the same letter written in red.
Specifically, generalized abstract responding is the ability to emit an appropriate response in the presence of novel stimuli with no regard to irrelevant dimensions, without direct training. Generalized identity responding is the ability to emit an appropriate response in the presence of novel stimuli with regard to identical features, without direct training. In essence, these terms refer to the same idea, the occurrence of an appropriate response in the presence of novel stimuli based on responses learned during training (Miller, 1997; Stokes & Baer, 1977; Stokes & Osnes, 1989).

Such ability to generalize learned skills without being taught explicitly is invaluable given that this ability enables struggling readers to make progress without receiving instruction for every new acquisition (Kennedy & Flynn, 2003). It is also a crucial skill people need to enjoy healthy, happy, and productive lives (Cooper, Heron, & Heward, 2007). For instance, Cooper et al. stated,

The most difficult and important challenge facing behavioral practitioners is helping learners achieve generalized change in socially significant behaviors. A behavior change – no matter how important initially – is of little value to the learner if it does not last over time, is not emitted in appropriate settings and situations, or occurs in restricted form when varied topographies are desired. (p. 653)

Baer (1999) also pointed out that an “effective” intervention must promote skill generalization. A copious number of studies have examined the effects of generalization procedures on numerous skills such as nonverbal imitation (Koegal & Rincover, 1977), blockbuilding (Goetz & Baer, 1973), eating (Van den Pol et al., 1981), and conversation imitations (Hughes, Harmer, Killina, & Niahos, 1995). Findings were similar to the
discussed reading studies; that is, participants required additional training in order to generalize learned skills.

**Generative Paradigms**

Within the behavioral literature, there are a few generalization paradigms that offer unique positions on the logic behind the occurrence of untrained behavior. These behavioral paradigms include stimulus equivalence, naming relation, and joint-control. To better describe these paradigms, principles, procedures, and Skinner’s (1957) verbal operants need to be described. See Tables 2.1 and 2.2 for terms, definitions and examples.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
<th>Example</th>
</tr>
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<tbody>
<tr>
<td>Classical conditioning or (Responding conditioning)</td>
<td>“A stimulus-stimulus pairing procedure. A neutral stimulus is presented with an unconditioned stimulus until the neutral stimulus becomes a conditioned stimulus that elicits the conditioned response” (p. 703)</td>
<td>The sound of a bell is paired with a biological stimulus (food), and as a result, the dog salivates to the sound of a bell, that had no such evoking power prior to the pairing.</td>
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<tr>
<td>Higher-order relation or (second- or high order condition)</td>
<td>“Development of a conditioned reflex by pairing a neutral stimulus with a conditioned stimulus” (p. 697).</td>
<td>The sound of the bell (conditioned stimulus) can also be paired with another neutral stimulus such as a flash of light. With pairing, the light also serves as a conditioned stimulus that evokes salivation.</td>
</tr>
<tr>
<td>Operant conditioning</td>
<td>“The basic process by which learning occurs; consequences results in an increased or decreased frequency of the same type of behavior under similar motivational and environmental conditions in the future” (p. 700)</td>
<td>Humans learn to make a car move forward or stop from the consequences of stepping on the gas or brake pedal.</td>
</tr>
<tr>
<td>Two-term contingency</td>
<td>A basic unit of analysis that includes the behavior and consequence</td>
<td>A baby says “balloon,” (behavior) and receives a balloon (consequence).</td>
</tr>
<tr>
<td>Three-term contingency</td>
<td>“The basic unit of analysis in the analysis of operant behavior; encompasses the temporal and possibly dependent relations among an antecedent stimulus, behavior, and consequence” (p. 706).</td>
<td>A baby sees a balloon (antecedent), says “balloon,” and receives the balloon (consequence).</td>
</tr>
<tr>
<td>Four-term contingency or (conditional discrimination)</td>
<td>“The interrelationship among contextual variables, antecedents, behavior and consequences” (Sulzer-Azaroff &amp; Mayer, 1991, p. 590)</td>
<td>A baby is hungry and sees both mom (who always feeds her) and dad (who always plays with her) in front of her. The baby would likely ask mom for food.</td>
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* Definition is from Cooper, Heron, and Heward (2007)

Table 2.1: Definitions of principles and procedures
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
<th>Example</th>
</tr>
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<tbody>
<tr>
<td>Mand</td>
<td>“An elementary verbal operant that is evoked by a motivating operation and followed by specific reinforcement” (p. 699)</td>
<td>After not eating for a couple of days (motivation), a person is likely to ask (mand) for food upon seeing the nearest person.</td>
</tr>
<tr>
<td>Tact</td>
<td>“An elementary verbal operant evoked by a nonverbal discriminative stimulus (SD) and followed by generalized conditioned reinforcement” (p. 705)</td>
<td>A baby sees a teddy bear and says, points to, and signs “bear.”</td>
</tr>
<tr>
<td>Echoic</td>
<td>“An elementary verbal operant involving a response that is evoked by a verbal SD that has point-to-point correspondence and formal similarity with the response” (p. 694)</td>
<td>Hearing a teacher say /a/, a toddler imitates the sound by also saying /a/.</td>
</tr>
<tr>
<td>Autoclitic</td>
<td>“A secondary verbal operant in which some aspect of a speaker’s own verbal behavior functions as an SD or an MO for additional speaker verbal behavior. The autoclitic relation can be thought of as verbal behavior about verbal behavior” (p. 690).</td>
<td>A person sees a red bird fly by and land on a nearby tree. Subsequently, the person says, “Find the red bird,” and repeats in a self-echoic way, while scanning the nearby tree for the bird. Upon seeing the bird, the person would say “red bird” reporting that one has found the red bird.</td>
</tr>
</tbody>
</table>

*Note:* All definitions are from Cooper, Heron, and Heward (2007)

Table 2.2: Definition and example of Skinner’s verbal operants

*Stimulus equivalence.* Stimulus equivalence is defined by its three properties of basic mathematic equivalence relations: reflexivity, symmetry, and transitivity (Sidman & Tailby, 1982; Sidman, 1990). Sidman and Tailby defined reflexive relation as “each stimulus bears the relation to itself” (p. 6). For example, linking stimulus A to stimulus A
may be seen as matching a printed letter to the same printed letter. Basically, the reflexive relation may be described as follows: if A, then A, and if B, then B. The reflexive relation is an excellent example of the identity match-to-sample (MTS; conditional discrimination training) procedure in which the sample stimulus and the comparison stimuli share identical features.

Unlike the reflexive conditional relation in which the relation between stimulus A to stimulus A holds true, the symmetric conditional relation is the relation between stimulus A (printed letter) to stimulus B (plastic letter) and stimulus A (printed letter) to stimulus C (spoken letter). (This conditional relation is occurring in an arbitrary MTS where the sample stimulus and the comparison stimuli do not share identical features.) This relation is also known as bi-directionality, because it may be described as follows: if A, then B and if B, then A. In particular, Sidman and Tailby (1982) stated, “Given a subject who is familiar with each of the stimuli separately, both as sample and comparison, the proof of relation A to B symmetry is functional sample-comparison reversibility” (p. 6). With the concept of reversibility or bi-directionality, one can say that the comparison stimulus could function as the sample stimulus and vice versa because the relation is symmetric. When a symmetric relation is demonstrated, generalized abstract responding has occurred.

For transitive conditional relation to exist, the prerequisite is to have reflexive and symmetric relations. To assess for a transitive relation, a third untrained relation is usually assessed after directly training two other relations. For example, having learned to connect the printed letter (A) as sample stimulus to the plastic letter (B) as the comparison stimulus, and having learned to connect the plastic letter (B) as the sample
stimulus and the spoken letter (C) as the comparison stimulus, the participant must then be able to connect the picture (C) as the sample stimulus and the objects (B) as the comparison stimulus and vice versa without explicit training, thus exhibiting transitivity or stimulus equivalence. Based on the description of the symmetric and transitive relations, they can be classified as generalized abstract responses. In this sense, stimulus equivalence is a form of generalization with the combination of generalized identity (reflexivity) responses and generalized abstract responses (symmetry and transitivity).

See Figure 2.1 for a diagram of the three relations.

![Figure 2.1: The stimulus equivalence paradigm. Solid lines denote relations that are explicitly trained (e.g., relations A-B and A-C). These explicitly taught relations are often referred to as baseline training since they are prerequisites training for the emergence of equivalence. Dotted lines denote relations that are untrained such as relations B-A and C-A (symmetry), B-C and C-B (transitivity), and the A-A, B-B, and C-C (reflexivity).](image)

In general, subsequent to the baseline training, equivalence tests are conducted by presenting the “training stimuli in pairs that were not presented during training and/or by
presenting trained stimulus pairs in reverse temporal order” (McIntire, Cleary, & Thompson, 1987, p. 393). Although these definitions and descriptions of stimulus equivalence are concise, they do not provide an explanation for the emergence of equivalence relations. And so, Sidman (1990) postulated a few explanations for the phenomenon. However, only one supposition that is relevant to the current study is presented.

Sidman (1990) speculated that stimulus equivalence is a fundamental behavior based on the contingencies of survival. It is a basic mechanism in which species’ behaviors are altered in accordance to the schedule of reinforcement and punishment for survival. In essence, humans are born with the ability to form equivalence relations based on experience. As such, equivalence is a primitive or a given ability that cannot be analyzed, and does not derive from more basic processes. However, at a later time, Sidman made some changes to his original speculation (Sidman, 1994, 2000). Specifically, he noted that the original assumption holds true (i.e., equivalence is primitive) but added that the phenomena of stimulus equivalence are the built-in effect of the reinforcement contingency. Reinforcement contingency is defined as the relationships among the antecedent stimuli, the behavior, and the consequences of this behavior (Pierce & Epling, 1999).

According to Sidman (1994, 2000), as a direct outcome of the reinforcement contingencies, not only are analytic units (i.e., the two-term, three-term, and four-term contingencies) generated, but the equivalence relations are also generated. This new notion is interesting in that all analytic units listed in this paper can produce equivalence relations rather than just the four-term contingency (conditional discrimination), as he
once believed. (The MTS procedures are used to teach participants to conditionally relate stimulus A to stimulus B, and relate stimulus B to stimulus C, and they are also used to assess the equivalence relation by testing if participants can relate stimulus A to stimulus C). Moreover, only the conditional stimulus (sample stimulus) and discriminative stimulus (comparison) serve as the controlling variables that connect the involved stimulus (e.g., A-printed letter, B-plastic letter, C-spoken) into a class. In other words, Sidman proposed that in addition to the four-term contingency, the three-term and the two-term contingencies are also effective in producing stimulus equivalence. Specifically, any variable within the analytic units, regardless of it being a stimulus, a response, or a reinforcer, may serve as a point to which all the variables are linked into a stimulus class, allowing the occurrence of the equivalence relations. All elements (e.g., conditional stimulus, discriminative stimulus, response, and reinforcer) of the four-term units are part of the equivalence.

Under the new supposition, the reinforcer and the response may also serve as sample or comparison stimuli. To do so, the reinforcer and response must be specified. See Figure 2.2 for a comparison between a standard conditional discrimination procedure (MTS) and the modified version with a defined reinforcer, called outcome-specific reinforcement contingencies (Sidman, 1994, 2000). Figure 2.2 (Panel A) represents a standard conditional discrimination procedure in which the reinforcer is not defined, and Panel B represents the outcome-specific reinforcement contingencies in which the reinforcer is defined.
Figure 2.2: Panel A depicts standard conditional discrimination and Panel B depicts the outcome-specific reinforcement procedures. This Figure is adapted from Sidman (1990).
As one can see, there are two sets of stimuli involved in this illustration. One set of stimuli is denoted as A1 (conditional stimulus), B1 (discriminative stimulus), R1 (response), SR1 (reinforcer), and the other set of stimuli is denoted as A2, B2, R2, SR2. Notice that in the standard conditional discrimination procedure, the reinforcers used between the two sets of stimuli are kept constant (e.g., SR1 [candy] was used in both A1 and A2 conditions), whereas the outcome-specific reinforcement contingencies used different types of reinforcers (e.g., SR1 [candy] was used for condition A1 and SR2 [cookie] was used for condition A2). According to Sidman, procedures carried out under the outcome-specific reinforcement contingencies would allow the candy (SR1) or the cookie (SR2) to serve as the sample stimulus and the former samples (A1 and A2) or the former comparisons (B1 and B2) to serve as comparison stimuli, thus allowing the test for the supposition. If the supposition holds, then participants would be able to match SR1 to A1 and B1, and SR2 to A2 and B2 because each reinforcer has served as a binding factor to attach the involved stimuli into a class. A few studies (Dube, McIlvane, Mackay, & Stoddard, 1987; Dube, McIlvane, Maguire, Mackay, & Stoddard, 1989; Kastak, Schusterman, & Kastak, 2001; McIlvana, Dube, Kledaras, de Rose, & Stoddard, 1992) provided some evidence for this postulation. However, these studies were not conducted according to Sidman’s specifications with the exception of Kastak et al. In particular, Kastak et al. successfully used a class-specific reinforcer to train sea lions to classify dissimilar stimuli into equivalence classes and demonstrate that the specified reinforcer can become member of an equivalence class.

Similarly, when the response is defined, it should have the same effect as the defined reinforcer. The defined response should acquire the binding power to attach the
involved stimuli into a class. Figure 2.3 illustrates this. Panel A represents A-B conditional discrimination training, Panel B represents B-C conditional discrimination training, and Panel C represents testing for B-C relation or equivalence.
Figure 2.3: Stimulus equivalence paradigm. Panel A denotes training A-B relations, Panel B denotes training B-C relations, and Panel C denotes the assessment for stimulus equivalence C-A. In Panel C, stimulus equivalence is demonstrated when participants, contingent on C1, presses A1 two times and contingent on C2, presses A2 three times. This Figure is adapted from Sidman (1990).
Starting at Panel A, the sample (A₁ or A₂) is followed by R₁, and the comparison stimuli (B₁ and B₂) are followed by R₂ for B₁ and R₃ for B₂. R denotes the response, and the number next to it denotes the number of responses. So, for example, R₁ is pressing the button one time, R₂ is pressing the button two times, and R₃ is pressing the button three times. The responses are defined by the number of times the button is pressed. So, in the A-B conditional discrimination training, following the presentation of the sample stimulus (A₁ or A₂), the participant is required to press the sample button one time (R₁) which leads to the simultaneous presentation of the comparison stimuli (B₁ and B₂). And conditional upon the sample stimulus (A₁), the participant pressing the comparison stimulus (B₁) two times (R₂), and conditional upon the sample stimulus (A₂), the participant pressing the comparison stimulus (B₂) three times (R₃) will lead to reinforcement (SR₁). In the B-C conditional discrimination training (Panel B), an identical process takes place except that the involved stimuli being formally presented as the comparison stimuli (B₁ and B₂) in A-B conditional discrimination training are now the sample stimuli, and the new stimuli (C₁ and C₂) are the comparison stimuli. In both A-B and B-C relations training, the reinforcer (SR₁) stays constant. Having learned the relations between stimulus A to stimulus B and stimulus B to stimulus C, testing is conducted to see if the participant can correctly match stimulus A to stimulus C and vice versa (Panel C). For example, stimulus equivalence is demonstrated when the participant is able to correctly match the two stimuli by, in the presence of stimulus C₁, pressing A₁ two times, and in the presence of stimulus C₂, presses A₂ three times. If the participant passes the equivalence test, then Sidman’s (1994, 2000) speculation is correct in that by assigning a characteristic to the responses, it allows the responses to become substitutable.
stimuli within the stimulus class. Unfortunately, this is only a speculation based on previous findings from studies (Dube, et al., 1987, 1989; McIlvana et al., 1992) that are inadequate to confirm its accuracy. No study has been done in accordance with the training schematic Sidman suggested.

Further in-depth analysis of this supposition reveals a problem. For instance, in Figure 2.2 (Panel A), if defining the reinforcer results in attaching the involved stimuli into a class, then A1, A2, B1, and B2 would not become two separate stimulus classes, but rather a large stimulus class, given that both sets of stimuli use the same reinforcer (SR1) during training. Interestingly, training in this manner has always been the standard and a predictable method to establish separate classes of equivalence. Here is where the new speculation runs into a problem. It contradicts a method that has been demonstrated to be effective in prompting equivalence through strong empirical support. As a solution, Sidman (2000) proposed the following:

Our theory requires us to assume that when the two outcomes of the reinforcement contingency come into conflict, the analytic unit takes precedence over the equivalence relation… in order for the common response and reinforcer elements to retain their membership in the analytic unit, they must selectively drop out of the equivalence relation… making it possible for the smaller classes.

(p. 132)

Essentially, Sidman predicts that the analytic unit or training structure will take priority over the influence of reinforcement in establishing the equivalence relations, allowing A1, B1 and A2, B2 to form (Figure 2.2). That is, if a common reinforcer is used during training, the common reinforcer will lose its effect as a binding factor in uniting
the two classes of stimuli into a larger class, and the training structure will take over in uniting each set of stimuli into a separate stimulus class. However, no empirical evidence is available to support this account.

Sidman (1994, 2000) further speculated that the origin of equivalence can also come from classical conditioning (respondent conditioning). Using the example aforementioned, after the bell is paired with food, it also acquires the same evoking power like food. For example, prior to conditioning, the dog only salivates in the presence of the food, but not the sound of the bell. Subsequent to the conditioning, the dog salivates in the presence of food and the sound of the bell, indicating that they may have become functionally the same. This postulation leads Sidman to rethink the primary role of classical conditioning: Not only is classical conditioning effective in establishing conditioned stimulus, but it also may play a crucial part in the formation of equivalence relations. Logically, this may be true given that pairing also occurs in the three-term contingency in which the discriminative stimulus is correlated with the reinforcer, which resulted in the discriminative stimulus gaining evoking power over the response. With this speculation, Sidman concluded that all analytic units can establish equivalence relations, not just the four-term contingency. For instance, since the four-term contingency influences the three-term, the three-term influences the two-term, and in reverse, the stimulus-response (classical conditioning) is somehow connected to the three-term, these variables seem to fit together. However, no findings have yet supported this speculation.

In summary, Sidman (1994) answered the question of where equivalence relations come from with this answer: “The reinforcement contingency creates the (analytic) unit
and with it, the equivalence relation… the establishment of equivalence relations is, then, one of the outcomes of reinforcement contingencies” (p. 387). In other words, because of the role of reinforcement and the structure of the analytic units, equivalent relations would be emergent. As an analogy, the training sequence (analytic units) and the effects of reinforcement will automatically produce a situation in which it may serve as a pot where stimuli that are placed inside are assorted, thus ensuring one variable from the pot can represent the others within the same pot. To Sidman, this is a satisfying answer to the origin of equivalence relations, no other explanatory notion is necessary.

**Naming.** On the contrary, Dugdale and Lowe (1990), McIntire, Cleary, and Thompson (1987), Horne and Lowe (1996), and other researchers strongly disagreed with Sidman’s (1990, 1994, 2000) theory. Rather than accepting the emergence of equivalence relations as a given, these researchers argued vehemently that equivalence relations do derive from something more basic: response mediation. Response mediation theorists assume that “mediating responses must occur, although perhaps in a reduced form, when a participant demonstrates either baseline or emergent stimulus-stimulus relations” (Sidman, 1994, p. 380). In other words, unobservable responses must occur between each related pair of stimuli to serve as the “mediating event,” thus allowing a participant to link one stimulus to another. Simply speaking, the mediating event is a device that connects the stimuli together (McIntire et al., 1987).

Nevertheless, the term *response mediation* was eventually replaced by *naming* (in its early stage) for the lack of an accurate and consistent definition (Dugale & Lowe, 1990). In addition to the definition of response mediation as defined, naming also incorporated language or verbal responses into its definition. Conceptually, response
mediation and naming are the same. Both concepts presume that a mediating event is required for the establishment of equivalence relations. However, naming is not merely a simple mediating event but rather it is described as a symbolic skill (verbal responses; Dugdale & Lowe), having properties of symmetry that functions as a bridge to connect arbitrary stimuli.

For example, Lowe and Beasty (1987) demonstrated the naming function with the experimental paradigm presented in Figure 2.4. In this study, during baseline training (A-B, A-C), participants were taught to link the vertical line sample stimulus (A) to a green comparison stimulus (B) and to link the vertical line sample stimulus (A) to a triangle comparison stimulus (C). Theoretically, after the baseline training, participants should demonstrate stimulus equivalence by linking (B) to (C) and (C) to (B). However, only some participants passed the equivalence test. Accordingly, Lowe and Beasty then taught participants who failed the equivalence tests to say “Up-Green” on the A-B baseline trials and “Up-Triangle” on the A-C baseline trials. Consequently, assigning the verbal responses to the stimuli resulted in the immediate emergence of equivalence relations (B-C and C-B). As a result, Dugdale and Lowe (1990) reasoned that because both the triangle and green stimuli controlled the common spoken word “Up,” these two stimuli became equivalent. As such, they believe that by assigning a common spoken name to the stimuli, the name may have become the active contributing factor for the emergence of stimulus equivalence.
Furthermore, Dugdale and Lowe (1990) speculated that naming would involve language production (e.g., verbal response evoked by a particular stimulus) and comprehension (e.g., selection of a comparison stimulus based on a particular verbal stimulus). In this sense, naming would require the participant to function both as a speaker and a listener (Skinner, 1957). The verbal response would serve as the true emergent of symmetrical relation in linking two stimuli into a class. According to this account, the participants in Lowe and Beasty’s (1987) study learned to name the stimuli (taught to emit a particular response in the presence of each member of the involved stimulus [a vertical line, green, triangle]), and as a result, gained the ability to establish a symmetrical relation between the stimuli (the sample and comparison stimuli) thus
allowing them to successfully pass the equivalence tests. The participants’ successes, Dugale and Lowe theorized, may have been the outcome of the verbal responses becoming symbolic and serving as a common name to the involved stimuli.

