CREATIVE YOGA INTERVENTION FOR CHILDREN WITH AUTISM SPECTRUM DISORDER

by

Maninderjit Kaur

A dissertation submitted to the Faculty of the University of Delaware in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Biomechanics & Movement Sciences

Summer 2016

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# TABLE OF CONTENTS

LIST OF TABLES .............................................................................................................. xi  
LIST OF FIGURES ........................................................................................................ xii 
ABSTRACT ...................................................................................................................... xiv  

Chapter

1. OVERVIEW OF IMPAIRMENTS AND INTERVENTIONS FOR AUTISM SPECTRUM DISORDER (ASD) .......................................................... 1
   1.1. Multisystem Impairments in ASD .............................................................. 1
   1.2. Motor Impairments in ASD ...................................................................... 3
      1.2.1. Gross and Fine Motor Performance in ASD ................................. 4
      1.2.2. Motor Coordination in ASD ......................................................... 5
   1.3. Traditional Interventions for ASD ......................................................... 6
   1.4. Yoga Intervention for ASD .................................................................. 8
      1.4.1. Literature Review ......................................................................... 9
      1.4.2. Rationale for the Current Study .................................................. 12
   1.5. Aims and Hypotheses ......................................................................... 15

2. EFFECTS OF CREATIVE YOGA INTERVENTION ON THE MOTOR AND IMITATION SKILLS OF CHILDREN WITH AUTISM SPECTRUM DISORDER (ASD) .............................................................................. 19
   2.1. Introduction .............................................................................................. 19
      2.1.1. Motor Impairments in ASD ........................................................... 20
      2.1.2. Praxis/Imitation Impairments in ASD ......................................... 21
      2.1.3. Impact of Motor Impairments on ASD ....................................... 22
      2.1.4. Motor and Imitation Interventions for ASD .............................. 24
      2.1.5. Yoga Intervention for ASD ......................................................... 27
      2.1.6. Aims and Hypotheses of the Study ............................................. 29
2.2. Methods ........................................................................................................... 30
  2.2.1. Research Design and Study Timeline .................................................. 30
  2.2.2. Participants .............................................................................................. 31
  2.2.3. Training Protocol .................................................................................... 34
    2.2.3.1. Training Principles and Goals ......................................................... 35
    2.2.3.2. Training Activities .......................................................................... 36
  2.2.4. Testing Protocol ...................................................................................... 37
    2.2.4.1. Testing Measures ............................................................................. 37
    2.2.4.2. Behavioral Coding .......................................................................... 39
    2.2.4.3. Statistical Analysis ......................................................................... 41
  2.3. Results ........................................................................................................... 42
    2.3.1. Training-Related Changes in BOT-2 ............................................... 42
    2.3.2. Training-Related Changes in SIPT-PP .............................................. 45
    2.3.3. Training-Related Changes in Yoga Pose Test ................................. 47
    2.3.4. Parent Reports on Exit Questionnaire ............................................ 48
  2.4. Discussion ..................................................................................................... 49
    2.4.1. Summary of Results ............................................................................ 49
    2.4.2. Effects of Yoga Intervention on the Motor and Imitation Skills of ASD .................................................. 50
    2.4.3. Limitations of the Study ................................................................. 53
  2.5. Conclusions ................................................................................................ 54

3. EFFECTS OF CREATIVE YOGA INTERVENTION ON COMMUNICATION, JOINT ATTENTION, AND BEHAVIORAL SKILLS OF CHILDREN WITH AUTISM SPECTRUM DISORDER (ASD) ........................................... 55
  3.1. Introduction ................................................................................................ 55
    3.1.1. Communication Impairments in ASD ............................................. 56
    3.1.2. Joint Attention in ASD ....................................................................... 58
    3.1.3. Restricted and Repetitive Behaviors in ASD .................................... 59
    3.1.4. Traditional Interventions for ASD .................................................... 61
    3.1.5. Yoga Intervention for ASD ............................................................... 62
3.1.6. Aims and Hypotheses of the Study ........................................... 65

3.2. Methods ................................................................................. 67

3.2.1. Research Design and Study Timeline .................................... 67
3.2.2. Participants ......................................................................... 68
3.2.3. Training Protocol ................................................................ 71
  3.2.3.1. Training Principles and Goals ......................................... 72
  3.2.3.2. Training Activities ....................................................... 73

3.2.4. Testing Protocol ................................................................. 74
  3.2.4.1. Testing Measures .......................................................... 74
  3.2.4.2. Behavioral Coding ......................................................... 76
  3.2.4.3. Statistical Analysis ....................................................... 78

3.3. Results ................................................................................... 79

3.3.1. Training-Related Changes in JTAT ....................................... 79
3.3.2. Training-Related and Activity-Related Changes in
       Verbalization/ Vocalization .................................................. 81
3.3.3. Training-Related and Activity-Related Changes in
       Affective States ..................................................................... 84
3.3.4. Training-Related and Activity-Related Changes in
       Maladaptive Behaviors ....................................................... 87