Moreover, Dugale and Lowe (1990) claimed that not only is naming necessary for equivalence but also for the forming of a bidirectional or symmetrical relation between two visual stimuli. For instance, when two visual stimuli are involved in a symmetrical relation, it is called stimulus-stimulus symmetry. However, when a stimulus (visual) and a response (spoken) are involved, it is called stimulus-response symmetry (naming is stimulus-response symmetry). According to Dugale and Lowe, visual-visual (or stimulus-stimulus) symmetry requires the component of naming, suggesting that the schematic of stimulus-stimulus symmetry would be described as stimulus-response-stimulus. That is, the response serves as a common name, or symbolizes that all involved stimuli are the same. From this view, the equivalence relation is not a given built-in survival mechanism dependent on the reinforcement contingencies (Sidman, 1990, 1994, 2000) rather it is derived from something more basic, naming (Dugdale & Lowe). Dugdale and Lowe further hypothesized that naming emerges naturally as part of the human’s linguistic development cycle as humans are repeatedly exposed to reinforcement contingencies such as receiving reinforcement for correct stimulus-response relation (e.g., sees printed word car and says “car”) and stimulus-response reversals (e.g., hears /car/ and selects printed word car). Interestingly, like other researchers (Randell & Remington, 2006; Stromer, Mackay, & Remington, 1996), Dugdale and Lowe concluded their paper suggesting that naming cannot be identified with topographical features alone and should be analyzed from a functional analysis of verbal behavior.
One of the main criticisms was that the naming account is another hypothetical construct used in the explanatory process because it cannot specify where the naming derived from. In response to the criticisms, Horne and Lowe (1996) incorporated Skinner’s analysis of verbal behavior and the theoretical work of social behaviorists Vygotsky and Mead in an attempt to redefine the definition of naming, describe where naming come from, and how it gives rise to the emergence of equivalence relations. However, only the information relevant to the current study is reported in this paper. Other unrelated suppositions proposed in Horne and Lowe’s article are beyond the scope of this paper.

Unlike the previous naming definition in which Dugdale and Lowe (1990) used linguistic terms such as *language production* and *comprehension*, the new definition includes some of Skinner’s basic verbal operants (Horne & Lowe, 1996). Although there is a change from the linguistic to behavioral paradigm, one component remained the same. The naming account is still viewed as a circular relation in that it requires the behaviors of both the speaker and listener to occur under the same skin (Skinner, 1957). That is, these two behaviors do not occur in two persons, where one acts as a speaker and the other acts as a listener, but within one person. This involves a person not only acting as a speaker, but also as a listener responding to their own speaking response (more about this later), thus displaying the circular relation. The circular relation is demonstrated when one sees an apple, says “apple,” and upon hearing one’s own voice /apple/ (hearing will be denoted by slash [/] symbols) attends to the apple again (Figure 2.5, Panel A). In essence, the naming relation comes directly from the tact and the echoic operants. Using the same example provided, seeing an apple and saying “apple” would be the tact, and
hearing one’s own voice and repeating the word “apple” would be the echoic, leading one back to seeing the apple, therefore forming a full circle.

Figure 2.5: All three panels (A, B, & C) illustrate the circular relation in the naming account. Panel A represents what occurs in a conditional discrimination training of spoken word-object relation. Panel B represents what occurs in a conditional discrimination training of spoken word-written word relation. And Panel C represents an emergence of a common name (“apple”) from which equivalence relations derived. This Figure is adapted from Horne and Lowe (1996).
In this sense, the emergence of equivalence relations and bi-directionality may be explained using the circular relation concept (Horne & Lowe, 1996). Suppose on baseline training trials (A-B, A-C relations) using an auditory-visual MTS procedure where stimulus A is a spoken word “apple,” stimulus B is a picture of an apple, and stimulus C is a printed word apple, a participant establishes equivalence relations as follows: Upon hearing the spoken word /apple/, the participant sees the comparison stimulus (can be a picture [Figure 2.5, Panel A] or printed word of an apple [Figure 2.5, Panel B] depending on the relation training). She then says “apple” (echoic), which is followed by repeating “apple” (self-echoic) and orienting to the comparison stimulus. As a result, the word “apple” becomes a common name for all the involved stimuli, thus creating the stimuli equivalence (Figure 2.5, Panel C). During the equivalence tests (B-C, C-B relations), in the presence of a sample stimulus (either the picture of an apple or the printed word apple), it would evoke the participant to say the common name “apple” (tact), and she repeats (self-echoic) the word again upon hearing herself saying /apple/. Subsequently, the participant would select whichever corresponding comparison stimulus that is available thus demonstrating equivalence (Figure 2.5, Panel C). Presumably, the same explanation may also apply to visual-visual equivalence. For example, if the involved stimuli are novel abstract symbols, the participant may look for resembling features among the involved stimuli and give them a common name that is only applicable to the participant. With a common name, the process of establishing equivalence would be the same as the auditory-visual equivalence.

Yet, one question still remains: How did the participant learn to name? To explain this, a similar diagram to Horne and Lowe (1996, p. 200) is used (see Figure 2.6). In
addition to explaining how naming is learned, the figure also illustrates the development of the circular relation in respect to the listener and speaker behavior. More to the point, the figure’s overview represents the interactions between the participant (a child; represented with the inner box) and her verbal community (could be a parent, relative, sibling, and so on; represented with the outer box). The diagram starts with an arrow symbol containing (START 1). Here, in the presence of the child, the parent sees the apple, points to an apple (object), and says “apple.” Upon seeing the apple and hearing /apple/ from the parent, the child orient toward or points to the apple. Seeing the child looking and pointing to the apple,” the parent praises the child “yes, it is an apple.” Hearing /yes, it is an apple/ serves as a reinforcer for the child’s pointing or selecting response under the conditions of seeing an apple and hearing /apple/. Up to this point, the child still needs the parent’s prompt to evoke the pointing response. However, after many trials, the correlation between seeing an apple, hearing /apple/, pointing to the apple, and hearing the praise /yes, it is an apple/, the spoken name “apple” eventually becomes a discriminative stimulus for the child to point to the apple independently without parental prompts. Horne and Lowe argued that this is how the child learned the listener’s behavior. In other words, the listener’s behavior is demonstrated when in presence of hearing /apple/ the child points to, orient toward, or selects a stimulus that specifies what she heard.

From this point (Figure 2.6, START 2), the child can not only independently point to an apple in response to hearing /apple/, she can also say “apple” in the presence of an apple (demonstrating symmetry or bidirectional relation). Horne and Lowe (1996) argued that the ability to do this is the result of the reinforcement the child received for pointing
or orienting at the object in the presence of seeing an apple and hearing /apple/. This takes us back to the circular relation example provided earlier. In the presence of an apple (object), the child tacts the object by saying “apple” which she repeats after hearing her own response /apple/ (echoic). As a result, the child points to or orients back to the apple (object) again. Here, the child demonstrates the speaker behavior. With training, the listener and speaker behavior of the child merges into the circular relation as a higher order relation.

To summarize, numerous studies (Horne, Lowe, & Harris, 2007; Randell & Remington, 2006; Stromer et al., 1996; Dugdale & Lowe, 1990) have shown the role of naming as the vital key component in producing stimulus equivalence. Specifically, Horne et al. (2007) assessed the ability of preschool age children to pass equivalence tests after teaching them a hand sign as a common name to represent one set of stimuli. Results indicated that teaching a common name using a hand sign was effective in producing equivalence relations in these children. This completes the naming account in which the child has learned the ability to name stimuli, which involves both the speaker and listener behavior in a circular relation. As such, “Naming involves the establishment of bidirectional or closed loop relations between a class of objects and events and the speaker-listener behavior they occasion” (Horne & Lowe, 1996, p. 200).
Figure 2.6: A diagram explaining how naming is learned by a child. The inner box represents the child’s responses and the outer box represents the caregiver’s response. The curvy arrows indicate the circular relation in naming and the dotted arrows indicate the sequence of events occurring between the child and caregiver. This Figure is adapted from Horne and Lowe (1996).
Joint (stimulus) control. Alternatively, there is another explanation for the occurrence of equivalence relations, joint control. Although both the naming and joint-control paradigms are similar in that they both used Skinner’s analysis of verbal behavior, they are different logistically in interpretation and in the use of Skinner’s verbal operants. Moreover, the joint-control account involves three verbal operants (e.g., tact, echoic, and descriptive autoclitic; see Table 2.2) instead of two (e.g., tact and echoic), like in the naming relations.

See Figure 2.7 for a schematic account of joint control. Provided with the definition and description of joint control, the next section of the paper will determine the effectiveness of the account in explaining the occurrence of equivalence relations under this account. Using Figure 2.7 (Panel A) as an example of what occurs during A-B relation training, one can also assume the same phenomenon to occur with A-C relation training, where C is represented by a picture of the cup (Figure 2.7, Panel B). And so, with the baseline training (A-B, A-C) completed, the test for equivalence would be to assess if the participant can respond appropriately when stimulus C (picture of a cup) serves as the sample stimulus, formerly the comparison stimulus during baseline training, and the stimulus B (actual cup) as the comparison stimulus (Figure 2.7, Panel C), and vice versa. For instance, from the figure, one can see that the mechanism of joint control works the same as in the baseline training (A-B, A-C) and equivalence tests (C-B and C-B), except that during the tests, the tact (“cup”) is initially emitted in the presence of the sample stimulus (picture of a cup or actual cup) prior to engaging in the self-echoic of the same word. In this case, the explanation for the emergence of equivalence appears to be based on the tact (give the stimulus a name) and joint control. As a result of the baseline
training, the participant has learned a common name for the involved stimuli, allowing
the occurrence of the tacting response in the presence of the sample stimulus (an
explanation of this phenomenon will be discussed in the next section). However, for
equivalence to emergent (B-C, C-B), joint control must occur. That is, after tacting the
sample stimulus (picture of a cup or actual cup) initially, the participant would engage in
a self-echoic response, and upon tacting the comparison stimulus (picture of a cup or
actual cup), the two responses (self-echoic and tact) at that instance would jointly evoke a
common response, “cup” and the selection response (selecting the appropriate
comparison stimulus).
Figure 2.7: A schematic account of joint control. Panel A indicates what occurs within the A-B relation training, Panel B indicates what occurs within the A-C relation training, and Panel C indicates the account of joint control during equivalence training. This Figure is adapted from Lowenkron (2004).
However, where did joint control originate? Rather than relying on a higher-order relation (Lowenkron, 2004a) like naming, or a given factor like stimulus equivalence, the joint control model explains the phenomenon of equivalence through behavior principles.

The development of joint control comes from three unmediated operants (Panels A, B, and C) as shown in Figure 2.8. However, once acquired, these unmediated responses eventually interact and turn into mediated responding under joint control (panels F and G). Although the simple operants appeared to be labeled in an alphabetic manner, a participant (child) can learn them in any given order.

The first operant (Panel A) is generally referred to as unmediated selection in a conditional discrimination. Upon hearing the spoken word sample stimulus /cup/, the participant is prompted to select a cup (object) from among an array of other objects. As a result of responding correctly, the participant’s behavior is reinforced, thus increasing the probability of pointing to or selecting the actual cup in the presence of hearing /cup/ in the future. The second operant (Panel B) is described as an echoic. Here, upon hearing the word /cup/ the participant repeats the word “cup,” and as a result of reinforcement, the probability of repeating the word is increased in its presence. The third operant (Panel C) is the tact. Here, in the presence of the cup, the participant is prompted (e.g., What is this?) to emit the correct response “cup.” As a consequence for the correct response, the participant receives a reinforcer, which increases the probability of that response occurring in the presence of the cup. Following the acquisition of these three unmediated operants, it sets the occasion for them to interact, and as a result of reinforcement, affect the participant in the following ways.
Figure 2.8: Schematic account of how joint control is developed. Bolded words represent words spoken by others; /slash/ represents words heard by participant; non-bold words represent words spoken by participant. This Figure is adapted from Lowenkron (2004).
First, it allows the echoic to be functional in a more complex environment. This complex environment is generated when, in a conditional discrimination, the presentation of the comparison stimuli is delayed rather than the simultaneous presentation of the sample and comparison stimuli as shown in Panel A. For example in Panel D, upon hearing /cup/, the participant repeats “cup” (echoic), which turns into a self-echoic while waiting for the comparison stimulus to appear. Eventually, the comparison stimulus (an actual cup) appears thereby allowing the participant to select the correct comparison stimulus (Panel E) as the result of joint control. Specifically, while the self-echoic (Panel D) is still occurring, the presentation of the comparison stimulus also turns the word “cup” into a tact (Panel C). Thus, as the participant encounters the comparison stimulus (the cup), saying the word “cup” now served as both a tact and a self-echoic demonstrating the onset of joint self-echoic/tact control.

Subsequently in Panel F, given that the participant has already learned to select the cup in the presence of its name or hearing /cup/ (as shown in Panel A – unmediated selection), this unmediated selection occurs here and is reinforced. The selection of the cup also evokes a tact that enters the currently rehearsed self-echoic and is also reinforced. Finally Panel G, it shows that the participant is able to demonstrate generalized performance (equivalence relations) after receiving many different name-object combinations (e.g., spoken word to picture, spoken word to object, spoken word to sign, etc.) training as illustrated in Panel F. Through the different name-object combinations training, Lowenkron (1998) declared that joint control has become “a generic stimulus event for selecting stimuli… [since during training], selections of objects that enter into joint control are differentially reinforced because the joint-control
event itself is the only stimulus event that consistently precedes all reinforced selections” (p.92). That is, once a participant has learned to respond under joint control, further training in object-word responding (e.g., actual apple to “apple”) would produce untrained word-object responding (i.e., selection of object [actual apple] as the comparison stimulus in the presence of its name [“apple”]; symmetric relation).

For instance, referring back to Figure 2.8 (Panels A and B), during A-B and A-C relations training, in the presence of hearing /cup/, the participant rehearses the word while at the same time scanning the objects or pictures of the objects. At that point, the event of joint control has not occurred yet because the participant does not know how to tact the object or picture yet. However, once a participant has selected a correct object, the word “cup,” along with the object or picture, enters into joint control that then is followed by reinforcement which strengthens the joint control event of uniting the echoic with the object or picture, thereby producing a common name “cup” for the object and picture.

There is a major difference between the naming relation and the joint-control paradigm in their account to elucidate the emergence of equivalence relations. Unlike the naming relation in which the process of achieving equivalence relies on a circular relation (Figure 2.5), the joint-control account explains the process of achieving equivalence through the multiple sources of control (Lowenkron, 1998). That is, more than one factor is controlling a single verbal response. However, Lowenkron pointed out that the sources of control in joint control do not come from the multiple controls (e.g., multiple causation and supplementary stimulation) as Skinner (1957) suggested. According to Lowenkron (1998), Skinner’s multiple controls are defined as:
In the case of multiple causation... several stimuli contribute strength to the initial evocation of a single response, and under supplementary stimulation... one or more stimuli contribute strength to the ultimate evocation of a topography that has been determined by prior events. (p.331)

The joint control model, in contrast, does not fall under Skinner’s multiple controls, but rather a third one, which Lowenkron and colleagues (Lowenkron, 1984, 1991, 1998, 2006a; 2006b; Lowenkron & Colvin, 1995) called joint (stimulus) control. In joint control, the selection response (as in selecting a comparison stimulus) is not evoked by multiple variables but by a single event:

The occurrence of joint control over some other topography, generally the topography rehearsed as the duplic. Thus, when the appropriate comparison was encountered, the rehearsed response was no longer solely a self-duplic, because now, with no change in its topography, it could also be emitted as a tact for that shape. (Lowenkron, 1998, p. 331)

In other words, the joint control event evokes the selection response, not the other multiple sources of control. And so, the joint control model is based on a third type of multiple controls (Lowenkron) and existing behavior principles to explain the emergence of equivalence relations.

Findings from studies (Gutierrez, 2006; Lowenkron, 1984, 1988, 2006a; Lowenkon & Colvin, 1995, Sidener & Michael, 2006; Tu, 2006) have strongly supported this notion. In particular, Sidener and Michael replicated a study conducted by Lowernkon (1984) which served as the foundation of joint control. Sidener and Michael assessed preschoolers’ ability to perform generalized identity responding with spatial
orientation of two-dimensional shapes subsequent to receiving training with and without overt mediating stimulus. A handheld device was used as the overt mediating stimulus to “symbolize” or code the two-dimensional shapes. Results indicated that preschoolers who received training with the overt mediating stimulus performed better in generalized identity matching than preschoolers who were not trained.

In summary, each of the three paradigms provides an explanation for and supports the origin of untrained relations. In Sidman’s account, equivalence relations are basic survival mechanisms in which further analysis is not possible. The emergence of the untrained relations is unmediated, and they come directly from the contingency of reinforcement, and in particular, from the analytic units. Because of the structure of the analytic units, stimuli and responses encompassed within an analytic unit become equal to each other. Simply speaking, any stimulus or response selected from within a particular analytic unit is said to be substitutable to all the other stimulus and responses included in same unit. And so, stimulus equivalence is just part of the process of these contingencies.

The naming account, however, assumes that the emergence of equivalence relations does come from more basic units. These basic units, the tact and the echoic operants, serve as a mediating event or name between stimuli. Assumingly, this naming event occurs in a circular relation. Moreover, the mediating event or name also functions as a common name for the involved stimuli thus connecting them together. However, with this model, the mediating event or naming relation is said to derive from a higher-order relation that humans learned through their verbal community.
Joint control also uses Skinner’s verbal operants (tact, duplc, and autoclitic) to explain the reason behind the origin of equivalence relations. Unlike the naming model, joint control does not occur in a circular relation, but rather it comes from the controls of multiple sources, mainly the echoic and the tact. Instead of relying on higher order relation for explanation in naming, the joint-control relies on empirically supported behavior principles.

Limitations of the paradigms. Unquestionably, the stimulus equivalence paradigm has been the most influential model in both practical and theoretical perspectives of behavior analysis. To be precise, this paradigm has greatly contributed to the applied settings as the model procedure in facilitating equivalence relations. And, its theoretical perspective has generated controversies from which other models (naming and joint control) are derived. However, as explained earlier, many researchers believe that the theoretical framework of stimulus equivalence is limited. This shortcoming, as pointed out by Lowenkron, (1998, 2006a), Horne and Lowe (1996), and Dugdale and Lowe (1991), is the use of unmediated selection account as the explanatory factor for the phenomena of equivalence relations. (Stimulus equivalence training, in general, uses a conditional discrimination procedure). That is, the selection response (selecting a comparison stimulus) evoked in a conditional discrimination is unmediated. This is because the sample stimulus does not “specify” (no response mediation) like a common name does, but rather it sets the occasion for one of the comparison stimuli to become a discriminative stimulus as a result of reinforcement (Lowenkron, 2004).

To elaborate, an unmediated selection account assumes that in the presence of a conditional stimulus (sample stimulus) it makes one of the comparison stimuli to function
as a discriminative stimulus for its own selection thus leading to reinforcement. For this reason, the probability of the selection response (pointing to the correct comparison stimulus) occurring is increased in the presence of the conditional stimulus (sample stimulus). Under this account, only the sample and comparison stimuli that are trained would evoke a particular selection response, and nothing else. In other words, if the strength of the controlling stimulus is strong, then the probability of the selection response occurring is high. On the other hand, if the strength of the controlling stimulus is weak, then the probability of the selection response occurring is low. In this sense, both identity and arbitrary matching are treated the same, since “virtually any stimulus may act as a conditional stimulus for any discriminative stimulus” (Lowenkron, 2006a, p. 124) to trigger a particular selection response. Thus, the conditional stimulus (sample) gaining power in making one of the comparison stimuli a discriminative stimulus is in no way said to be representational: the conditional stimulus does not “specify” for the selection response, but rather it is due to the reinforcement history. Simply speaking, a particular selection response would only occur in the presence of a trained stimulus.

Ultimately, the unmediated selection account leads to a few problems. This account cannot explain the emergence of novel responding to identical relations (i.e., generalized identity matching, Lowenkron, 2004). For example, as shown in Figure 2.9 (Panel A), after a participant receives training in identity matching, triangle to triangle and square to square, the participant is not expect to be able to select circle to circle because this relation was not trained.
Figure 2.9: An example of identity (Panel A) and arbitrary (Panel B) matching-to-sample procedures.

Likewise, (Panel B), similar results should also be obtained for arbitrary matching given that the unmediated account operates the same way for both identity and arbitrary matching. Interestingly, for the most part, the arbitrary MTS procedure is used during baseline stimulus equivalence training (A-B, A-C). As a result of the training, the participant demonstrates not only reflexivity (generalized identity matching) but also other relations. As such, the unmediated selection account encounters problems. One, the identity MTS procedure was not even used during baseline training, so where does the reflexive relation come from? And even if the identity MTS procedure was included
during training, the unmediated selection account does not support such identity
generalization. Two, if the unmediated selection account holds true, then symmetry and
transitivity relations cannot possibly exist. To the contrary, these three relations, often
times, do emerge as the product of the stimulus equivalence baseline training.

Logically, the unmediated selection account also cannot explain the emergence
of word-object generalization (i.e., generalized arbitrary matching; Horne & Lowe, 1996;
Lowenkron, 2004). For example, as shown in Figure 2.10, the participant is trained to
select “Triangle over circle” and “Square over line” under the arbitrary MTS procedure
and as a result demonstrates word-object generalization by correctly responding to
“Square over circle” and “Triangle over line.” Once again, under the control of
unmediated selection, this is not possible since any stimuli acquiring evocative strength
does not specify or represent something. That is, the controlling stimulus does not “stand
for” something; it merely evokes a selection response at a higher or lower rate, which is
due to the history of reinforcement.
Likewise, Lowenkron (1996) pointed out that the naming relation also shares the problem in explaining the emergence of equivalence. Recall, according to the naming account (Horne & Lowe, 1996), the naming relation requires two kinds of behavior, the listener and speaker. The listener behavior is verified when an individual, in response to a spoken name, orients toward and points to its corresponding object (name-object relation). As for the speaker behavior, it is demonstrated when the individual, in the presence of the object, emits the object’s name (tact; object-name relation), and repeats
the spoken word based on prior repetitions (self-echoic). Through many training trials, these two relations (name-object and object-name) merge into a higher order, bidirectional relation, such that “the presence of either one [relation] presupposes the other” (Horne & Lowe, p. 207). One way to look at this is: if one relation (name-object or object-name) is acquired, the other relation will automatically appear without additional training. And so, a new alternative relation emerges as a result of the covert practice of the naming relation elements (e.g., the tact and echoic occurring in a circular relation).

For example, during object-name training (speaker behavior), the participant looks at the new object in response to the trainer’s and his own spoken name. Consequently, because of the circular relation in naming, the object-name training also results in name-object pairing thus allowing the participant to match the object (comparison stimulus) in response to its spoken name (sample stimulus) in a conditional discrimination. Assumingly, during the object-name relation training, the name-object relation is also somehow strengthened without reinforcement. This is where the problem becomes visible. As Lowenkron (1996) pointed out, “during spontaneous name-object pairing, responding to the object under the control of its name is never differentially reinforced… subjects just rehearse the new name while looking at the new object [during object-name pairing]… [so]… what behavioral process is this? Memory?” (p. 253).

Suppose a pen is used as the object during object-name relation training, and we want to see how this training would come to affect the name-object relation according to the naming account. So, during object-name training, the training sequence would probably occur in this manner: In the presence of a pen, the trainer would point to the pen and say “pen.” Upon seeing the pen and hearing /pen/, the participant would also repeat
“pen” and eventually say “pen,” which would result in reinforcement. On the other hand, if the participant does not say “pen” but say “pencil,” no reinforcer is delivered, thus the behavior (“pen”) is differentially reinforced in the object-name relation that contributes to saying “pen” in the presence of the pen. According to the naming paradigm, once the participant learned the object-name relation, he should also be able to perform the name-object relation without training (bidirectional responding). However, why is the participant able select the pen in the presence of its name /pen/ during the name-object relation test, even thought this behavior was never differentially reinforced during object-name training? That is, in the object-name training, the participant merely repeats “pen” while looking at the pen and saying “pen.” The selection of pen in the presence of hearing its name (name-object relation) was never reinforced during object-name training.

And so, with the limitations just pointed out, one can see that the stimulus equivalence (Sidman, 1990, 2000) and the naming (Horne & Lowe, 1996) paradigms are insufficient to provide a satisfying answer to the question of the origin of equivalence relations or untrained generalization. On the contrary, the notion of joint control can easily be expanded on, and it can reconcile the limitations of the other two paradigms (Lowenkron, 1996, 1998, 2004, 2006a). To illustrate this, Lowenkron relies on data from his previous studies (Lowenkron, 1984, 1988, 1989) in which overt topographies were used as mediating responses. Results revealed that bidirectional relations may be the product of the tact (object-name relation) interacting with the self-echoic.

For example, see Figure 2.11, Panel A. Suppose an individual is asked to find an “apple” (sample stimulus) among an array of actual fruits such as apple, banana, pears,
and oranges (comparison stimuli). The individual would proceed to find the apple by scanning all the given fruits while engaging in self-echoic (repeating the sample stimulus – “apple”) response. Eventually, the individual would encounter the stimulus (apple) which evokes the same self-echoic response topography (saying “apple”) as a tact. At this point, the onset of joint control has occurred. Correctly pointing (descriptive autoclitic) to the actual apple is thus controlled by a joint self-echoic/tact control. The descriptive autoclitic is different from the listener behavior (selecting or pointing to a stimulus upon hearing a word) in that this verbal operant is not under the control of the sample stimulus. Rather it is under the control of “the elements common to the transition from self-echoic to joint control… thus it necessarily generalizes to performances with novel stimuli, and serves to report any stimulus that produces a transition to joint control” (Lowenkron, p. 252).

The joint control account resolves the limitations of the stimulus equivalence and naming account. As described above, Lowenkron (1996) stated the reasons why the naming relation cannot explain the bidirectional relation between the name-object and object-name without training. However, in order for object-name and name-object bidirectionality to exist, the participant must already have learned to select under joint control. That is, the participant has learned to emit an echoic or self-echoic response in the presence of hearing a word and concurrently emit a word in the presence of an object.
Figure 2.11: Joint-control paradigm. Panel A and B illustrate occurrence of joint control with different stimuli. Panel C represents the emergence of stimulus equivalence using the joint control account in which participants create their own common name (N1) for all the involved stimuli. This Figure is adapted from Lowenkron (2004).
For instance, as shown in Figure 2.11 (Panel B), the diagram denotes an object-name (the trained relation) and a name-object relation (the untrained relation). So, starting with the object-name relation training, in the presence of the object (dot in circle) the participant hears /dot in circle/ from the trainer, leading the participant to rehearse “dot in the circle” and repeats after the trainer “dot in circle,” which results in reinforcement. In other words, the participant learned to tact (“dot in circle”) the object. Next, without additional training, the participant can perform name-object relation by the same description. In the presence of hearing /dot in circle/ (sample stimulus), the participant would rehearse the words and at the same time scan the comparison stimuli. Upon seeing the comparison stimulus that evokes “dot in circle,” the tact is emitted while the rehearsing of “dot in circle” is currently taking place. At this moment, joint control has occurred, triggering the selection response as a descriptive autoclitic, demonstrating untrained bidirectional responding. In other words, the joint control event mediates over the common topographies. Using the same description just provided, the joint-control account could also amend the limitations from the stimulus equivalence model with the same explanation (Figure 2.11, Panel C).

One important point that needs emphasis is the relation between the joint-control and naming accounts. These two accounts are the same in that they both assume that a common name, serving as a mediating event, is responsible for linking different stimuli into an equivalence class. Moreover, both accounts also assume that the role of verbal behavior is a vital component in producing equivalence relations in humans. However, with the limitations of the naming account as described, joint control appears to provide a better explanation.
Summary

Collectively, the reading literature has suggested that children, regardless of types of disabilities, have the capability to learn how to read. Specifically, instruction that is comprised of explicit instruction, errorless procedures, prompts, and fading seem to be the most effective for children with developmental disabilities. However, three decades of research in reading for children with developmental disabilities have produced only a handful of studies that meet evidence-based practices. In regard to the type of disabilities, reading research on children with ASD is even more limited. Among the studies that meet Horner et al.’s (2005) and Gersten et al.’s (2005) indicators of quality research, two extremely important but least researched reading skills are phonics and phonemic awareness. Although research has shown a strong positive relationship between these skills and mastering reading, no known study that meet the evidence-based criteria has examined the effects of phonics instruction for children with ASD. Reading is one skill that must be mastered in order to function efficiently in society; thus, all children including those with ASD should have access to effective reading instruction.

Unfortunately, phonics and phonemic awareness are two skills that children with ASD lack when compared to their typical peers. It these children do not receive the instruction that focuses on teaching such skills by the end of the third grade, it is likely that these children will have permanent disadvantages in all academic subjects. Thus, it is vital that these children master these fundamental skills in the least amount of time. To do that, an effective intervention that teaches generatively is needed. To teach generatively, the instructional strategy should be efficient in that it requires less training but yet produces more learning. In addition, the intervention must also be systemically
consistent. One instructional paradigm that meets the requirements is joint-control training, which lends itself to phonics given that the model emphasizes using different sense modalities (e.g., visual and auditory), as compared to phonemic awareness, which is an auditory skill.

To acquire phonics, an individual needs to recognize the correspondence relationships between letter and sound. That is, the ability to recognize the relations between: sound-sound, sound-print, and print-sound. For instance, when a child sees a printed letter, s/he says its corresponding sounds, or when a child hears a letter sound, s/he selects a respective printed letter among other printed letters. In the same way, the joint-control model emphasizes the training of the tact (seeing a printed letter and saying its respective sound) and echoic (hearing a letter sound, imitating the sound) operants, which allows the children to demonstrate bi-directionality or sound-letter correspondence.

Rather than just focusing on teaching students to tact a printed letter (i.e., visual to auditory relation), joint-control training also teaches students to echo or imitate a letter sound (i.e., auditory to auditory relation). The echoic training in joint control plays an essential role in teaching phonics to children who have not acquired phonemic awareness. For students who lack the ability to make association between sounds, it may be difficult for them to acquire phonics skills. Without sound association, these students may not be able to distinguish between the sounds, and thus learning phonics may be more difficult given that phonics require both sound-sound and sound-print association (Bursuck & Damer, 2007).
In this sense, joint-control training not only focuses on teaching students to respond to letter-sound correspondence, it also teaches students to associate between sound to sound and then sound to printed letters. For instance, in joint-control training, students must repeat the sound of a letter correctly before progressing to the next training step, which is discrimination training of print letter and its sound. Having students echo the sound of a presented sound may also serve another function. For students who lack the ability to make the association between sounds, acquiring this ability may serve as a prerequisite for these students to learn phonemic awareness. Phonemic awareness skills “rely on students hearing individual phonemes, not seeing them” (Bursuck & Damer, 2007, p. 33).

Moreover, the joint-control model consists of all the components of effective instruction and has shown to be an effective generative approach for children with severe to profound mental retardation (Lowenkron, 1989). Joint-control training is effective instruction in that it employs explicit instruction, skill mastery, fast pacing, and active student responding (Heward, 1994). Explicit instruction in joint-control training is provided through clear and consistent feedback on students’ successes and errors as well as adequate modeling, guided practice, and independent practice. More specifically, modeling and guided practice in joint-control training are prompts (“What sound?”) and feedback (“That’s right!”) from the instructor. As students master (reached a pre-determined criteria) a skill, prompts are faded, allowing students to independently practice the relevant responses.

Instruction is also fast pace. Such instruction increases student attention and learning, while it also minimizes the transition time between academic tasks such as the
student’s response and the teacher’s next question (Bursuck & Damer, 2007; Englert, 1992). Furthermore, students receiving fast pace instruction are less likely to waste time, be uncooperative, or tune out (Bursuck & Damer). Moreover, joint-control training requires students to emit a detectable response to on-going instruction. By requiring students to “actively” engage with the relevant instruction materials, allows the instructor to measure appropriate responses and provide immediate feedback to correct and incorrect responses as stated above. Studies have revealed that students who engaged in active participation during instruction are highly correlated with achievement than students who did not (Heward, 1994)

In sum, joint-control training is comprised of the mechanisms of effective instruction as well as a theoretical background that is consistent with behavior principles. From this perspective, joint-control training should be extended in an effort to provide educators and parents with more efficient means of teaching essential reading skills to children with developmental disabilities. If successful, joint-control training may provide teachers with an efficient way to teach an extremely important reading skill that many educators and parents traditionally thought could not be mastered by children with severe disabilities.
Chapter 3

Method

This chapter describes the procedures used in this study. Ethical provisions, participants, experimenter and observer, setting, materials, definition and measurement of dependent variables, data collection, experimental design, and procedures are described. Procedures used to acquire treatment integrity, interobserver agreement, and social validity data are also discussed.

Ethical Provisions

Before conducting this study, the experimenter ensured that the ethical guidelines set forth by The Ohio State University’s Institution Review Board (IRB) were followed. First, the experimenter and the second observer successfully completed the Collaborative Institutional Training Initiative (CITI). The CITI is a web-based course aims to educate researchers in topics related to conducting ethical human participants. Second, all research protocols were approved by the IRB at The Ohio State University. These protocols are described below (e.g., the inclusion criteria, recruitment procedures, data collection procedures, and etc.). Moreover, the IRB recognized the possible risks and benefits of participants participating in the study and approved the forms used to acquire parental consent (Appendix A) and teachers assent (Appendix B).
To obtain parent/guardian consent, a letter and a consent form were sent home with potential participants. By returning a signed consent form, parents/guardians indicated that they understood the study’s purposes, expectations, release of liabilities (e.g., information would be recorded and may be exhibited for educational purposes, allowed observers for data collection purposes, duration of the entire study which was estimated to take two months, etc.), and the right of the participant to withdraw from the study at any time without penalty. Upon receiving the parents/guardians consent, a written assent script was verbally read to each of the participant. The study commenced after the experimenter received signed consent forms as well as the assent script was read to each participant.

Participants

Three children participated in this study. These children were recruited from a learning center that specialized in teaching individuals with autism spectrum disorders (ASD) using behavior analysis principles. The participants’ instructional curriculum consisted of developing social, language, academic, and self-help skills. Instruction usually occurred in a teacher and student ratio of 1 to 3. According to school records, the participants did not receive any phonics instruction. However, IEP objectives indicated that all participants received letter naming instruction at some point during their school years. All recruited children met the following inclusion criteria: (a) diagnosed with ASD, (b) between the ages of 5 and 10, (c) demonstrated limited vocal abilities (e.g., unable to construct more than 4 word sentences), and (d) unable to perform the targeted skills (letter-sound correspondence) that were taught in the study. Standardized assessments (Dynamic Indicators of Basic Literacy Skills [DIBELS]; Good & Kaminski,
 Childhood Autism Rating Scale [CARS]; Schopler, Reichler, & Renner, 1988; Woodcock Reading Mastery Tests-Revised [WRMT-R]; Woodcock, 1998) were administered to all participants to ensure participation qualification. Results from CARS and other information provided in participants’ school records are displayed in Table 3.1. DIBELS, WRMT-R, and other related information are displayed in Table 3.2.

The study’s population and age group were targeted for three reasons. First, limited reading research has focused on teaching phonics to children with ASD. Second, studies have suggested that children should learn phonics as early as possible, given that this skill has significant positive effects on children’s reading abilities later on. Teaching phonics to children at an early age may also prevent reading failure.
<table>
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<th>Pseudonym</th>
<th>Alex</th>
<th>Charlie</th>
<th>Mandy</th>
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<tr>
<td>PLS-4 (Total)</td>
<td>Significant deficits</td>
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<td>N/A</td>
</tr>
</tbody>
</table>

Notes: CARS = Childhood Autism Rating Scales; GARS = Gilliam Autism Rating Scale (2nd edition); VABS = Vineland Adaptive Behavior Scales; ROWPVT = Receptive One-Word Picture Vocabulary Test; LIPS-R = Leiter International Performance Scale-R; PLS-4 = Preschool Language Scale-4

Table 3.1: Participants’ characteristics

Likewise, Alex also received a score of 0 for DIBELS subtests of Initial Sound Fluency (ISF), Letter Naming Fluency (LNF), Phoneme Segmentation Fluency (PSF), and Non-Sense Word Fluency (NWF). Based on the Kindergarten’s DIBELS Benchmark Goals and Indicators of Risk, these scores indicate that Alex’s ISF was deficit (established was ISF >=25), LNF was at risk (low risk was LNF >=27), PSF was deficit (established was PSF >=35), and NWF was at risk (low risk was NWF>= 25). At the time of the study, Alex’s IEP goals included greeting peers or adults; using oral speech to request desirable items; initiating social interaction; participating in cooperative play;
sorting pictures and objects by feature, class, and function; learning to use new nouns, verbs, and pronoun; and using three-word sentences.

Charles was a 9-year-old African American male diagnosed with ASD. Based on the Childhood Autism Rating Scale, Charles had a score of 35, which placed him in the moderate-severe autistic range. As indicated in Charles’ school records, because of his attention span and delays, he was not given an IQ assessment. On the WRMT-R, Charles received a raw score of 0 on the word attack subtest and a raw score of 7 on the word identification subtest. Based on the score, Charles’ work attack was equivalent to a beginning kindergarten (K.033) performing at the 33th percentile, and his age was equivalent to a 5-year old (K-033) also performing at the 33th percentile. Charles’ word identification test was equivalent to scores of a first grader (1.1), and performed at the age equivalent of a six-year old (6-8). At nine years old, Charles should be able to obtain a raw score of 25 for the word attack and 59 for word identification. Charles scored 0 on both the DIBELS subtests of Non-Sense Word Fluency (NWF) and Oral Reading Fluency (ORF). The DIBEL’s Third Grade Benchmark Goals and Indicators of Risk suggested that Charles’ ORL was at risk (low risk was ORF >= 110). Charles NWF score was also at risk (established was NWF >= 50) based on the DIBEL’s second grade indicators. At the time of the study, Charles’ IEP goals included identifying the requested word receptively when given pictures of words or written words; saying the sounds of written words, pictures, and symbols; answering to who and what questions; sorting items such as silverware, clothing items, and food items; matching plastic coins to their graphic representations; matching coin to value; and following visual schedule and checklist.
Mandy was an 8-year-old Caucasian female diagnosed with ASD and Chiari Malformation (CMs). CMs are structural defects in the cerebellum, which controls balance. CMs can cause a range of symptoms including dizziness, muscle weakness, numbness, vision problems, headache, and problems with balance and coordination (National Institute of Neurological Disorders and Stroke, 2009). Mandy scored 38.5 or moderate-severe autistic range on the Childhood Autism Rating Scale, high probability of autism on the Gilliam Autism Rating Scale (GARS; Gilliam, 1985), and significant deficits on the Vineland Adaptive Behavior Scales (VABS; Sparrow, Balla, & Cicchetti, 1984). Mandy also took daily medications to help her sleep and reduce her aggressive behaviors. However, the names of the medications were not reported in her school records. IQ assessment was not conducted due to Mandy’s attention span and delays. On the Receptive One-Word Picture Vocabulary Test (ROWPVT; Gardner, 1985), Mandy achieved a score of 64 out of 100 indicating that her receptive skills were at the age equivalent of 2 years, 8 months. Mandy scored 0 (raw score) on both of the WRMT-R subtest, word attack and word identification. From the scores, Mandy’s work attack was equivalent to a beginning kindergarten (K.0\textsuperscript{33}) performing at the 33th percentile, and her age was equivalent to a 5-year-old (K-0\textsuperscript{33}) also performing at the 33th percentile. Mandy’s word identification test was equivalent to scores of a beginning kindergarten (K.0), and performed at the 13\textsuperscript{th} percentile of a 5-year-old. For her age, Mandy should be able to obtain a raw score of 19 on the word attack and a raw score of 48 on the word identification. Mandy received a score of 0 for DIBELS subtests of Non-Sense Word Fluency (NWF) and Oral Reading Fluency (ORF). DIBELS’s Second Grade Benchmark Goals and Indicators of Risk indicated that Mandy’s NWF was deficit (established was
NWF >= 50) and ORF was at risk (low risk was ORF >= 90). At the time of the study, Mandy’s IEP goals included counting up to 30, copying her name from model, reading sight words, identifying 26 upper and lower case letters when given a letter name, toileting skills, dressing herself, decreasing problem behavior, and writing her name.