3.4. Discussion ............................................................................. 90

3.4.1. Summary of Results .......................................................... 90
3.4.2. Effects of Yoga Intervention on the Joint Attention and
       Communication Skills of ASD ............................................. 91
3.4.3. Effects of Yoga Intervention on the Affective States and
       Maladaptive Behaviors of ASD .......................................... 94
3.4.4. Limitations of the Study ..................................................... 96

3.5. Conclusions ......................................................................... 97

4. COMPARISON OF THE EFFECTS OF MOVEMENT-BASED MUSIC,
   ROBOT, AND YOGA INTERVENTION IN CHILDREN WITH AUTISM
   SPECTRUM DISORDER (ASD) ....................................................... 98

4.1. Introduction ........................................................................... 98
4.1.1. Multisystem Impairments of ASD .............................................. 98
4.1.2. Traditional Interventions and Need of Multisystem Interventions for ASD ................................................................. 99
4.1.3. Novel Multisystem Interventions for ASD .................................. 101
4.1.4. Aims and Hypotheses of the Study ........................................... 105

4.2. Methods .................................................................................. 107
4.2.1. Research Design and Study Timeline ....................................... 107
4.2.2. Participants ........................................................................... 108
4.2.3. Training Protocol .................................................................. 111
4.2.4. Testing Protocol ..................................................................... 117

4.2.4.1. Testing Measures .................................................................. 117
4.2.4.2. Behavioral Coding ................................................................. 118
4.2.4.3. Statistical Analysis ............................................................... 120

4.3. Results ..................................................................................... 121
4.3.1. Effects of Movement Interventions on BOT-2 ......................... 121
4.3.2. Effects of Movement Interventions on Verbalization/ Vocalization ................................................................. 122
4.3.3. Effects of Movement Interventions on Affective States ............ 125

4.4. Discussion ................................................................................ 126
4.4.1. Summary of Results ............................................................... 126
4.4.2. Effect of Movement Interventions on the Motor Skills of ASD ................................................................. 127
4.4.3. Effect of Movement Interventions on the Communication Skills of ASD ................................................................. 128
4.4.4. Effect of Movement Interventions on the Affective States of ASD ................................................................. 130
4.4.5. Limitations of the Study .......................................................... 132

4.5. Conclusions ............................................................................ 132

5. CONCLUSIONS ........................................................................ 133
5.1. Yoga Intervention for Children with ASD .................................. 134
5.2. Comparing Movement Interventions for Children with ASD .......... 135
5.3. Limitations and Future Directions ............................................. 137
Appendix

A. FIDELITY CHECKLIST ................................................................. 159
B. BRUNINIKS OSERETSKY TEST OF MOTOR PROFICIENCY (BOT-2) 163
C. SENSORY INTEGRATION AND PRAXIS TESTS- POSTURAL PRAXIS (SIPT-PP) ................................................................. 165
D. YOGA POSE TEST .................................................................. 166
E. EXIT QUESTIONNAIRE ........................................................... 167
F. JOINT ATTENTION TEST (JTAT) ............................................ 168
G. IRB APPROVED CONSENT FORM ........................................ 170
LIST OF TABLES

Table 1.1: Literature Review of Yoga Intervention in ASD ........................................ 13
Table 2.1: Study Timeline .......................................................................................... 31
Table 2.2: Participant Demographics ....................................................................... 33
Table 2.3: Activities Practiced within Yoga Session .................................................. 37
Table 2.4: Parent Reports on Exit Questionnaire ....................................................... 49
Table 3.1: Study Timeline ......................................................................................... 68
Table 3.2: Participant Demographics ....................................................................... 70
Table 3.3: Activities Practiced within Yoga Session .................................................. 74
Table 3.4: P-values of Activity-Related Comparisons for the Maladaptive Behaviors ................................................................................................................................. 89
Table 4.1: Study Timeline ......................................................................................... 108
Table 4.2: Group Demographics .............................................................................. 110
Table 4.3: Similarities in the Movement Groups ....................................................... 116
<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Yoga Training Session</td>
<td>35</td>
</tr>
<tr>
<td>2.2</td>
<td>Training-Related Changes in BOT-2</td>
<td>44</td>
</tr>
<tr>
<td>2.3</td>
<td>Training-Related Changes in Balance of BOT-2</td>
<td>44</td>
</tr>
<tr>
<td>2.4</td>
<td>Training-Related Changes in SIPT-PP</td>
<td>45</td>
</tr>
<tr>
<td>2.5</td>
<td>Training-Related Changes in Prompts of SIPT-PP</td>
<td>46</td>
</tr>
<tr>
<td>2.6</td>
<td>Training-Related Changes in Yoga Test</td>
<td>47</td>
</tr>
<tr>
<td>2.7</td>
<td>Training-related Changes in Prompts of Yoga test</td>
<td>48</td>
</tr>
<tr>
<td>3.1</td>
<td>Yoga Training Session</td>
<td>72</td>
</tr>
<tr>
<td>3.2</td>
<td>Training-Related Changes in Cue Level of JTAT</td>
<td>80</td>
</tr>
<tr>
<td>3.3</td>
<td>JTAT Cue Level for Verbal and Gestural Bids</td>
<td>81</td>
</tr>
<tr>
<td>3.4</td>
<td>Training-Related Changes in Verbalization/ vocalization</td>
<td>82</td>
</tr>
<tr>
<td>3.5</td>
<td>Activity-Related Changes in Verbalization/ Vocalization</td>
<td>83</td>
</tr>
<tr>
<td>3.6</td>
<td>Affective States</td>
<td>84</td>
</tr>
<tr>
<td>3.7</td>
<td>Activity-Related Differences in Interested Affect</td>
<td>86</td>
</tr>
<tr>
<td>3.8</td>
<td>Activity-Related Differences in Positive Affect</td>
<td>86</td>
</tr>
<tr>
<td>3.9</td>
<td>Activity-Related Differences in Negative Affect</td>
<td>87</td>
</tr>
<tr>
<td>3.10</td>
<td>Maladaptive Behaviors</td>
<td>88</td>
</tr>
<tr>
<td>3.11</td>
<td>Activity-Related Differences in Maladaptive Behaviors</td>
<td>89</td>
</tr>
<tr>
<td>4.1</td>
<td>Music Training Session</td>
<td>113</td>
</tr>
<tr>
<td>4.2</td>
<td>Robot Training Session</td>
<td>114</td>
</tr>
<tr>
<td>4.3</td>
<td>Yoga Training Session</td>
<td>116</td>
</tr>
</tbody>
</table>
Figure 4.4: Training-related Changes in BOT-2 .................................................. 122
Figure 4.5: Training-Related Changes in Verbalization/ Vocalization ............. 123
Figure 4.6: Group-Related Differences in Verbalization/ vocalization ............ 124
Figure 4.7: Group-Related Differences in Affect ............................................. 125
ABSTRACT