<table>
<thead>
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<th>Pseudonym</th>
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<th>Mandy</th>
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<tr>
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*Notes: OT = ST = Speech Therapy; Occupational Therapy; PT = Physical Therapy; WRMT-R = Woodcock Reading Mastery Test – Revised; DIBELS = Dynamic Indicators of Basic Literacy Skills; ISF = Initial Sound Fluency; LNF = Letter Naming Fluency; PSF = Phoneme Segmentation Fluency; NWF = Non-Sense Word Fluency; ORF = Oral Reading Fluency (2nd Grade)*

Table 3.2: Participants’ reading skills and other services
Experimenter and Observer

The experimenter served as the primary observer. He received his Bachelor’s degree in psychology and Master’s degree in experimental and applied behavior analysis from the Department of Psychology at the California State University, Los Angeles. At the time of the study, the experimenter was a third-year doctoral student in the Special Education and Applied Behavior Analysis Program at The Ohio State University. He was a board certified behavior analyst and had 6 years of experience working with children and adults with various developmental disabilities in both home and school settings. He has implemented behavior interventions in one-on-one and group settings.

The second observer was also a third-year doctoral student in the Special Education and Applied Behavior Analysis Program at The Ohio State University. She received her Bachelor’s, Master’s, and Doctoral degrees in child development from the Department of Child Development and Family Studies at Yonsei University, Seoul, Korea. Before attending the doctoral program at The Ohio State University, she was a college instructor for 13 years and had worked 4 years with children with and without developmental disabilities in Korea.

Setting

The study took place in a private school serving students with ASD in preschool through twelfth grade (ages 3 to 22). All training and testing sessions were conducted in a 10 ft. x 12 ft. room, which contained a small table and two chairs in the center, and a video camera (Panasonic SDR-H40) at one of the corners. During all experimental sessions (i.e., baseline, intervention, maintenance), the experimenter sat next to a participant at a small table to prevent participants from leaving the table. Potential
reinforcers were kept beside the experimenter, visible to but out of reach from the participants. One to two sessions were conducted per day five days per week. Each session lasted approximately 20-30 minutes. The duration of the entire study was approximately 8 weeks.

Materials

Materials used in this study were a timer and sound cards from Engelmann, Haddox, and Bruner (1986). In total, there were 44 sound cards. Each sound card was approximately 2 in. x 4 in. with a printed lower-case letter(s) (e.g., a, c, d, ea, ou and so on) printed in the center (Appendix C). Of the 44 sound cards, only 24 were chosen for the study. The other 20 sound cards with long sounds (e.g., a, e, i, o, u, y, and oo), digraphs (e.g., th, ch, wh, ing, and sh), diphthongs (e.g., ou), and letter-sound combinations (e.g., ar, er, ea, ai) were excluded. The sound cards for letters q and k were also excluded because (a) for q, the sound card was printed as qu. (b) the sounds for /k/ and /c/ were identical and letter c is more commonly seen in reading materials. The sound cards with long sounds were not used because they sound similar to their names (e.g., the long sound for a, e, and so forth are identical to their name). Letter-combinations and others were excluded to prevent confusion. In addition, sound cards used as training stimuli have their own distinctive sounds. In other words, only the sound for c was used, not k. Two sets of four sound cards (i.e., 8 sound cards in total) were individually selected for each participant based on their performances on the pre-baseline assessment, which measured the letter-sound and sound-letter relationships. Set 1 and 2 were used as training stimuli for Experiment 1 and 2, respectively. See Table 3.3 for participants’ training stimuli.
Items ranked as the top four from the preference assessment were used as individualized reinforcers throughout the study within training sessions. A timer was used to measure the time a participant was allowed access to a reinforcing activity or item.

<table>
<thead>
<tr>
<th>Pseudonym</th>
<th>Sound Cards (Set 1)</th>
<th>Sound Cards (Set 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alex</td>
<td>t, c, n, s</td>
<td>v, h, w, p</td>
</tr>
<tr>
<td>Charles</td>
<td>a, d, t, s</td>
<td>z, e, v, y</td>
</tr>
<tr>
<td>Mandy</td>
<td>a, d, t, i</td>
<td>n, c, h, g</td>
</tr>
</tbody>
</table>

*Notes: Set 1 was used in Experiment 1 and Set 2 was used in Experiment 2*

Table 3.3: Participants’ training stimuli of Sets 1 and 2

Definition and Measurement of the Dependent Variables

Two dependent variables were measured in the study, the tact response (letter-sound relations) and the selection response (sound-letter relations).

*Tact response.* Tact response was a participant’s oral response to a visual stimulus. For example, when presented with a sound card and verbal directions to name the sound (i.e., “What sound?”), the participant emitted a letter sound. A correct was recorded when the participant emitted the letter sound that corresponded to the presented sound card within 3 seconds. An incorrect or no response was recorded when the participant emitted a different sound or no response was emitted within 3 seconds. An incorrect was also recorded if participants provided the correct response after the experimenter’s prompt.
Selection response. The selection response was a participant’s response to an auditory stimulus. For instance, when presented with a letter sound, the participant selected (e.g., pointed to, touched, or picked up) a sound card from an array of four sound cards. A correct response was recorded when the participant selected the sound card that corresponded to the presented letter sound within 3 seconds. An incorrect or no response was recorded when the participant selected a sound card that did not correspond to the presented letter sound or no response was emitted within 3 seconds.

Both the tact and selection responses were measured as the number of letters correct per session. These measurements were taken across all experimental conditions (i.e., baseline, intervention, and maintenance). However, during intervention sessions, these two responses were recorded immediately following the intervention.

Data Collection

Pre-Assessments

Preference assessment. The Reinforcer Assessment for Individuals with Severe Disabilities (Fisher, Piazza, Bowman, & Amari, 1996; see Appendix D) was administered with each participant’s classroom teacher to identify a list of non-allergic preferred edibles and toys for their students. With the obtained information from teachers, direct observations were conducted using a multiple stimulus without replacement (MSWO) preference assessment (DeLeon & Iwata, 1996) to determine if the identified preferred items were potential reinforcers. For instance, each participant was presented with an array of five to six items in a horizontal fashion within reach and asked to select one. If a participant selected an activity item (e.g., toy), the participant was allowed 15 s to interact with that item before starting a new trial. If an edible item was selected, the experimenter
waited until the participant consumed the item and started a new trial. Each trial, except the first trial, consisted of only the remaining stimuli that were not chosen. This procedure continued until only one stimulus remained. Each session consisted of five trials. A total of four sessions were conducted.

A procedure used by Cannella (2005) was implemented to determine the rank order of items. For instance, if an item was selected first, it was given a score of 1/1 (i.e., 1.0) indicating that it was selected once out of one opportunity. The next item that was selected in the second trial was given a score of 1/2 (i.e., 0.5) indicating that the item was selected once out of two opportunities. This procedure continued until the last item, which was given the score of 1/5 (i.e., 0.2). Each calculated score was then multiplied by 100%. The scores for each item were then averaged, allowing the items to be ranked from highest to lowest average. Results of the MSWO assessment are presented in the next chapter.

*Pre-baseline assessment.* There were two reasons for conducting the pre-baseline assessment. First, results from the assessment were used to determine training stimuli (i.e., two sets of four sound cards) for each participant. For instance, the sound cards to which participants incorrectly responded (both tact and selection responses) were used as training stimuli. Second, this assessment was employed as a way to identify which students to include or exclude from the study. The following 24 lower-case letters were assessed: m, s, a, t, r, d, i, c, o, n, v, p, e, b, y, j, f, u, l, w, g, h, x, and z.

In total, there were 48 unidirectional (24 bi-directional) relations of which 24 were tact (letter-sound) and 24 were selection (sound-letter) relations. Participants who performed correctly on more than 16 relations (bi-directional [letter-sound and sound-
letter] or unidirectional [letter-sound or sound-letter]) were also assessed with the other 20 excluded sound cards (recall 20 of the 44 sound cards from Engelmann et al., 1986 were letter-sound combinations, diphthongs, etc.). However, none the participants received a score higher than 16 relations. This assessment was necessary because if a participant responded correctly on more than 16 sound cards, uni-directionally or bi-directionally (both the letter-sound and sound-letter relations), not enough training stimuli would have been available for that participant unless the excluded sound cards were used. The experimenter continued implementing the pre-baseline assessment until the participant either correctly responded to more than 16 unidirectional or bidirectional relations, or the 24 sound cards expired.

Prior to assessing for tact and selection responses (letter-sound and sound-letter relations), the sound card (k), one of the excluded training stimuli, was used as a model to teach appropriate response. For a tact response, the experimenter presented the sound card (k) and said “This sound is /k/. What sound?” Next, the experimenter presented the same card and asked the participant “What sound?” If the participant responded correctly, the experimenter praised the participant. If the participant did not respond or responded incorrectly, the experimenter repeated the same step. For the selection response, the experimenter placed four of the excluded sound cards (e.g., k, ar, er, sh) in front of the participant and said, “Find /k/.” If the participant responded correctly by selecting the corresponding card, the experimenter praised the participant. If the participant did not respond or responded incorrectly, the experimenter repeated the same step. These steps ensured that participants were able to engage in the required response prior to pre-baseline assessment, and thus was intended to improve the accuracy of the assessment.
To assess for the tact response (letter-sound), the experimenter presented an individual sound card to a participant and asked “What sound?” A correct response was recorded if the participant emitted a sound that corresponded to the presented sound card within 3 seconds. An incorrect response was recorded if the participant emitted a sound that did not correspond to the presented sound card or did not respond within 3 seconds.

To assess for the selection response (sound-letter), the experimenter orally emitted a sound (e.g., /a/) in addition to placing four sound cards, one of which corresponded to the emitted sound, in front of the participant. The four sound cards were randomly taken from the 24 sound cards. A correct response was recorded if the participant selected (pointed to, touched, or picked up) the appropriate card within 3 s from the onset of the sound card. An incorrect response was recorded if the participant selected any card other than the appropriate card or did not respond within 3 s from the onset of the sound card.

The difference between the tact (letter-sound relation) and selection (sound-letter relation) response was that the two did not share formal similarity. Namely, in the tact response (letter-sound relation), a visual stimulus (sound card) was presented and the participant emitted a verbal response. On the other hand, in the selection response (sound-letter relation), an auditory stimulus (the experimenter said a sound) was presented and the participant emitted a selection response (pointed to, touched, or picked up) a sound card among other cards (visual stimuli). No feedback/prompt, praise, or reinforcer was delivered.

*Baseline.* In this condition, bi-directionality relations (letter-sound and sound-letter) of the Set 1 (for Experiment 1) and Set 2 (for Experiment 2) sound cards were assessed. This condition was identical to the pre-baseline assessment except that the
stimuli used here were only Set 1 or Set 2 sound cards. A total of eight trials were conducted per session, four for the letter-sound (tact response) and four for the sound-letter (selection response) relations. With each tact (letter-sound) trial, the experimenter randomly held one of the sound cards and asked the participant, “What sound?” and waited 3 seconds. Regardless of performance (correct, incorrect, or no response), the experimenter presented the next sound card until all sound cards from a sound card set expired. No praise, prompt, or reinforcer was provided. With each selection (sound-letter) trial, the experimenter presented four sound cards on the table in front of the participant and asks the participant “Find ___” and waited 3 seconds. Regardless of performance, the experimenter continued saying the next sound until all the sounds that corresponded to the sound cards from a sound card set expired. No praise, prompt, or reinforcer was provided in this condition. See Appendix E for baseline data sheet.

Probes. Immediately following the intervention sessions, eight probe trials were conducted. Four probes trials were conducted to assess letter-sound relation (tact response) taught during the intervention and four were conducted to assess sound-letter relation (selection response). Probes trials were identical to pre-baseline and baseline trials. No feedback, prompt/feedback, or reinforcer was delivered in all probes trials. (See bottom half of Appendix F or G for data sheet).

Maintenance. Each probe was conducted in the same manner as the pre-baseline and baseline trials.

Interobserver agreement (IOA). Observer training was conducted prior to IOA data collection. During the observer training, the experimenter discussed the definitions of the dependent variables and switch role with the observer. That is, the experimenter
played the role of a participant and the observer played the role of the experimenter while collecting data. This process allowed the observer to experience a real experimental situation, and it allowed the experimenter to immediately clarify any confusion and provide feedback to the observer. Subsequently, the observer practiced recording data from videotapes of sessions not used for IOA until her data matched 100% of the experimenter’s recorded data for three consecutive sessions.

Twenty percent of the videotaped sessions of each participant across experiments (e.g., 1; tact training and 2; joint-control training) and conditions (i.e., baseline, intervention, and maintenance) were used for IOA, except the maintenance condition, which only had one session, 100% were used. The second observer was presented with videotapes of participants in all experimental conditions of the study. In each observation session, an agreement was recorded when the observer and experimenter recorded the same event (correct, incorrect, or no response) on each trial. The IOA data sheets for all experimental conditions were identical, thus only the tact training data sheet is included as an Appendix H. Interobserver agreement was calculated by the number of agreements / the number of agreements + the number of disagreements x 100.

Experimental Design

A multiple baseline across participants design (Cooper, Heron, & Heward, 2007) was used. There are several reasons for choosing the multiple baseline design over the typical designs employed in similar studies (e.g., Gutierrez, 2006; Lowenkron, 1984, 1988, 2006; Lowenkron & Colvin, 1995, Sidener & Michael, 2006; Tu, 2006). First, the multiple baseline design was better at demonstrating experimental control in this study. Second, given that the targeted responses were vital for later reading proficiency, it was
undesirable or unethical to reverse such responses (Cooper et al.). In addition, such responses may not be reversible. Moreover, a multiple baseline design, rather than a multiple probe design, was used because the probes, baseline or otherwise, were relatively simple and short in duration. For instance, participants were required to respond only eight times per baseline probe, four times for the selection response (sound-letter) and four times for the tact response (letter-sound).

Decision Rules

Transition from baseline to intervention condition. A minimum of three baseline probes were conducted for all participants. A participant with the most stable baseline began intervention first (first tier). If more than one participant had a stable baseline, one participant was randomly selected to go first. Decision to move participants from the baseline to the intervention condition was depended on participants’ tact and selection performance. This ensured that participants did not have knowledge of the training stimuli prior to interventions.

Transition from intervention to maintenance condition. Decisions to move participants from the intervention to the maintenance condition was based on participants’ tact performance (i.e., emitting the appropriate sound in the presence of the sound card) rather than both responses (tact and selection) given that it was directly trained. To move from the intervention to the maintenance condition, participants needed to respond correctly to three tact (letter-sound) probes in three consecutive sessions.

Starting participants on subsequent tiers. Decisions to start participants in subsequent tiers (e.g., 2 or 3) were also based on participants’ tact performance. For instance, if a participant in the first tier demonstrated non-overlapping intervention data
with baseline data in three consecutive sessions, a participant in tier two was moved from the baseline to the intervention condition. This sequence continued until all participants received intervention.

*Starting participants in experiment 2.* Regardless of their performance, participants in the maintenance condition were moved to the next experiment of the study.

**Procedures**

A few assessments were conducted prior to the beginning of the study. These assessments included a preference assessment, DIBELS subtests, and a pre-baseline to determine potential reinforcers, participants’ reading skills (e.g., phonemic awareness and phonological awareness, and fluency), and appropriate training stimuli, respectively. The study consisted of two individual experiments. The experimental conditions (i.e., baseline, intervention, maintenance) of the two experiments were identical. The only difference between the two experiments was the use of different training strategies during the intervention conditions. Intervention in Experiment 1 was tact training, whereas intervention in Experiment 2 was joint-control training. The purpose of Experiment 1 (Set 1 sound cards) was to determine if participants would demonstrate bi-directionality or selection response (sound-letter relation) after receiving only tact training (letter-sound relation). The purpose of Experiment 2 (Set 2 sound cards) was to assess the same responses as in Experiment 1 except that the intervention was joint-control training.

**Baseline**

Although there were literacy goals in all participants’ IEPs, none of participants was receiving any type of phonics instruction in their daily classroom routine. Rather, all
three participants were receiving instruction on sight word reading (e.g., shapes, animals, items, pictures, etc.). In addition to sight word instruction, Alex was the only participant who received letter naming instruction, although it was not listed in his IEP. The majority of their daily classroom instruction focused on communication, social, and living skills as well as decreasing inappropriate behaviors. Of the three participants, Alex is the only participant who did not receive speech, physical, nor occupational therapy. The other participants received both speech and occupational therapy twice a week, 40-45 minutes per session, and Mandy also received physical therapy twice a week, 40-45 minutes per session. All participants did not receive feedback or reinforcer for their responses during the baseline sessions.

*Interventions*

*Tact training (Experiment 1).* Similar to the baseline trial, each sound card from Set 1 was individually presented to the participant in each trial. Within a trial, the experimenter held a sound card in front of the participant and asked, “What sound?” The experimenter waited for 1 s, then said the sound (e.g., /a/). If the participant emitted a correct sound within 3 s from the onset of the sound card, reinforcement (e.g., praise such as “That’s right,” “Great job,” “Yes,” etc. and/or a reinforcer) followed and a new trial began. However, if the participant emitted an incorrect sound or did not respond within 3 s from the onset of the sound card, the experimenter said, “The sound is ___. What sound?” and waited another 3 seconds for the participant to respond. When the participant continued to emit the incorrect sound or did not respond, the experimenter repeated the same step again. When the participant still emitted an incorrect response or
did not respond on the experimenter’s third prompt, the experimenter presented a different sound card, indicating a new trial.

To put it another way, a trial ended as a result of one of three situations: (a) The participant responded correctly within 3 s following the experimenter’s first question (“What sound?”); (b) the participant did not respond correctly after the first prompt; a corrective feedback/prompt (e.g., “This sound is ___. What sound?”) was given; and subsequently, the participant responded correctly within 3 s; (c) the participant still did not respond correctly even after a third prompt. Reinforcement was delivered contingent on all correct responses. In total, each intervention session was comprised of 40 trials with 10 trials allocated to one letter-sound relation. The sound cards were randomly presented until 10 trials for each card expired. A correct (C) response was recorded if participants emitted a sound that corresponded to the presented sound card. An incorrect (I) or no response (N) was recorded if participants emitted a sound that did not correspond to the sound card or did not response, respectively. (See Appendix I for data sheet).

_Joint-control training (Experiment 2)._ This condition taught participants to emit a tact response (e.g., respond with an appropriate sound when presented with a letter card) while emitting an echoic response (imitating the sound the experimenter was emitting), and thus producing joint (tact-echoic) control. Similar to the intervention condition in Experiment 1, 10 trials were allocated to each sound card (i.e., 40 trials total) of Set 2. Each sound card was randomly presented until the 10 trials expired. Moreover, a trial also ended in the three above-mentioned situations. To teach joint-control, the following steps were taken:
1. In Step 1 (echoic), the experimenter emitted a sound (e.g., “/a/”) and waited 3 s for the participant to imitate the sound. If the participant imitated the sound, the experimenter immediately moved to Step 2. However, if the participant did not imitate the sound, a similar prompting sequence to the intervention condition in Experiment 1 was used. That is, the experimenter emitted the sound (“/a/”) again and waited 3 s before repeating the sound and prompt again. When upon the third prompt, and the participant still did not imitate the sound, a new trial with a different sound was introduced. When the participant imitated the sound on the second or third prompt, the experimenter immediately moved to Step 2.

2. In Step 2 (tact), immediately following the participant’s vocal imitation, the experimenter presented the respective sound card and said, “What sound?” If the participant looked at the sound card and repeated the sound, reinforcement followed. This completed a full joint control training trial. However, if the participant responded incorrectly or did not respond, the experimenter made the sound card not visible to the participant and repeated Step 1. If the participant still responded incorrectly or did not respond upon reaching this step three times, a different sound card was presented, indicating a new trial.

Two responses were recorded in each joint-control training trial. In Step 1, a correct response (C) was recorded if participants imitated the sound. An incorrect (I) or no response (N) was recorded if participants emitted a different sound or did not response. In Step 2, a correct (C) response was recorded if participants emitted a sound that corresponded to the presented sound card. An incorrect (I) response or no response (N)
was recorded if participants emitted a sound that did not correspond to the presented sound card or did not response, respectively (See Appendix J for data sheet).

Prompts given in Step 1 were short. For example, instead of saying, “say /a/,” the experimenter said only the letter sound /a/. The purpose of providing short prompts was to (a) avoid prompt dependence and (b) try to prevent students from repeating the entire phrase, including the prompt (given that echolalia is a common characteristic of children with autism).

**Probes**

Immediately following the intervention sessions, eight probe trials were conducted. Four probes trials for each relation (letter-sound and sound-letter). Probes trials were identical to pre-baseline and baseline trials. No reinforcer was delivered in all probes trials (See bottom half of Appendix F or G for data sheet).

**Maintenance**

A maintenance probe was conducted two weeks after participants met criteria. Each probe in this condition was conducted in the same manner as the pre-baseline and baseline procedures.

**Procedural Integrity**

*Procedural Integrity.* Procedural integrity was also recorded during IOA sessions. The observer was trained to meet a certain criterion prior to any procedural integrity recording (i.e., the observer’s recorded data matched at least 90% of the experimenter’s recorded data for three consecutive sessions). Procedural integrity training was comparable to IOA training in that these sessions consisted of the experimenter verbally describing and explaining the intervention (tact training and joint-control training) and
probing procedures, presenting the definitions of the procedures in written form, and allowing the observer to play the role of the experimenter.

Similar to the IOA assessment, 20% of the videotaped sessions of each participant across experiments (1; tact training and 2; joint-control training) and conditions (i.e., baseline, intervention, and maintenance) were used to assess for procedural reliability. Identical procedural integrity data sheets (See Appendix F for tact training and Appendix G for joint-control training; the bottom portions of the forms were also used to collect IOA for baselines and probes) specific to each condition was used during the procedural integrity training and actual observation sessions. In the data sheet, the numbers in each item (trial) represent the pre-defined procedures. By circling a number listed in each trial, it indicated that the experimenter had correctly followed the procedure represented by that number. By crossing out the number, it indicated that the experimenter had not correctly followed the procedure or had skipped that step in the procedure. Numbers that had not been circled or crossed out indicated that the procedure was not necessary. For instance, prompting would not have been required when a participant emitted the correct response upon seeing or hearing the training stimulus. Procedural integrity was calculated with the following formula: total number of experimental procedures correctly implemented / the total number of experimental procedures x 100.

Social Validity

The acceptability of the experimental procedures (i.e., tact and joint-control training) and targeted responses were indirectly assessed through a 16-item questionnaire (Appendix K). The questionnaire incorporated a 5-point Likert-type scale. One open-ended question along with extra space was also provided for additional comments.
Participants’ teachers and the program coordinator were requested to complete the social validity questionnaire and submitted anonymously at the conclusion of the study. Prior to completing the questionnaire, the teachers and the program coordinator watched two short video clips (approximately 2 minutes each), one for tact training and the other for joint-control training, of Alex receiving instruction. In general, the questionnaire inquired teachers and the program coordinator about the efficiency and effectiveness of the procedures, and if given the opportunity, would they incorporate the procedures into their classroom instruction.
Chapter 4

Results

This chapter is divided into three sections. The first section presents the results of preference assessment, pre-baseline assessment, and interobserver agreement (IOA). The second section of the chapter presents the experimental results of Experiment 1 (Tact Training) and Experiment 2 (Joint-Control Training). The final section presents the procedural integrity and social validity data.

Preference Assessment

Based on the multiple stimuli without replacement assessment (Table 4.1), indicates the selection ranking of potential reinforcers for each participant. For Alex, preference was assessed with a piece of Cheetos’ Jumbo Puffs, three blows of Gazillion® Bubbles, one piece of M & M® Plain, one piece of Skittles® candy, one piece of Market Pantry™ gummi bears, and one piece of Market Pantry™ Chocolate Raisin. Item assessed for Charles were one piece of M & M® Plain, one piece of Market Pantry™ gummi bears, one piece of M & M® Plain, one piece of Skittles® candy, one piece of Market Pantry™ Chocolate Raisin, and a hand size red Power Rangers figurine. As for Mandy, preference was assessed with one piece of M & M® Plain, one piece of Market Pantry™ gummi bears, one piece of M & M® Plain, one piece of Skittles® candy, access
to Barney the Purple Dinosaur, and a stuffed animal (bear). Three different stuffed
animals (bears) were available.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Alex</th>
<th>Charles</th>
<th>Mandy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cheetos Puffs</td>
<td>M &amp; M Plain</td>
<td>Gummy Bears</td>
</tr>
<tr>
<td>2</td>
<td>Bubbles</td>
<td>Gummy Bears</td>
<td>Stuffed Animals (Bears)</td>
</tr>
<tr>
<td>3</td>
<td>M &amp; M Plain</td>
<td>Skittles</td>
<td>M &amp; M Plain</td>
</tr>
<tr>
<td>4</td>
<td>Skittles</td>
<td>Red Power Rangers Figurine</td>
<td>Skittles</td>
</tr>
<tr>
<td>5</td>
<td>Chocolate Raisin</td>
<td>Chocolate Raisin</td>
<td>Barney the Dinosaur</td>
</tr>
<tr>
<td>6</td>
<td>Gummy Bears</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Table 4.1: MSWO preference assessment results

Pre-baseline Assessment

Twenty-four letter-sound and sound-letter relations were measured in the pre-
baseline assessment for all participants. These lower-case letters included all letters of the alphabet except for letters k and q. Results of the pre-baseline assessment for all participants are displayed in Table 4.2.

For Alex, in the letter-sound relations (tact response) test, he did not respond or responded incorrectly to all sound cards presented to him. For letters m, s, a, t, d, i, c, n, v, p, e, b, y, j, f, w, and g, Alex either made irrelevant sounds, said the letter name, or asked “What is it?” Alex did not respond to letters r, o, l, h, x, and z.
In the sound-letter relations (selection response) test, Alex provided a response to all presented sound cards. The sound cards he correctly selected were letters m, a, r, e, and y. Letters incorrectly selected were s, t, c, d, i, o, n, v, p, b, j, f, u, l, w, g, h, x, and z. In total, Alex responded incorrectly to 19 bidirectional relations of letters s, t, c, d, i, o, n, v, p, b, j, f, u, l, w, g, h, x, and z. Of these letters, eight (t, c, n, s, v, h, w, and p) were randomly selected for training. Letters t, c, n, and s were used for Set 1, and letters v, h, w, and p were used for Set 2.

For Charles, in the letter-sound relations (tact response) test, he did not respond or responded incorrectly to all sound cards presented to him. For letters m, s, a, t, d, i, n, v, p, e, b, and y, Charles either said an irrelevant sound, a letter name (e.g., he was able to correctly say the names of letters a, y, e, and p), or asked the experimenter a question unrelated to the given task (e.g., pointed to an object and asked “what color?”). Charles did not provide a response to letters r, c, o, j, f, u, l, w, g, h, x, and z. He looked away or looked at the sound cards with no expression.

In the sound-letter relations (selection response) test, Charles incorrectly responded to letters m, s, a, t, r, d, i, c, n, v, p, e, b, y, j, f, u, and l and did not respond to letters w, g, h, x, and z. In total, Charles responded incorrectly to all 24 bidirectional relations of the presented letters. Of these letters, eight (a, d, t, s, z, e, v, and y) were randomly selected for training. Letters a, d, t, and s were used for Set 1, and letters z, e, v, and y were used for Set 2.

For Mandy, in the letter-sound relations (tact response test), she responded correctly to letters s, r, and f, and incorrectly to letters m, a, t, d, i, c, n, v, p, e, b, y, j, u, g,
Mandy did not respond to letters o, l, w, and z. When Mandy did not respond to the sound cards, she looked at her watch and said “go home.”

In the sound-letter relations (selection response) test, Mandy incorrectly responded to letters a, t, d, i, c, n, v, p, e, y, u, w, g, h, and x and did not respond to letters r, o, l, and z. Mandy correctly selected letters m, s, b, j, and f. In total, Mandy responded incorrectly to 19 bidirectional relations: letter a, t, d, i, c, n, v, p, e, y, u, w, g, h, x, r, o, l, and z. Of these letters, eight (a, d, t, l, n, c, h, and g) were randomly selected for training. Letters a, d, t, and i were used for Set 1, and letters n, c, h, and g were used for Set 2.

Table 4.2: Pre-baseline assessment results

<table>
<thead>
<tr>
<th>Pseudonym</th>
<th>Incorrect Responses</th>
<th>No Response</th>
<th>Correct Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tact</td>
<td>Selection</td>
<td>Tact</td>
<td>Selection</td>
</tr>
<tr>
<td>Alex</td>
<td>m, s, a, t, d, i, c, n, v, p, e, b, y, j, f, w, g</td>
<td>s, t, c, d, i, o, n, v, p, b, j, f, u, l</td>
<td>r, o, u, l, h, x, z</td>
</tr>
<tr>
<td>Charles</td>
<td>m, s, a, t, d, i, n, v, p, e, b, y</td>
<td>m, s, a, t, r, d, i, c, o, n, v, p, e, b, y, j, f, u, l</td>
<td>r, c, o, j, w, g, h, x, z</td>
</tr>
<tr>
<td>Mandy</td>
<td>m, a, t, d, i, c, n, v, p, e, b, y, j, u, g, h, x</td>
<td>a, t, d, i, c, n, v, p, e, b, y, j, u, g, h, x</td>
<td>o, l, w, z, r, o, l, z</td>
</tr>
</tbody>
</table>

Table 4.2: Pre-baseline assessment results
Interobserver Agreement

The mean IOA across participants and conditions in Experiment 1 (i.e., tact training) was 89% (range 75-100%) under letter-sound conditions and 100% under sound-letter conditions. However, due to the placement angle of the camera from which the observer could not clearly see the presented training stimuli, only 14% of the sound-letter conditions data were used for IOA. The mean IOA across participants and conditions in Experimenter 2 (i.e., joint-control training) was 94.4% (range 91.6-100%) under letter-sound conditions and 93% (range 87.5-100%) under sound-letter conditions. Overall, the averaged IOA scores for both Experiments (1 & 2) under letter-sound conditions were 91.7% (range 75-100%) and sound-letter conditions was 89.5% (range 50-100%).

Experimental Data

Experiment 1 (Tact Training)

Here, participants’ performances of Experiment 1 (Tact Training) are reported in the following format. Mandy’s, Charles’, and Alex’s Tact Training performances are described first, second and third, respectively. Within the description of each participant’s performance, baseline data are presented first, followed by intervention data, and lastly, maintenance data. Experiment 1’s data for all participants are displayed in Table 4.3, graphed in Figure 4.1. Participants’ training responses in Experiment 1 are depicted in Figure 4.2.

Mandy. A total of six baseline sessions were conducted for Mandy. Mandy was unable to correctly tact any of the presented letters in Set 1 (a, d, t, and i) across all sessions. However, for Mandy’s selection response, she made one correct response (25%)
in sessions 1 and 2. She correctly selected the letters d and a in sessions 1 and 2, respectively. Of the three participants, Mandy’s baseline data were stable at zero correct for the last four sessions. Thus, she was placed in Tier 1. Mandy’s overall mean correct tact and selection responses across all baseline sessions were 0% and 8.3% (range 0-25%), correspondingly.

Mandy received a total of nine intervention sessions to attain the condition criterion (i.e., correctly tact three letters across three consecutive sessions). Across the nine sessions, Mandy was able to correctly tact at least one presented stimulus in a given session. In general, her tacting responses showed an increasing trend across the intervention sessions. In sessions 7, 8, and 9, Mandy made 25% correct in tacking the presented stimuli such as letters t, t, and i, respectively. In sessions 10 through 12, Mandy was 50% correct in tacking the presented stimuli. She correctly tacted letters t and i in sessions 10 and 11 and letters t and d in session 12. In sessions 13 through 15, Mandy was 75% correct in tacking the presented stimuli and correctly tacted t, d, and i across the last three sessions. Overall, Mandy’s mean correct tact response across nine sessions was 50% (range 25-75%).

Across the nine intervention sessions, Mandy was able to select at least one letter correctly except for session 11 in which she did not select any correct letters (0% correct). In session 7, Mandy’s selection response was 50% correct in that she correctly selected letters a and t. From sessions 8 to 10, she selected 25% of the presented stimuli correctly. Mandy correctly selected letter t in session 8 and letter a in sessions 9 and 10. In sessions 12 and 14, Mandy correctly responded to 50% of the presented stimuli. She correctly selected letters t and d in both sessions. In session 13, Mandy correctly
responded to 75% of the presented stimuli. She correctly selected letters t, d, and a. In the last session, Mandy correctly responded to 100% of the presented stimuli. She correctly selected all the letters. Overall, Mandy’s mean correct selection response across nine intervention sessions was 44.4% (range 0-100%).

At the two weeks maintenance check, Mandy continued to correctly tact 75% of the presented stimuli. She correctly tacted letters t, d, and i. However, Mandy’s correct selection response dropped from 100% in the last intervention session to 25%. She only selected letter t correctly. The maintenance condition consisted of one session.

Charles. Charles was placed in Tier 2. A total of nine baseline sessions were conducted for Charles. Charles was unable to correctly tact any of the presented letters in Set 1 (a, d, t, and s) until sessions 7 and 8 in which he correctly tacted 25% of letters (a and d), respectively. However, in session 9, Charles’ correct tact response went back down to 0%. As for Charles’ selection response, his correct response was 0% in sessions 1, 2, 4, 7, 8, and 9. For the other sessions, he correctly responded to at least 25% of the presented stimuli with the exception of session 3 in which he responded correctly to 50% of the presented stimuli (s and a). In session 5, he correctly selected letter t and in session 6, he correctly selected letter s. However, the stimuli that Charles responded correctly across the sessions were not consistent. That is, the letters Charles selected correctly were random. Charles’ overall correct tact and selection responses across all baseline sessions were 5% (range 0-25%) and 11% (range 0-50%), correspondingly.

In the intervention condition, Charles received a total of six sessions of instruction to correctly tact three letters across three consecutive sessions (condition criterion). Similar to Mandy, Charles was able to correctly tact at least one presented stimulus in a
given session across the six intervention sessions. In general, his tacting responses showed an increasing trend across the sessions. Across the first three sessions (10, 11, and 12), Charles correctly tacked letter a (25% of the presented stimuli). In sessions 13, 14, and 15, Charles correctly tacked letters a, s, and d (75% of the presented stimuli). In all the intervention sessions, Charles was unable to tact letter t. Charles’ overall mean correct tact response across six sessions was 50% (range 25-75%).

For Charles’ selection response across the six sessions, he was able to select at least one letter correctly (25% correct). In general, his selection response data showed a stable trend under the intervention condition. Charles’ lowest performance was in session 10 in which he only selected letter d correctly (25%). For the rest of the sessions, Charles’ selection response was at 50% correct. In sessions 12, 13, and 15, Charles correctly selected letters (t and d), letters (a and d), and letters (s and d), respectively. In sessions 11 and 14, Charles correct response was at 75%. He responded correctly to letters a, s, and t in session 11, and he correctly responded to letters a, s, and d in session 14. Overall, Charles’ mean correct selection response across six intervention sessions was 45.8% (range 25-75%).

At the two weeks maintenance check, Charles’ correct tact response dropped from 75% in the last intervention session to 50%. Charles was able to tact letters a and s correctly. On the other hand, Charles’ correct selection response increased from 25% to 75%. Charles selected letters a, t, and d correctly.

*Alex.* A total of 15 baseline sessions were conducted for Alex. He was placed in Tier 3. Alex was unable to correctly tact any of the presented stimuli in Set 1 (t, c, n, and s) across all baseline sessions (0%). Similar to Charles, Alex’s correct selection response
in sessions 1, 2, 3, 6, 9, 12, 13, and 15 was 0%. However, for the other sessions, Alex responded correctly to at least 25% of the presented stimuli. Alex correctly selected 50% of the presented stimuli in session 4 (letters s and t) and in session 5 (letters s and c). In sessions 7, 8, 11, and 15, Alex correctly selected letter s (25%) and in session 10, he responded correctly to letter t (25%). Alex’s overall mean correct tact and selection responses across all baseline sessions were 0% and 15% (range 0-50%), correspondingly.

In the intervention condition, Alex received a total of seven sessions of instruction to meet the condition criterion. Similar to Mandy and Charles, Alex’s tact responses showed an increasing trend across the sessions. Likewise, Alex was able to correctly tact at least one presented stimuli in a given session across the seven intervention sessions. In sessions 16, Alex responded correctly to letter s (25%). In sessions 17 and 19, Alex’s correct response rate was 50% where he correctly tacked letters s and c and letters s and n, respectively. In sessions 18 and 20, Alex correctly tacked three (75%) of the presented stimuli (letters s, c, and n). Likewise, he also responded correctly to 75% of the presented stimuli (letters s, n, and t) in session 22. In session 21, Alex responded correctly to 100% of the stimuli in Set 1 sound cards. Overall, Alex’s mean correct tact response across seven sessions was 65% (range 25-100%).

As for Alex’s selection response across the seven sessions, he was able to select at least two letters correctly (50% correct). Compared to Mandy and Charles, Alex’s selection response showed a more stable and higher level of 25% (i.e., responded to one more letter correctly). The sessions in which Alex performed the lowest were 18 (letters n and s) and 20 (letters s and t) where he correctly responded to 50% of the presented stimuli. In session 17, Alex responded correctly to 75% of the presented stimuli (letters s,
t, and n). In all the other sessions (16, 19, 21, and 22), Alex correctly responded to 100% of the letters in Set 1. Overall, Alex’s mean correct selection response across the seven intervention sessions was 82% (range 50-100%).

At the two weeks maintenance check, Alex’s correct tact response dropped from 75% in the last intervention session to 50%. Alex was able to tact letters t and s. As for Alex’s selection response, he continued to maintain the correct response rate of 100%. 

109
<table>
<thead>
<tr>
<th>Sessions</th>
<th>Mandy</th>
<th>Charles</th>
<th>Alex</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tact</td>
<td>Selection</td>
<td>Tact</td>
</tr>
<tr>
<td>1</td>
<td>---</td>
<td>d</td>
<td>---</td>
</tr>
<tr>
<td>2</td>
<td>---</td>
<td>a</td>
<td>---</td>
</tr>
<tr>
<td>3</td>
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<tr>
<td>6</td>
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</tr>
<tr>
<td>7</td>
<td>t&lt;sup&gt;1&lt;/sup&gt; a, t&lt;sup&gt;1&lt;/sup&gt;</td>
<td>a</td>
<td>---</td>
</tr>
<tr>
<td>8</td>
<td>t</td>
<td>t</td>
<td>d</td>
</tr>
<tr>
<td>9</td>
<td>i</td>
<td>a</td>
<td>------</td>
</tr>
<tr>
<td>10</td>
<td>t, i</td>
<td>a</td>
<td>a&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td>11</td>
<td>t, i</td>
<td>---</td>
<td>a</td>
</tr>
<tr>
<td>12</td>
<td>t, d</td>
<td>t, d</td>
<td>a</td>
</tr>
<tr>
<td>13</td>
<td>t, d, i</td>
<td>t, d, a</td>
<td>a, s, d</td>
</tr>
<tr>
<td>14</td>
<td>t, d, i</td>
<td>t, d</td>
<td>a, s, d</td>
</tr>
<tr>
<td>15</td>
<td>t, d, i</td>
<td>a, d, t, i</td>
<td>a, s, d</td>
</tr>
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<td>t&lt;sup&gt;2&lt;/sup&gt;</td>
<td>a, s&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>17</td>
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<td>S, n, t</td>
<td></td>
</tr>
<tr>
<td>18</td>
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<tr>
<td>22</td>
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<tr>
<td>23</td>
<td>t, s&lt;sup&gt;2&lt;/sup&gt;</td>
<td>s, c, n, t&lt;sup&gt;2&lt;/sup&gt;</td>
<td></td>
</tr>
</tbody>
</table>

Notes: <sup>1</sup> and <sup>2</sup> indicate that participants are in intervention and maintenance conditions, respectively.

Table 4.3: Participants' performance across experimental conditions of Experiment 1 (Tact Training)
Figure 4.1: Participants’ experimental data for Experiment 1 (Tact Training).
Figure 4.2: Participants’ training responses in Experiment 1 (Tact Training).
Experiment 2 (Joint-Control Training)

In this section, participants’ performances in Experiment 2 (Joint-Control Training) are reported according to the Tier the participant was in. Charles’ performances are described first, followed by Alex’s, and then Mandy’s. Within each participant’s performance, baseline data are presented first, followed by intervention data, and lastly, maintenance data. Experiment 2’s data for all participants are displayed in Table 4.4 and graphed in Figure 4.3. Participants’ training responses in Experiment 2 are depicted in Figure 4.4.

Charles. A total of four baseline sessions were conducted for Charles. Charles was unable to correctly tact any of the presented letters in Set 2 (e, z, v, and y) across all sessions. For selection response, Charles correctly selected letter v (25% correct) in session 1. Charles’ overall mean correct tact and selection responses across all baseline sessions were 0% and 6.2% (range 0-25%).

In the intervention condition, Charles received a total of 13 sessions. Although Charles received more intervention sessions than the other participants, he was unable to meet the condition criterion (i.e., correctly tact three letters across three consecutive sessions). Across the 13 sessions, Charles was able to correctly tact at least one presented stimuli (25% correct) in a given session except for sessions 5 and 10 in which he was unable to tact any presented stimuli (0% correct). In general, Charles’ data showed a stable trend with a 25% higher level of correct responses compared to his baseline data. Of all the intervention sessions, Charles best performance was in session 7 where he correctly tacted 75% of the presented stimuli such as letters z, e, and v. In sessions 6, 8, 9, 12, 13, 15, and 17, Charles’ correct rates of responding was 25%. In sessions 6, 8, and 9,
he correctly tacted letter z. In sessions 12, 13, and 17, Charles correctly tacted letter v and in session 17, he correctly tacted letter y. In sessions 11, 14, and 16, Charles’ tact responses were 50% correct in that he tacted letters z and v in sessions 14 and 16 and letters z and e in session 11. Overall, Charles’ mean correct tact response across 13 sessions was 30.7% (0-75%).

As for Charles’ selection response, he was able to select at least one letter correctly (25%) in 5 out of 13 intervention sessions. In general, Charles’ data revealed a decreasing trend in the first four sessions and a stable trend during the last four sessions. In sessions 8, 10, 11, 12, and 13, Charles’ rates of correct selection response was 0%. Charles correctly responded to 50% of the presented stimuli in sessions 6, 7, 9, and 17, where he selected letters y and e, letters y and z, letters e and v, and letters v and z, respectively. In sessions 5, 15, and 16, Charles correctly responded to 75% of the presented stimuli. He was able to select letters y, v, and e in sessions 5; letters z, e, and v in session 15; and letters y, z, and e in session 16. Overall, Charles’ mean correct selection response across 13 intervention sessions was 32.6% (range 0-75%). Given that Charles was unable to meet the condition criteria during the intervention condition, he was not placed in maintenance condition.

*Alex.* Alex was placed in Tier 2 and stayed in baseline condition for eight sessions. In all the sessions, Alex was unable to correctly tact any of the presented stimuli (0%) of Set 2 (v, w, h, and p). Compared to Charles, Alex’s correct selection response was occurring at a higher rate. In general, Alex responded correctly to at least 25% of the presented stimuli except for sessions 1, 5, and 6 in which he responded correctly to 0% of the presented stimuli. In sessions 2 and 4, Alex correctly selected letters p and h,
respectively. In sessions 3 and 8, Alex correctly selected letters v and w (50% correct). In session 7, he correctly selected letter v and h. Alex’s overall mean tact and selection responses across all baseline sessions were 0% and 31.2% (range 0-50%).

In the intervention condition, Alex received a total of eight sessions of instruction to meet the condition criterion. In all of the sessions, Alex’s lowest performance was in sessions 9 and 10 in which he correctly tacted 25% of the presented stimuli or letter s. For all the other sessions, Alex was able to correctly tacted at least 50% of the presented stimuli. In sessions 10, 12, and 13, he correctly tacted letters v and w, letters v and h, and letters w and h, respectively. In sessions 14 and 15, Alex correctly tacted letters v, w, and h (75% correct). In the last session, Alex correctly tacted all (100%) of the presented letters (v, w, h, and p). Overall, Alex’s mean correct tact response across eight sessions was 56.2% (range 25-100%).

As for Alex’s selection response across the eight sessions, he was able to select all the presented stimuli (100%) in Set 2 except for sessions 10 and 11 in which he correctly selected 75% of the letters such as w, h, and p and v, w, and p, correspondingly. Compared to the other participants, Alex had the highest correct selection response rate under the intervention condition. Alex’s data showed a high level and stable trend across sessions. Further, there was a big difference between Alex’s baseline (at least 25% correct) and intervention selection performances (at least 75% correct). Overall, Alex’s mean correct selection response across the eight intervention sessions was 93.7% (range 75-100%).

Similar results were acquired for Alex at the two weeks maintenance check. Alex’s correct tact response dropped from 100% in the last intervention session to 75% in
the maintenance condition. Alex was able to tact letters h, v, and w. As for Alex’s
selection response, he continued to maintain the correct response rate of 100%.

*Mandy.* Mandy was placed in Tier 3. A total of 11 baseline sessions were
conducted for Mandy. Mandy was unable to correctly tact any of the presented letters
(0%) in Set 2 (n, c, h, and g). As for Mandy’s selection response, her data showed a 25%
level with a stable trend. In sessions 1, 3, 4, 6, and 7, Mandy correctly selected 0% of the
presented stimuli. The sessions in which Mandy correctly selected 50% of the presented
stimuli were 2 (letters g and c), 5 (letters g and c), 8 (letters h and c), and 9 (letters h and
c). Mandy correctly selected letter n or 25% of the presented stimuli in sessions 10 and
11.

In the intervention condition, Mandy received a total of six sessions to meet the
modified condition criterion (i.e., correctly tact three letters across three consecutive
sessions). The condition criterion was modified for two reasons. First, Mandy was unable
to say the sounds to letters c and g due to her physical limitation. Second, when prompted
to say the correct sounds to letters c and g, Mandy engaged in self-injurious (e.g., hitting
self on face) and non-compliant behaviors (ignoring directives or walking out of the
session). Thus, the condition criterion was changed to correctly tacting two letters,
(letters n and h where she could correctly say the sound) across three consecutive
sessions to prevent Mandy from engaging in the mentioned inappropriate behaviors.
Moreover, the condition for instruction was also modified. Instead of teaching all four
letter sounds to Mandy as in sessions 12 to 14, two sounds (e.g., /n/ and /h/) were taught
in sessions 15 to 17 since Mandy was able to say them correctly. In other words, each
session from 12 to 14 consisted of 40 trials (10 trials per letter) whereas each session
from 15 to 17 consisted of 20 trials. (See Figure 4.5 for Mandy’s data showing only the
included letters (n and h) across all conditions.) Even though modification was made to
the instructional sessions, probing remained the same. That is, Mandy was tested with all
four letters even though she was taught two letters during the intervention sessions. In
session 12, Mandy’s percentage of correct tact response was 0%. In sessions 13 and 14,
she correctly tacted letters n and h (50% correct) and letter n, respectively. As for
Mandy’s selection response, she correctly selected letter n for sessions 12 and 13 and
letters h, c, and n for session 14. Percentage correct was 50% for both tact and selection
responses from sessions 15 to 17, Mandy correctly tacted and selected letters n and h.

At the two weeks maintenance check, Mandy’s selection response maintained the
same (50%). As for Mandy’s tact response, it dropped from 50% in the last intervention
session to 25%. She tacted letter n correctly.
<table>
<thead>
<tr>
<th>Sessions</th>
<th>Charles</th>
<th>Alex</th>
<th>Mandy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tact</td>
<td>Selection</td>
<td>Tact</td>
</tr>
<tr>
<td>1</td>
<td>---</td>
<td>v</td>
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<td>18</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: 1 and 2 indicate that participants are in intervention and 2-week maintenance conditions, respectively.

Table 4.4: Participants’ performance across experimental conditions of Experiment 2 (Joint-Control Training)
Figure 4.3: Participants’ experimental data for Experiment 2 (Joint-Control Training).
Figure 4.4: Participants’ training responses in Experiment 2 (Joint-Control Training).
Procedural Integrity Data

Treatment fidelity for Experiment 1 (Tact Training) under intervention condition was 100%. Similarly, treatment fidelity under baseline and maintenance conditions was also 100%. Treatment fidelity for Experimenter 2 (joint-control training) under intervention condition was 89.5% (range 85-96%) and 100% under both baseline and maintenance conditions. Overall, the averaged treatment fidelity scores of both Experiments (1 & 2) under intervention conditions equaled to 94% (range 85-100%) and 100% under the baseline and maintenance conditions.
Social Validity Data

Participants’ classroom teachers were given a questionnaire to assess the acceptability of the experimental procedures (i.e., tact and joint-control training) and the targeted responses for instruction. The questionnaire consisted of three sections: General, Tact Training, and Joint-Control Training. In total, the questionnaire was comprised of 16 questions in which four questions indirectly assessed the importance of learning reading skills for children with autism (General), and 12 questions (6 identical questions for each procedure, Tact Training and Joint-Control Training) indirectly assessed the social validity of the two training procedures.

The questionnaire was based on a 5-point Likert type scale. For the General section of the questionnaire, a score of 1 indicated “Not at all important” and a score of 5 indicated “Very important.” As for the Tact Training and Joint-Control Training sections of the questionnaire, a score of 1 indicated either “Not clear at all,” “Not at all,” “Not likely at all,” and “Strongly disagree.” One open-ended question provided teachers an opportunity to offer additional comment(s) about the study. In total, three classroom teachers and one program coordinator participated in social validity survey.

In general, results of the questionnaire indicated that participants favorably viewed the goals and procedures of the study. For the General section (the importance of reading), the mean scores ranged from 4.25 to 5 (Table 4.5). The mean scores for Experiment 1 (Tact Training) ranged from 3.25 to 4.25. As for Experiment 2 (Joint-Control Training), the mean scores ranged from 3.75 to 4.25. The social validity scores for Experiment 1 and 2 are displayed in Table 4.6.
Two participants provided comments in the open-ended question. One participant stated, “I think teaching phonics using Joint-Control method is very helpful for some of my students with autism.” The second participant questioned if “Joint-Control training acting as a verbal prompt…is going to be harder to break [fade] than teaching Tact training.”

**Social Validity Questionnaire (General)**

<table>
<thead>
<tr>
<th>Question</th>
<th>Mean Score</th>
<th>Range Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. One of the purposes of this study was to teach students’ phonics skill. Phonics is considered to be a foundational skill for learning to read. Do you think learning phonics is important for students with autism?</td>
<td>5</td>
<td>5-5</td>
</tr>
<tr>
<td>2. One specific phonics skill taught in this study was letter-sound correspondence. For example, when provided with a printed letter (S), the student was able to say its respective sound (“sss”) and when provided with the sound (“sss”), the student was able to select its respective printed letter (S) among other letters. Do you think that it is important for students with autism to be exposed to instruction that targets letter-sound instruction?</td>
<td>4.75</td>
<td>4-5</td>
</tr>
<tr>
<td>3. How useful do you think that the study’s instructional methods are in promoting letter-sound correspondence in children with autism?</td>
<td>4.25</td>
<td>3-5</td>
</tr>
<tr>
<td>4. How important do you think it is to identify teaching strategies that allow parents/teachers to teach a few skills and have other skills emerge without direct teaching?</td>
<td>4.5</td>
<td>3-5</td>
</tr>
</tbody>
</table>

Table 4.5: Results of the questionnaire on importance of reading for children with ASD
<table>
<thead>
<tr>
<th>Questions</th>
<th>Tact Training</th>
<th>Joint-Control Training</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean Score</td>
<td>Range Score</td>
</tr>
<tr>
<td>1. How clear is the instructional method used in this study?</td>
<td>4.25</td>
<td>2-5</td>
</tr>
<tr>
<td>2. How much do you like the instructional method used in this study?</td>
<td>4.25</td>
<td>3-5</td>
</tr>
<tr>
<td>3. How likely are you willing to implement this instructional method in your classroom/home?</td>
<td>4.25</td>
<td>3-5</td>
</tr>
<tr>
<td>4. There are many aspects of the instructional method that I don’t like.</td>
<td>3.25</td>
<td>2-5</td>
</tr>
<tr>
<td>5. The instructional method appears to be an effective phonics instructional method for teaching children with autism.</td>
<td>4.25</td>
<td>3-5</td>
</tr>
<tr>
<td>6. I would recommend parents/teachers to use this instructional to teach their students/children with autism phonics.</td>
<td>3.75</td>
<td>2-5</td>
</tr>
</tbody>
</table>

Table 4.6: Results of questionnaire on Tact and Joint-Control Training
Chapter 5

Discussion

The purposes of this study were to evaluate the joint-control account of the emergence of bi-directionality, to examine its usefulness as an instructional tool for teaching phonics skills to children with ASD, and to extend and address some limitations identified in a previous joint-control study (Tu, 2006). The joint-control model was selected over other behavior models because of its conceptual consistency with behavior principles and its instructional similarity to effective phonics instruction. Specifically, phonics instruction and joint-control training are similar in regard to the emphasis on the visual and auditory relation. For instance, an individual demonstrates phonics by saying a letter sound that corresponds to a written letter and vice versa. In a similar way, the joint-control model teaches letter-sound relation and sound-letter relation by focusing on increasing the tact and echoic operants.

This chapter includes, first, discussion of the findings of the investigation in relation to each of the research questions presented in Chapter 1. Next, the limitations of the study are identified and recommendations for future research are presented. Finally, implications for practice are discussed.
Research Questions

Research Question 1: What are the effects of joint-control training on the production of letter-sound bi-directionality in children with ASD?

Only the relevant data are reported in response to this question. Tact response data are not discussed here because participants’ tact responses were taught directly. Thus, in order to answer this question, the untrained relation data of Experiment 2 are analyzed and reported. Participants’ ability to demonstrate generalization or bi-directionality is based on the emergence of their selection response or untrained relation, subsequent to joint-control training.

Charles. Charles’ overall average performance showed an increase in selection response from baseline to training. His selection responses increased from 6.2 to 32.6% accuracy. Although Charles’ performance increased after training, his performance was low compared to the other participants. Respectively, Charles’ performance and selection responses reversed back to baseline levels in sessions 8, 10, 11, 12, and 13 (See Figure 4.3 and Table 4.4). Within the mentioned sessions, Charles was extremely aggressive (e.g., he screamed and kicked surrounding objects, such as chairs, a table, and the experimenter) when prompted to follow directions. He also exhibited difficulties staying on task and occasionally fell asleep during these sessions.

Informal interview with Charles’ teacher during these incidents revealed that Charles’ overall academic performance in other settings was also reduced drastically on the same days, and he engaged in more aggressive and non-compliant behaviors. A consistent pattern use of sexual language was also observed by the experimenter and his teacher. Given the sudden changes of Charles’ behavior across skills and settings, indirect
environmental control or setting events (Davis & Fox, 1999) outside of the school might have changed. However, such speculation was not confirmed.

It should be noted that Charles did not meet the training condition criterion (i.e., correctly tact three letters in three consecutive sessions), and thus was not moved to the maintenance condition. For this reason, the effectiveness of joint-control training was questioned. However, in sessions 5, 15 and 16, Charles was able to correctly select 75% of the presented stimuli correctly (See Table 4.4 for letters selected correctly), thus refuting the assumption that joint control was ineffective. A more likely explanation for Charles’ low performance was his inappropriate responses competing with the targeted responses of the study. Namely, when Charles engaged in non-compliant or aggressive behaviors, he did not respond to the presented stimuli during these training and probing sessions. Charles was also observed to fall asleep or lose concentration. Such behaviors would likely impede his performance.

Despite the inappropriate competing behavior and low performance data in some sessions, joint-control training appears to be an effective instructional method in producing letter-sound bi-directionality for Charles.

Alex. Bi-directional responding was the most obvious in Alex’s data (Figure 4.3). Of the three participants, Alex’s selection response data were the most steady and constant in the training condition. His lowest selection response performance was in sessions 10 and 11, in which he correctly selected 75% of the presented stimuli. In all other training condition, Alex’s selection response performance was 100%. Likewise, the two-week maintenance probe showed Alex still maintained performance at 100%. In baseline, Alex’s average selection response performance was 31.2% correct and
subsequent to training, it was 93.7%. That was a substantial increase of 62.5 percentage points. Alex made the most improvement in selection responses when compared to other participants.

A few factors may have contributed to Alex’s remarkable improvement. First, Alex might have been familiar with (although had not mastered) some of the letter-sound relations. For instance, in sessions 3, 8 and 9, he correctly selected letter v. In sessions 3 and 8, he correctly selected letter w, and in sessions 4 and 7, he correctly selected letter h. However, this assumption is difficult to confirm because of a 25% chance of correct response in any given selection response probing session.

Second, informal observations indicate that Alex exhibited no problem behavior, and he was able to stay on task longer than other participants. Alex’s classroom teacher also made the same observation. Being able to stay on task might have increased the effectiveness of training, and thus facilitated more untrained correct responses.

Third, Alex’s home environment might have influenced his performance. Reportedly, Alex’s parents read to him every day and teach him to communicate his desires using verbal language. Numerous studies have documented parental involvement as an important element of effective behavior interventions for children with disabilities (Baker, 1989; Koegel & Koegel, 2006; Wolf, Risley & Mees, 1964). Finally, Alex’s CARS (Table 3.1) data suggested that he fell under the “mild” category of ASD, which might have given Alex an advantage in comparison to the other participants, who were diagnosed with moderate to severe ASD. Overall, Alex’s data implied that joint-control training is an effective instructional method in producing letter-sound bi-directionality.
Mandy. As mentioned in the previous chapter, Mandy was unable to say two of the four letters sounds due to restricted physical ability. For this reason, the two letters (c and g) with which Mandy was having trouble was removed after three training sessions. As a result, probing sessions only measured the two letters that were targeted during training. Since the probing sessions for baseline and the training condition were modified, Mandy’s overall average performance cannot be used to verify the changes across conditions.

Visual inspection of the data presented in Figure 4.3 is also misleading. Based on the information depicted in Figure 4.3, there was no difference in selection response performance between baseline and training. However, an in-depth analysis of the data displayed in Table 4.4 revealed otherwise. Comparison of the data within and across conditions suggests that in baseline, the correct responses were likely attributed to chance. For instance, in sessions 2 and 5, Mandy correctly selected letters c and g. But in the training sessions before the mentioned modifications took effect (i.e., sessions 12, 13 and 14), Mandy, in all three sessions, incorrectly responded to these letters. Similar outcomes can be observed with letters h and c as well. In sessions 8 and 9, Mandy responded correctly to these letters. However, in the training condition, Mandy did not respond correctly to these letters until the third session (session 14).

As such, the same logic can also be applied to the last three data points (sessions 15, 16, 17) on Figure 4.3. That is, the correct responses (letters h and n) could not be due to chance. First, Mandy was unable to correctly respond to these two letters in majority of the baseline sessions. For instance, Mandy correctly responded to letter h in sessions 8 and 9 and letter n in sessions 10 and 11. Second, Mandy was able to correctly respond to
these letters in three consecutive sessions. This suggests that Mandy has mastered the two letters after receiving training. Two weeks maintenance data also confirmed the conclusion. Mandy was able to select letters h and n.

While the modification and the visual inspection from the graphed data made it challenging to interpret the effects of joint-control training as a bi-directional letter-sound relation producing agent, thorough analysis suggested that it might be. Although the effects are limited, Mandy appeared to respond correctly to letters h and n steadily following intervention.

Summary. All three participants demonstrated letter-sound bi-directionality even after joint-control training modifications were made for one participant. This conclusion was further supported with the multiple-baseline design. To be exact, performance across conditions and participants confirmed the three elements (i.e., prediction, replication and verification) of baseline logic (Cooper et al., 2007). In addition, these results are consistent with findings from previous research showing development of picture-sound bi-directionality in typical preschool children (Lowenkron, 1984, 1989; Lowenkron & Colvin, 1995), children with ASD (Tu, 2006), and children with profound mental retardation (Lowenkron, 1988) following joint-control training. Taken together, joint-control training appears to have a positive effect on producing letter-sound bi-directionality relation in children with ASD.

Research Question 2: To what extent will the effect(s) differ between the tact and joint-control training in producing letter-sound bi-directionality in children with ASD?

Strictly speaking, this question cannot be directly answered with the current experimental design given that no functional relation was established between the two
experiments. That is, these experiments were conducted as separate experiments. Moreover, the number of training sessions participants received was different across experiments and participants. On the other hand, the available data can be employed to partially answer this question. To do so, selection response data from both Experiments (1 and 2) are used. Individual averaged data and group averaged data can be compared to assess the difference of responding under the two experiments. As mentioned, with the limited experimental control of these experiments, results should be interpreted with caution and can only be used as preliminary suggestion for future research.

*Alex.* In Experiment 1, Alex received a total of 7 training sessions to meet condition criterion. On average, Alex’s baseline and training selection response performance was 15% (range 0 to 50%) and 82% (range 50-100%) correct, respectively. Alex’s selection mean response performance was improved by 67 percentage points following tact training.

In Experiment 2, Alex received a total of 8 training sessions to meet condition criterion. Alex’s average baseline and training selection response performance increased from 31.2% (range 0-50%) to 93.7% (range 75-100%), respectively. Alex’s mean selection response performance was improved by 62.5 percentage points. In both the tact and joint-control maintenance conditions, Alex’s selection response performance remained at 100%. No difference was observed except for the range percentage. From these data, both types of training appeared to have a similar effect on Alex.

*Charles.* Charles received six training sessions in Experiment 1 to meet criterion condition. In Experiment 2, Charles did not meet the same criterion in 13 training sessions. In Experiment 1, on average, Charles increased his mean selection response
performance from 11% (range 0-25%) in baseline to 45.8% (range 25-75%) in training condition (improvement of 34.8 percentage points). In Experiment 2, on average, Charles increased his selection response performance from 6.2% (0-25%) to 32.6% (0-75%) in baseline to training condition (26.4 percentage points), respectively.

However, Charles’ data cannot be compared because of possible confounding variables, mentioned previously (e.g., environmental factors outside of the training setting might have influenced Charles’ performance during Experiment 2). In spite of this shortcoming, a general statement can be made about Charles’ performance across the experiments. Charles’ overall letter-sound bi-directionality improved under both instructional conditions. For instance, only following training did Charles’ selection response increased to 75% correct in both experiments (e.g., sessions 11 and 14 in Experiment 1; sessions 5, 15, and 16 in Experiment 2).

*Mandy.* Based on visual inspection, tact training may have been more effective in producing letter-sound bi-directionality for Mandy. Mandy’s averaged performance between the two conditions also confirmed this claim. For instance, Mandy’s overall averaged correct selection response performance was 15% (range 0-50%) during baseline and 82% during tact training. However, as to which instruction (tact versus joint-control training) produced better letter-sound bi-directionality; it is impossible to differentiate the difference with the available experimental data.

Like Charles, Mandy’s experimental data between the two experiments cannot be compared. The problem is related to the adjustment made to Mandy’s condition criterion. Mandy’s criterion was adjusted to two letters correctly for three consecutive sessions instead of three letters for three consecutive sessions due to previously stated reason.
during the fourth session or session 14 of the joint-control training (Figure 4.3). Visual inspection of Mandy’s joint-control training implies that her selection response performance made little to no improvement from baseline to training. However, that figure distorted the true representation of Mandy’s performance. In-depth analysis of the experimental data revealed improvement in Mandy’s selection response performance.

**Summary.** From the available data, it is unclear whether there is a difference in how each instructional method affects participants’ letter-sound bi-directionality. These findings seem to contradict Tu’s (2006) findings. In Tu’s study, participants demonstrated object-word bi-directionality with no additional training only after receiving the joint tact and echoic control. In this study, participants demonstrated untrained bi-directionality after receiving only tact training. On the other hand, the findings from the current investigator are more consistent with Sidener and Michael (2006). Sidener and Michael found that participants demonstrated high levels of generalized relational matching to sample with the coding response or mediating stimulus (i.e., joint-control training) and lower levels without the mediating stimulus (i.e., tact training). Although occurring at lower levels, generalized relational matching did arise without the stimulus mediation or joint-control training.

Even though the experimental data cannot be used to differentiate the instructional methods’ affect, these data showed that both instructional methods were effective in producing letter-sound bi-directionality in children with ASD. Both instructional methods met the criteria for establishing functional relations.
Research Question 3: How will the joint-control training function as phonics instruction for children with ASD?

The experimental data presented thus far suggest that joint-control training can function as effective phonics instruction. All participants not only made improvements in their tacting responses but also in their bi-directionality responses, which were not directly trained. Among the participants, Alex’s improvement of both tact and selection response performance was the most apparent. His tact response increased from a mean of 50% correct to 100% correct in session 16, the last session of training. Alex’s selection response performance was even more noticeable, after receiving only four training sessions, this response remained at 100% correct throughout the training sessions and was maintained two weeks following the last training session.

Similarly, even though the improvement in Charles’ and Mandy’s tact and selection responses was not as obvious as Alex’s, their performance increased only after joint-control training was administered (See Figure 4.3). Interestingly, Charles’ (session 5) and Mandy’s (session 12) probe after the first training was 0% correct. The low performance might indicate that these participants were not familiar with the joint-control instruction. At least two sessions were needed for Charles (session 6) and Mandy (session 12) to be familiar with the instruction before changes in performance were observed. This assumption appears valid in that joint-control training is not a typical method school teachers would use to instruct phonics.

Although joint-control training is not the typical method used in school for phonics instruction, this positive functional relation might be related to the similarly of the repertoires required for phonics and the repertoires joint-control training targets.
Another account for the positive functional relation might be associated with the joint-control instruction being an explicit or direct instructional method. This speculation is consistent with suggestions for effective phonics instruction made by Browder et al. (2006) and Bursuck and Damer (2007). These researchers indentified a few components that make reading instruction, in general, effective: (a) have a clear instructional goal, (b) provide clear directives, (c) provide adequate modeling/demonstration and guided practice, and (e) provide clear and consistent corrective feedback on success and errors.

For instance, in the current study, the instructional goal was to teach participants eight letter-sound and sound-letter relations. During joint-control training, clear directives were provided (e.g., presented a sound card and asked “What sound?”) and when participants emitted a response, corrective feedback was provided for incorrect responses (e.g., “The sound is ___, what sound?”) and correct responses (e.g., “That’s right!”). In addition, the joint-control procedure prevented participants from practicing errors by providing participants with the correct sound prior to requesting them to tact the corresponding sound card (e.g., the experimenter provided the participant with a letter sound, and immediately afterward, presented the sound card in front of the participant and asked “What sound?”).

Research Question 4: To what extent will the assumptions of joint-control accurately predict letter-sound bi-directionality performance of children with ASD?

To answer this question, the notion of joint-control must be analyzed. Once analyzed, the collected data are interpreted through the lens of these assumptions. The joint-control model is based on two assumptions (Lowenkron, 1998). First, individuals need to acquire the repertoire of joint-control before untrained generalization or bi-
directionality can occur. Namely, joint-control is based on the notion that response mediation is required for bi-directionality to occur. In this sense, joint control is response mediation that allows an individual to associate one stimulus to other stimuli or to generalize without additional training. Second, once an individual acquires the joint-control repertoire, subsequent untrained generalization or bi-directionality occurs with only the tact response being taught. In simple terms, after an individual acquires the ability to respond to multiple stimulus control (joint control) such as tact and echoic, untrained generalization or bi-directionality will occur if that individual is taught only the names of novel events (i.e., tacting the novel events).

Results of Experiment 1 are inconsistent with Tu (2006) and thus do not appear to support the first assumption. Specifically, Tu found that participants only demonstrated object-word bi-directionality without additional training following joint control training. In this study, however, all three participants demonstrated bi-directionality after receiving only tact training (Experiment 1). That is, three children with ASD and limited verbal communication skills established letter-sound bi-directionality after receiving direct instruction in only one relation. This suggests that it may not be necessary for children with ASD to have response mediation or joint-control in order to produce untrained generalization. The assumption follows a simple logic. Oral communication is a form of response mediation that facilitate untrained generalization, and given that children with ASD often lack oral communication, the emergence of letter-sound bi-directionality should not occur in these children given that they have no response mediation to do so.

Results of Experiment 1 do not necessarily reject the first assumption of joint-control but rather they may merely indicate that participants in this study had already
acquired joint-control ability (i.e., support the second assumption of joint-control model). Even though participants exhibited deficits in communication skills; it does not signify that they did not have joint control. It merely decreases the possibility of participants who might have acquired the ability. Lowenkron (1984, 1988, 1989) and Lowenkron and Colvin (1995), for example, included only participants who were 5 years old or younger. Lowenkron assumes that the younger a child is, the greater the likelihood that s/he will have not acquired joint-control ability. Furthermore, it is difficult, if not impossible to determine if participants already acquired joint control, given that it is a covert skill unobservable by others (Palmer, 2006). Palmer further elaborated that the “history responsible for establishing joint-control… is usually buried in the subject’s past” (p. 211).

Results from both Experiments (1 and 2) showed that both instructional methods are effective in producing letter-sound bi-directionality. Moreover, results from these experiments cannot be compared to determine if participants respond differently to them. In light of this, joint control might not be the essential necessary skill or controlling variable for generalized performance and how untrained generalization emerges. In other words, other unobserved controlling variables might have influenced participants’ letter-sound bi-directionality correct performance.

*Research Question 5: How will the participants’ teachers rate the acceptability of the study’s goals, procedures, and outcomes?*

In general, teachers who completed the social validity questionnaires reported that the goals, procedures, and outcomes were acceptable and important. Prior to conducting this study, the director and program coordinator were informally interviewed
to rate the importance of teaching children with ASD to read, focusing on phonics instruction. Specifically, they were interviewed to ensure that (a) the goals of the study aligned with participants’ IEP goals and thus participants might benefit from the study, and (b) they understood the goals and purposes of the study to permit the experimenter to conduct the instruction in the school setting. Participants’ teachers were not interviewed prior to the study in order to prevent any confounding variable(s). In other words, if participants’ classroom teachers were aware of the study’s instructional methods, they might have implemented additional interventions, and thus confounded the controlling variables of the study.

Following the study, the program coordinator and participants’ classroom teachers (4 individuals) participated in the social validity questionnaire. The director was unavailable to participate in the questionnaire. The respondents rated phonics skill as a vital component to teach children with ASD to read (scores ranged from 4.75 to 5, 5 being very important and 1 being not so important). In general, the instructional methods in both experiments (both the tact and joint-control), were rated as fairly acceptable (scored ranged from 4.25 to 4.5). Individually, respondents’ ratings for the tact training and joint-control training procedures (i.e., how much they liked the procedures, how likely would be to implement them, how effective the procedure were in teaching phonics, and how likely they would be to recommend the procedures to other teachers and parents) were fairly high (scores ranged from 3.75 to 4.5). With the available data, it seems that respondents did not prefer one instructional method over the other. Both instructional methods received approximately the same overall score.
One major concern raised by the program coordinator after watching a 2 minutes video clip of the instruction is that participants might become prompt dependent under joint-control training. In other words, in the joint-control training, an appropriate sound that corresponds to a sound card was provided to participants prior to presenting the sound card. Thus, the concern is whether providing the sound prior to the target stimulus (sound card) can actually hinder students’ learning by becoming dependent on the sound.

Although a valid concern, results from Experiment 2 do not support the statement. Results actually showed that participants’ tact and selection responses increased after intervention. To be specific, a probe session was conducted immediately after participants received training and in probe sessions, no prompt was provided (see Chapter 3: Method). Instead of impeding participants’ phonics performance, providing the sound prior to presenting its respective letter card might actually facilitate better phonics performance for children with ASD (i.e., these children has the tendency to imitate sound).

The joint-control method may have served as an errorless training procedure for participants in this study in that it prevented participants from engaging in incorrect responses by providing the correct responses prior to expecting participants’ responding. This speculation seems to support another one of the teacher’s comments, “I think teaching phonics using joint-control method is very helpful for some of my students with ASD.” However, the teacher did not specify the reason behind this statement.

In particular, this study was conducted in a structured one-on-one setting, so educators might have serious concern over the procedures’ transferability to group settings in classrooms. The lack of concern for this matter may be related to the
classroom size in which these teachers instructed. Generally only two to four students were instructed in a classroom. In addition, instruction to students were individualized so group instruction usually do not occur. Provided that individualized, structured instruction generally occurred in this school setting, both tact and joint-control trainings are appropriate instructional methods. Perhaps for the mentioned reasons, respondents rated these procedures highly.

Limitations and Future Research

Several limitations of this study are identified and discussed. Immediately following each discussion of a limitation, recommendations are made to address the limitation in future research. First, the experimental design implemented in this study was unsuitable to answer research question number 2 (To what extent will the effect(s) differ between the tact and joint-control training in producing letter-sound bi-directionality in children with ASD?). As previously mentioned, although the study yielded valuable data, these data cannot be used to determine if one instructional method is more effective in facilitating letter-sound bi-directionality than the other one. This is because the instructional methods were evaluated with two separate experiments, thus no experimental control was acquired.

Given the comparison nature of question number 2, it would seem appropriate to use an alternating treatments design (Cooper et al., 2007). However, similar to the experimental design (multiple-baseline) used in the current study, an alternating treatment design would not be appropriate based on the notion joint-control. As aforementioned early in this Chapter, one of the major notions of joint control is once an individual acquires joint control ability, the individual needs to learn only to tact events
in order for untrained generalization to occur. Based on this assumption, an alternating instruction of tact and joint-control training would generate a critically confounding variable (interaction effect) of the two instructions. Loosely speaking, according to the notion of joint control, untrained generalization is primarily the result of joint control. Alternating the two instructional methods (tact and joint control) would create a situation in which the investigator would not be able to conclude if the bi-directionality is the direct product of the tact training or if it is the indirect product of the joint control interacting with the tact training.

And so, future research should consider using a group experimental design in which one group of participants is placed in the tact training condition, the second group is placed in the joint-control condition, and the third group is placed in a control condition. In this way, the interaction effect of the instructional methods and the difference of effect between group performance and within group performance can be analyzed (Lomax, 2007).

Second, in Experiment 2 (Joint-Control Training), a modification was made to Mandy’s condition criterion (i.e., correctly respond to two letters in three consecutive sessions instead of correctly respond to four letters in three consecutive sessions in order to move to the next experimental condition). The criterion was modified due to Mandy’s physical (i.e., speech) disabilities. She was unable to pronounce the sound correctly. When prompted to say the sound correctly, Mandy would engage in self-injurious (slapping self on face and thigh) and escape behavior (covering face with both hands). Further prompts would escalate Mandy to reject the instructional sessions completely. Therefore, to prevent Mandy from injuring herself and escaping this study’s academic
task, which might transfer to other settings, the condition criterion was adjusted to match Mandy’s skills.

In future investigations, a situation like this one can be avoided by conducting an informal assessment to evaluate if participants have the necessary ability to perform the study’s target response(s). In this situation, an assessment such as requesting participants to imitate all the letter sounds (without presenting the sound cards) should be sufficient to determine if participants have the skill to do so. Such assessment should not include any types of reinforcement for the correct imitation of a prompt.

Third, in Figure 4.1 under Experiment 1 baseline, Charles was able to correctly tact 25% of the presented stimuli in sessions 7 (letter a) and 8 (letter d). Given that Charles was able to tact letters a and d, he might have learned letter-sound correspondence for these letters. As a result, the effectiveness of the instructional method might have been compromised. To rectify this limitation, these two letters should have been replaced by other unknown letters and/or collect more data once a stable baseline is established.

Fourth, the target skill (letter-sound correspondence) in the current study requires participants to have at least simple oral imitation or language. When compared to earlier joint-control studies with exceptional children, participants from previous studies tended to have lower IQ scores (Lowenkron, 1988), were less vocal (Tu, 2006), and were younger (Lowenkron, 1984; Lowenkron & Colvin, 1995; Sidener & Michael, 2006) than the participants in the current study. For instance, in Sidener and Michael, participants were 3.6 to 5 years of age, and the necessary skills to participate in the study were basic motor skills such as holding and rotating an index card and a wooden cube.
These characteristics and prerequisite skill for phonics perhaps have limited the findings of this study. Thus, future studies that aim to evaluate the conceptual-base of joint control should consider recruiting participants who are 5 years old or younger, who do not have vocal communication skills, who have severe intellectual disabilities, and/or children with autism who have never been taught functional communication skills. These characteristics might make it less likely that the participants have already acquired joint control ability. In this sense, difficult skills (e.g., reading) that required higher performance should be avoided.

Fifth, the sequence of the letters in the letter card sets (1 & 2) was not randomly assigned to each of the experiments. As a result, a possible confounding variable, such as carry-over effect might have influenced the data for Experimenter 2 from Experiment 1. Future research should randomly assign the letters to each card set or counterbalance the card sets across participants.

Sixth, the current study did not use a zero-second time delay procedure. Future studies should consider implementing a zero-second time delay technique as an errorless learning procedure to prevent participants from engaging in unnecessary incorrect responses. Moreover, implementing the time delay procedure may increase the rate at which participants learn the material and emit spontaneous responses (Charlop, Schreibman, & Thibodeau, 1985).

Seventh, given that only one maintenance data point was collected in the current study, it was difficult to determine the effects of the instruction over time. This limitation can be addressed in future studies by collecting enough data points in the maintenance condition to establish a stable pattern.
Eighth, during Experiment 1, because of the placement of the camcorder, only a limited number of sound-letter relation data could be used for IOA. The camcorder was positioned in such a way that observers could not see participants’ selection responses (sound-letter relation). Thus, only 14% of the Experiment 1 data under sound-letter conditions were used for IOA. The situation can be prevented in the future by ensuring that the camcorder is placed at an angle where selection responses can be detected.

In sum, while the current study addressed one important limitation in reading literature (phonics instruction), there are many remaining questions related to teaching individuals with developmental disabilities reading (e.g., blending and segmenting). In the current study, only eight letter-sound correspondences were taught to participants. More advanced phonics skills, such as blending, were not taught. Clearly, more research is needed to explore the possibilities of using joint-control as reading instruction to further improve students’ reading skills.

One possibility is to explore joint-control as instruction that teaches both phonemic awareness and phonics skills at the same time given that joint-control training teaches both sound-sound and sound-print association. Rather than teaching random letter-sound correspondences, letter-sound correspondences should be taught according to simple words that are commonly seen in children’s books such as “cat,” “hat,” “rat.” After students have mastered the letter-sound correspondences of letters c, h, a, t, and r, joint-control training can be used to teach students to blend these letter/sounds into words.

For instance, a teaching format might follow these steps: (a) provide student with a word (e.g., cat) and emphasize each letter sound (e.g., /c/, /a/, /t/) in a continuous
manner; (b) after the student echoes the word, present the him or her with the word in printed form and have the student tact the word /cat/ without emphasizing the individual letter sounds; (c) use the other two words (e.g., hat and rat) to evaluate the transferability of students’ phonics and phonemic awareness skills to novel words.

In the current study, the experimenter taught participants phonics in a one-on-one setting. Hence, a second possibility is to explore joint-control in a small-group instruction format. This can be done by assessing students to determine their reading abilities and placing students with similar reading abilities in a small group, perhaps three to four students. In this setting, joint-control training can be conducted in a similar manner as the current study with two exceptions. First, for the tact response, students may engage in choral responding (Heward, 1994) contingent on the presented sound card. Second, for the selection response, students may use the provided the letter sound cards as response cards (Heward) contingent on the presented letter sound.

If shown to be an effective instruction in a small-group setting, then joint-control training can be further explored in a similar matter but in more typical special education settings (e.g., resource rooms). For example, joint-control training can be explored as a phonics instruction by incorporated peer tutoring (Kourea et al., 2007), which could make joint-control training more efficient and effective in larger classroom settings.

Implications for Practice

Based on the current investigation, several implications for practice are suggested. First, According to McLellan and Dewey’s (1908) perspective, both the tact training and the joint control training are efficient and practical. McLellan and Dewey stated that “The value of… theory… is determined by using it for accomplishing some definite purpose…”
If it removes friction, frees activity, economizes effort, makes for richer results, it is valuable” (p. 195). In this sense, tact training and joint control are efficient instructional tools that can produce results “beyond the information given.” Results of the current investigation also indicate that tact training and joint-control training can be employed as generative phonics instruction that may allow teachers of students with disabilities to teach more in less time. These procedures hold promise as methods that promote generalization.

Second, the current study’s findings also confirmed that both tact and joint-control training can be efficient and effective as phonics instruction for students with ASD. Participants demonstrated letter-sound bi-directionality after receiving only letter-sound relation. Educators need to consider a few points to ensure the effectiveness of these instructional methods for students with ASD. Educators must assess students to ensure that they (a) have simple vocal language skills (e.g., ability to communicate desires with 1 to 4 words sentences), (b) demonstrate on-task behavior (e.g., stay on a given task for more than 5 seconds), (c) have the physical ability to imitate letter sounds, and (d) have the motivation to complete the instruction (e.g., conducting a preference assessment and using preferred items to encourage learning).

Third, the current study meets Horner et al. (2005)’s quality indicators of single-subject research and thus contributes to establishing tact and joint control training as evidence-based methods for teaching phonics. That is, this investigation adds more evidence to the limited literature on phonics instruction for children with ASD. Particularly, the investigation’s results provide adequate evidence across three participants that young students with ASD can be taught phonics despite the conviction
that these children cannot learn complex skills due to limited cognitive capability (Mirenda, 2003) and should be taught functional sight-word instruction. While this study supports the view that students with ASD can benefit from learning phonics, it does not deny that, in some cases, sight-word instruction is more appropriate. As mentioned, to learn phonics, prerequisite skills are required. Thus, for students with profound disabilities and no language ability, teaching these students phonics might not be appropriate or beneficial. Browder et al. (2006) suggested that students with profound disabilities may benefit from sight word instruction that focuses on daily living such as cooking and grocery shopping. Moreover, to teach sight word reading and comprehension effectively, teachers should employ prompting and fading procedures such as time delay.

Fourth, given that the setting in the current study is similar to home settings, both tact and joint-control training might be easy and efficient for parents to implement with their children at home. Parents can provide one-on-one instruction.

Furthermore, although not examined in the current study, studies have suggested that phonemic awareness can help learners develop their decoding skills, which can enable them to acquire words that are not explicitly taught. Based on the current study’s findings and the literature supporting the importance of phonemic awareness, it seems students with ASD (with similar characteristics to this study’s participants) may benefit from instruction in both skill areas. Although participants in Hoogeveen and Smeets (1988) were not children with ASD, these researchers successfully taught children with mental retardation phoneme blending. Moreover, Hoogeveen and Smeets pointed out that “the ability to blend sounds does not emerge as a function of mastering letter-sound
correspondences but requires explicit training” (p.46). Presumably, when students learn these skills, it may enable them to decode novel words that are not explicitly taught.

Although the results of the current investigation are promising, more research is needed to further confirm the effectiveness of tact and joint-control trainings as phonics instruction. Specifically, the effects of tact and joint-control training on letter-sound and sound-letter relations have not been examined thoroughly with participants of different ages, disabilities, and skills. Hence, teachers should use extreme caution when interpreting the current findings.

Conclusions

Although the findings of the current study cannot confirm the accuracy of joint control model in explaining the emergence of untrained relations, nor do the findings refute the notion. Certainly, the findings extend the limited literature on phonics instruction (Browder et al., 2006) by demonstrating that joint-control training can serve as effective phonics instruction for children with ASD. By demonstrating that the joint control model is an effective phonics for this population, this implies that Skinner’s verbal analysis of behavior might play an important role in assisting children to become proficient readers. Thus, reading programs should consider incorporating the verbal behavior approach.

More importantly, joint control (of the echoic and tact) as a reading instruction was well received by participants’ educators. As in any evidence-based instruction, it should be conceptually based, simple to understand, and easy to implement. It seems that joint control as a phonics instruction has met such qualities. Joint-control training was effective in a context in which some students had been in school for awhile and had
received ineffective phonics instruction. Accordingly, educators might have given up on teaching them phonics. Yet, the results of the current study showed that participants learned eight letter-sound and sound-letter relations in eight weeks despite the assumption from educators and parents that children with autism do not have the cognitive capability to do so (Mirenda, 2003). In other words, joint-control may be used as remedial instruction for students who have failed to learn phonics skills previously.

In addition to meeting the aforementioned qualities, joint control also appears to be a generative instruction. This is especially important in that children with ASD and other severe disabilities (Browder & Snell, 1987) tend to receive a majority of their instruction time focusing on this component. As such, educators working with students with ASD should use joint control training given that it is an efficient and effective method of phonics instruction. Although joint-control was effective, one important environmental factor must be considered. One-on-one teaching arrangements, like the one used in the current study, are not feasible in many classroom environments. Joint-control training is likely more effective in a small classroom setting in which the ratio of teacher to students is 1 to 3 than in a typical special education classroom where there are likely to be many more students per teacher.

While phonics as an individual skill may be of little value to children with ASD, learning it with other components of reading may make phonics worthwhile (Barudin & Hourcade, 1990). Barudin and Hourcade pointed out that to truly benefit from reading, it is essential that students become functional readers. That is, students need to learn how to decode novel words without explicit instruction. For individuals with ASD, it is even more crucial that this population acquire the ability to learn new skills (i.e., reading novel
words) without additional training to live efficiently. [Individuals with ASD tend to have difficulties generalizing learned skills, which might attribute to overselectivity (Lovass, Schreibman, Koegel, & Rehm, 1971)]. To integrate successfully into society, individuals with ASD must learn to decode novel words. That is, societal situations will likely demand these individuals to read novel words to function efficiently.

Joint-control training has great potential to become generative instruction for skills other than phonics if continued to be explored and refined across skills, populations, and instructional settings. Results from further studies could perhaps help establish a paradigm shift in teaching individuals with disabilities generative skills without relying on supplemental training for generalization.
References


157


National Institute of Child Health and Human Development (2000). Report of the National Reading Panel. Teaching Children to Read: An Evidence-Based Assessment of the Scientific Research Literature on Reading and its Implications for Reading Instruction: Reports of the Subgroups (NIH Publication No. 00-4754). Washington, DC: U.S. Government Printing Office.


Appendix A: Parental Permission
The Ohio State University Parental Permission
For Child’s Participation in Research

Effects of Joint-control Training on Producing Letter-sound Bi-directionality in Children with Autism Spectrum Disorders

Researcher: Moira Konrad, Ph.D. and Ken Luu, M.S., BCBA

Sponsor:

This is a parental permission form for research participation. It contains important information about this study and what to expect if you permit your child to participate.

Your child’s participation is voluntary.

Please consider the information carefully. Feel free to discuss the study with your friends and family and to ask questions before making your decision whether or not to permit your child to participate. If you permit your child to participate, you will be asked to sign this form and will receive a copy of the form.

Purpose:
The purpose of the current research study is to identify efficient methods of teaching phonics to children with autism spectrum disorders. Efficient methods are those that require less instructional time but yet produce more learning.

Procedures/Tasks:
1. Your child’s school records will be examined to determine eligibility for participation (i.e., if student’s records indicate need for language and reading intervention, he/she will be eligible to participate)
2. Your child will complete standardized assessments on language, phonics, and autism, if necessary (i.e., if school records do not include needed information)
3. Your child will complete a preference assessment to identify his or her preferred items and activities. Specifically, the instructor will provide your child with an array of items (e.g., edibles such as fruits and small candies, small toys or other objects such as stickers, activities such as puzzle time, music, reading, etc.) to determine which items will serve as rewards during the study.
4. Your child will be taught phonics with typical instruction. Specifically, the instructor will show your child letters and directly teach the corresponding sounds. For example, the instructor will show your child the letter s and say, “Say sssss.” Your child will be prompted to make correct responses, and items identified in Step 3 will be used as reinforcers for correct responses.
5. Your child will then be taught phonics with modified instruction (“joint-control strategy”). Specifically, the instructor will prompt your child to say a sound before showing him/her the corresponding letter. While the student is saying the sound, the
instructor will introduce the printed letter. Again, your child will be prompted to make
correct responses, and items identified in Step 3 will be used as reinforcers for correct
responses.
6. Videotapes will be reviewed to collect data. Your child’s teacher and the investigator
(Ken Lio) and a second trained investigator from the university will view the
videotapes.

Duration:
Your child would be involved in this project for approximately three months. There will
typically be one 20-minute session per day. Your child may leave the study at any time. If
you or your child decides to stop participation in the study, there will be no penalty and
neither you nor your child will lose any benefits to which you are otherwise entitled. Your
decision will not affect your future relationship with The Ohio State University.

Risks and Benefits:
Risks -- We do not anticipate any risks associated with this study, but any time that your
child would appear uncomfortable or frustrated, the teaching session would be paused until
your child regains his or her typical comfort level.
Benefits -- Your child will have opportunities to learn phonics. Research has shown that
phonics can have positive effects on children’s ability to read.

Confidentiality:
Videotaped sessions will be used for data collection purposes only. Videotapes and data will
be viewed only by your child’s teacher and members of the research team and will be kept in
a locked container in a locked office when not in use. No personal identifiable information
about your child will be on the tape (other than his/her image). If we ever want to show a
videotape to anyone else -- such as at a professional conference -- we will first request your
written permission. You are always welcome to say “no” to such requests and doing so will
not affect your child’s participation in this project. Please be assured that your child’s name
will not be revealed in any publication, document, recording, computer storage, or any other
form of report or presentation developed from this research.

Efforts will be made to keep your child’s study-related information confidential. However,
there may be circumstances where this information must be released. For example, personal
information regarding your child’s participation in this study may be disclosed if required by
state law. Also, your child’s records may be reviewed by the following groups (as applicable
to the research):
• Office for Human Research Protections or other federal, state, or international
  regulatory agencies;
• The Ohio State University Institutional Review Board or Office of Responsible
  Research Practices;
• The sponsor, if any, or agency (including the Food and Drug Administration for FDA-
  regulated research) supporting the study.

Incentives:
Neither you nor your child will be paid to take part in this study.

**Participant Rights:**
You or your child may refuse to participate in this study without penalty or loss of benefits to which you are otherwise entitled. If you or your child is a student or employee at Ohio State, your decision will not affect your grades or employment status.

If you and your child choose to participate in the study, you may discontinue participation at any time without penalty or loss of benefits. By signing this form, you do not give up any personal legal rights your child may have as a participant in this study.

An Institutional Review Board responsible for human subjects research at The Ohio State University reviewed this research project and found it to be acceptable, according to applicable state and federal regulations and University policies designed to protect the rights and welfare of participants in research.

**Contacts and Questions:**
For questions, concerns, or complaints about the study you may contact Moira Konard at 614-292-0839.

For questions about your child’s rights as a participant in this study or to discuss other study-related concerns or complaints with someone who is not part of the research team, you may contact Ms. Sandra Meadows in the Office of Responsible Research Practices at 1-800-678-6251.

If your child is injured as a result of participating in this study or for questions about a study-related injury, you may contact Moira Konrad at 614-292-0839.
Signing the parental permission form

I have read (or someone has read to me) this form and I am aware that I am being asked to provide permission for my child’s teacher to provide my child’s school records to the research team for research purposes only and for my child to participate in a research study. I have had the opportunity to ask questions and have had them answered to my satisfaction. I voluntarily agree to permit my child to participate in this study.

I am not giving up any legal rights by signing this form. I will be given a copy of this form.

Printed name of subject

Printed name of person authorized to provide permission for subject

Signature of person authorized to provide permission for subject

Relationship to the subject

Date and time

AM/PM

Investigator/Research Staff

I have explained the research to the participant or his/her representative before requesting the signature(s) above. There are no blanks in this document. A copy of this form has been given to the participant or his/her representative.

Printed name of person obtaining consent

Signature of person obtaining consent

Date and time

AM/PM
Appendix B: Teacher Assent Form
Verbal Consent to Participate in Research

My name is Ken Luu, a graduate student in Special Education at The Ohio State University. One of the requirements for completing my Ph.D. study is to conduct a dissertation research project. I will be conducting my research under the supervision of my faculty advisor, Moira Konrad, Ph.D., a professor in the College of Education and Human Ecology.

The purpose of the study is to identify efficient methods of teaching phonics to children with autism spectrum disorders. A teaching method known as “joint-control,” that teaches children to learn materials audibly and visually, will be used to teach your student phonics or letter-sound relations. By learning the skill to respond to the same stimulus audibly and visually, it may facilitate your student to generalize learned skills. More importantly, phonics is a foundational skill children need to learn to become proficient readers.

Given that you have nominated your student(s) as someone who might benefit from our teaching services, you are also invited to participate in this study. Your participation will include watching a short video clip of your student(s)’s performance during the study and then filling out a 10-item questionnaire related to the effectiveness, efficiency, appropriateness, and acceptability of the instruction at the end of the study. Watching the video and filling out the questionnaire should take you approximately 20 minutes. You will not be paid or receive any direct incentives for your participation. The information you provide on the questionnaire as well as your personal information will be kept confidential as you will not be asked to put your name on the questionnaire. Further, your questionnaire will be accessible only to the research team.

Participation is voluntary and you may leave the study at any time. If you decide not to participate or to stop participating in the study, there will be no penalty to you, and you will not lose any benefits to which you are otherwise entitled. Your decision will not affect your future relationship with The Ohio State University. By agreeing to participate, you do not give up any personal legal rights you may have as a participant in this study.

We do not anticipate any risks associated with your participation in this study. For questions, concerns, or complaints about the study you may contact Moira Konrad (Konrad.14@osu.edu) or Ken (Cuong) Luu (Luu.18@osu.edu). For questions about your rights as a participant in this study or to discuss other study-related concerns or complaints with someone who is not part of the research team, you may contact Ms. Sandra Meadows in the Office of Responsible Research Practices at 1-800-678-6251.

If you are interested in participating, please say “YES” and a copy of this verbal consent will be given to you. If you are not interested in participating, please say “NO.”

Thank you for all your time.
Appendix C: Training Stimuli
Sounds Practice Cards

In addition to the lessons you teach, you can provide extra time to practice the sounds (after they have been introduced in the lessons). Resist the urge to have your child practice sounds before they are introduced. The number on the back of each card indicates the lesson on which the sound is introduced. There is also a key word for you (not for your child) to use. [Cut along the dotted lines to produce a card for every sound.]
Appendix D: Preference Assessment Form
The Reinforcer Assessment for Individuals with Severe Disabilities (RAISD)

PARTICIPANT’S NAME: ____________________________ DATE: ____________

NAME OF REPORTER: ____________________________

The purpose of this structured interview is to get as much specific information as possible from the parent (or caregiver) regarding what they believe would be useful reinforcers for the client. Therefore, this survey asks parents questions about categories of stimuli (e.g., visual, auditory etc.). After the parent has generated a list of preferred stimuli, ask additional probe questions to get more specific information on his/her preferences and the stimulus conditions under which the object or activity is most preferred (e.g., What specific TV shows are his favorite? What does she do when she plays with a mirror? Does she prefer to do this alone or with another person?)

We would like to get some information on ____________________________’s preference for different items and activities.

1. Some children really enjoy looking at things such as a mirror, bright lights, shiny objects, spinning objects, TV, etc. What are the things you think ________________ most likes to watch? ____________________________

RESPONSE TO PROBE QUESTIONS: ____________________________

2. Some children really enjoy different sounds such as listening sounds such as listening to music, car sounds, whistles, beeps, sirens, clapping, people singing, etc. What are the things you think ________________ most likes to listen to? ____________________________

RESPONSE TO PROBE QUESTIONS: ____________________________

3. Some children really enjoy different smells such as perfume, flowers, coffee, pine trees, etc. What are the things you think ________________ most likes to smell? ____________________________

RESPONSE TO PROBE QUESTIONS: ____________________________
What are the things you think ______________ most likes to smell? _____________

RESPONSE TO PROBE QUESTIONS:

4. Some children really enjoy certain foods or snacks such as ice cream, pizza, juice, graham crackers, McDonald’sTM hamburgers, etc. What are the things you think _____________ most likes to eat?

RESPONSE TO PROBE QUESTIONS:

5. Some children really enjoy physical play or movement such as being tickled, wrestling, running, dancing, swinging, being pulled on a scooter board, etc. What activities like this do you think ________________ most enjoys? ______________

RESPONSE TO PROBE QUESTIONS:

6. Some children really enjoy touching things of different temperatures, cold things like snow or an ice pack, or warm things like a hand warmer or a cup containing hot tea or coffee. What activities like this do you think _____________ most enjoys?

RESPONSE TO PROBE QUESTIONS:

7. Some children really enjoy feeling different sensations such as splashing water in a sink, a vibrator against the skin, or the feel of air blow on the face from a fan. What activities like this do you think _________________ most enjoys? ________________
RESPONSE TO PROBE QUESTIONS:

8. Some children really enjoy it when others give them attention such as a hug, a pat on the back, clapping, saying “Good job”, etc. What forms of attention do you think ________________ most enjoys? ________________

RESPONSE TO PROBE QUESTIONS:

9. Some children really enjoy certain toys such as puzzles, toy cars, balloons, comic books, flashlights, bubbles, etc. What are ________________’s favorite toys or objects? ________________

RESPONSE TO PROBE QUESTIONS:

10. What are some other items or activities that ________________ really enjoys?

RESPONSE TO PROBE QUESTIONS:

After completion of the survey, select all the stimuli that could be presented or withdrawn contingent on target behaviors during a session or classroom activity (e.g., a toy could be presented or withdrawn, a walk in the park could not). Write down all of the specific information about each selected stimulus on a 3 x 5 inch index card (e.g., “Having a female adult read him the “Three Little Pigs’ story”). Then have the parents select the top 16 STIMULI AND RANK THEM USING THE CARDS. THEN LIST THE RANKED STIMULI BELOW.
Appendix E: Baseline Data Sheet
Baseline Data Sheet

C – Correct Response  I – Incorrect Response  N – No Response

Session #

**Letter-sound assessment**

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Appendix F: Tact Training Procedural Integrity Form
Tact Training Procedural Integrity

Name ______________________ Date __________________ Session _____________

Training

1. Present a sound card to student and ask “What sound?” within 1 s
2. Provide prompt “The sound is ___, what sound?” within 3 s of incorrect or no response
3. Repeat Step 2 for two more times if necessary, then begin new trial
4. Deliver praise and/or reinforcer following all correct responses

Each box below represents a trial. Please circle the number in the box if the experimenter follows that step listed above.

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Letter-sound assessment

1. Present a sound card and ask “What sound?” within 1 s
2. Allow 3 s for participant to respond
3. Provide no prompt for incorrect or no response
4. Deliver no praise or reinforcement

Each box below represents a trial. Please circle the number in the box if the experimenter follows that step listed above.

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Sound-letter assessment

1. Present four sound cards
2. Present a letter sound that corresponds to one of the four sound cards
3. Allow 3 s for participant to respond (e.g., point to, touch or pick up)
4. Deliver no praise or reinforcement

Each box below represents a trial. Please circle the number in the box if the experimenter follows that step listed above.

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Appendix G: Joint-Control Procedural Integrity Form
### Joint-control Procedural Integrity

**Training**

**Part 1**
1. Provide a letter sound "___".
2. Repeat the letter sound again "___" within 3 s of incorrect or no response.
3. Repeat Step 2 for two more times if necessary, then begin new trial.

**Part 2**
1. Hold the respective sound card and ask "What sound?" immediately following Part 1.
2. Deliver praise and/or reinforcer for correct responses (e.g., look at sound card and repeat sound).
3. Make sound card unseen and repeat Part 1 for incorrectly or no response.
4. Repeat Step 3 for two more times if necessary, then being a new trial.

Each trial is divided into the gray (Part 1) and white (Part 2) boxes below. Please circle the number in each box if the experimenter follows that step listed above.

| 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 1 | 2 & 3 | 1 | 2 & 4 | 1 | 2 & 3 | 1 | 2 & 3 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 1 | 3 & 4 | 1 | 3 & 4 | 1 | 2 & 3 | 1 | 2 | 3 | 4 | 1 | 2 & 3 | 1 | 2 & 3 | 1 | 2 & 3 | 1 | 2 & 3 | 1 | 2 & 3 |
| 1 | 2 & 3 | 1 | 2 & 3 | 1 | 2 & 3 | 1 | 2 & 3 | 1 | 2 & 3 | 1 | 2 & 3 | 1 | 2 & 3 | 1 | 2 & 3 | 1 | 2 & 3 | 1 | 2 & 3 |
| 1 | 2 & 3 | 1 | 2 & 3 | 1 | 2 & 3 | 1 | 2 & 3 | 1 | 2 & 3 | 1 | 2 & 3 | 1 | 2 & 3 | 1 | 2 & 3 | 1 | 2 & 3 | 1 | 2 & 3 |

**Letter-sound assessment**
1. Present a sound card and ask "What sound?" within 1 s.
2. Allow 3 s for participant to respond.
3. Provide no prompt for incorrect or no response.
4. Deliver no praise or reinforcement.

Each box below represents a trial. Please circle the number in the box if the experimenter follows that step listed above.

| 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |

**Sound-letter assessment**
1. The experimenter places four sound cards in front of a participant.
2. The experimenter says a letter sound that corresponds to one of the four presented cards.
3. The experimenter waits 3 seconds for a participant to point to, touch or pick up the card that corresponds to the sound.
4. No praise or reinforcement is delivered.

Each box below represents a trial. Please circle the number in the box if the experimenter follows that step listed above.

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Appendix H: IOA Data Sheet
Interobserver Agreement (IOA) Form (Experiment 1 – Tact Training)

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Appendix I: Tact Training Data Sheet
Tact Training

Name ________________ Date ________________ Session _________

C – Correct Response     I – Incorrect Response     N – No response

Training

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Appendix J: Joint-Control Training Data Sheet
**Joint-control Training**

Name __________________ Date________________ Session________

C – Correct Response    I – Incorrect Response    N – No response

**Training**

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**Letter-sound assessment**

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**Sound-letter assessment**

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Appendix K: Social Validity Questionnaire
Social Validity Questionnaire

1. One of the purposes of this study was to teach students phonics skill. Phonics is considered to be a foundational skill for learning to read. Do you think learning phonics is important for students with autism?

   1  2  3  4  5
(Not at all important) (Very important)

2. One specific phonics skill taught in this study was letter-sound correspondence. For example, when provided with a printed letter (S), the student was able to say its respective sound (“sss”) and when provided with the sound (“sss”), the student was able to select its respective printed letter (S) among other letters. Do you think that it is important for students with autism to be exposed to instruction that targets letter-sound instruction?

   1  2  3  4  5
(Not at all important) (Very important)

3. How useful do you think that the study’s instructional method is in promoting letter-sound correspondence in children with autism?

   1  2  3  4  5
(Not at all useful) (Very useful)

4. How important do you think it is to identify teaching strategies that allow parents/teachers to teach a few skills and have other skills emerge without direct teaching?

   1  2  3  4  5
(Not at all important) (Very important)
Joint-Control Training

1. How clear is the instructional method (joint-control training) used in this study?
   
   1  2  3  4  5
   (Not clear at all) (Very Clear)

2. How much do you like the instructional method (joint-control training) used in this study?
   
   1  2  3  4  5
   (Not at all) (Very much)

3. How likely are you willing to implement this instructional method in your classroom/home?
   
   1  2  3  4  5
   (Not likely at all) (Not very likely)

4. There are many aspects of the instructional method that I don’t like.
   
   1  2  3  4  5
   (Strongly agree) (Strongly disagree)

5. The joint-control training appears to be an effective phonics instructional method for teaching children with autism.
   
   1  2  3  4  5
   (Strongly disagree) (Strongly agree)

6. I would recommend parents/teachers to use joint-control training to teach their students/children with autism phonics.
   
   1  2  3  4  5
   (Strongly disagree) (Strongly agree)
Tact Training

1. How clear is the instructional method (tact training) used in this study?
   1  2  3  4  5
   (Not clear at all) (Very Clear)

2. How much do you like the instructional method (tact training) used in this study?
   1  2  3  4  5
   (Not at all) (Very much)

3. How likely are you willing to implement this instructional method in your classroom/home?
   1  2  3  4  5
   (Not likely at all) (Not very likely)

4. There are many aspects of the instructional method that I don’t like.
   1  2  3  4  5
   (Strongly disagree) (Strongly agree)

5. The tact training appears to be an effective phonics instructional method for teaching children with autism.
   1  2  3  4  5
   (Strongly disagree) (Strongly agree)

6. I would recommend parents/teachers to use tact training to teach their students/children with autism phonics.
   1  2  3  4  5
   (Strongly disagree) (Strongly agree)

Please provide addition comment(s) that you think the researcher should know about the study.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

191