Autism Spectrum Disorder (ASD) is characterized by primary impairments in the social communication skills, and presence of restricted and repetitive behaviors, as well as secondary impairments in the motor skills of children. The rising prevalence of ASD (1 in every 68 children) emphasizes the need for effective interventions to promote better outcomes in this population. The primary goal of the current study was to examine the effects of a movement-based, creative yoga intervention on the motor, social communication, and behavioral skills of children with ASD. Additionally, we compared the efficacy of yoga to two other movement interventions delivered within a musical and robotic context in children with ASD. Twelve children with ASD between 5- and 12 years of age received 8-weeks of yoga intervention with 2 sessions delivered each week and additional home sessions delivered by the parents of the children. The activities practiced within the yoga sessions included poses, breathing exercises, eye gaze training, social games, and relaxation. We assessed the generalized changes in the motor, imitation, and joint attention of children using standardized tests administered before and after the intervention, and training-specific changes in the imitation, communication, affect, and maladaptive behaviors of children during the early, mid, and late training session. Our results indicated that children improved the gross motor performance, imitation accuracy, and response to joint attention bids on standardized tests following the yoga intervention.
In addition, the children showed training-specific improvements in the imitation of yoga poses and communication skills during the late training sessions compared to the mid and early sessions. In terms of differences between the three movement-based intervention, we observed similar training-related changes in the motor, communication, and affective states of children following the music, robot, or yoga intervention such that children improved the motor and communications skills, with no changes in the affective states following the intervention. We also observed group-related differences, such that the yoga group was associated with greater responsive social verbalization and interested affect, the music group had greater positive and negative affect, and lastly, the robot group had greater self-verbalization and negative affect compared to the other two groups. Overall, the current evidence suggests that movement-based interventions delivered within engaging and creative contexts could be promising tools for alleviating the primary social communication, as well as the secondary motor impairments of children with ASD.
Chapter 1

OVERVIEW OF IMPAIRMENTS AND INTERVENTIONS FOR AUTISM SPECTRUM DISORDER

1.1 Multisystem Impairments in Autism Spectrum Disorder

Autism Spectrum Disorder (ASD) is a childhood neurological disorder characterized by impairments in the social communication skills, and presence of restricted and repetitive behaviors (American Psychiatric Association (APA), 2013). To elaborate, the social impairments include reduced eye contact, lack of social and emotional reciprocity, reduced sharing of interests and enjoyment, and lack of appropriate peer relationships (Dawson et al., 2004; Mundy et al., 1986; Senju and Johnson, 2009). Communication impairments include verbal deficits such as difficulty understanding and responding to the comments and questions of others, as well as non-verbal deficits such as reduced showing and pointing (Eigsti et al., 2011; Landa, 2007; Tager-Flusberg et al., 2005). The restricted and repetitive behaviors include motor mannerisms such as hand flapping and body rocking, non-functional object play such as wheel spinning, and restricted interests such as adherence to inflexible routines and schedules (Leekam et al., 2011; Lewis and Bodfish, 1998; Turner, 1999). Although the diagnostic impairments of ASD are limited to the social communication and restricted/ repetitive behavior domain, children with
ASD show various additional comorbidities including motor deficits such as postural and gait instability, sensory deficits such as hypo- or hyper-responsiveness to sensory stimuli, and challenging behaviors such as non-compliance and self-injurious behaviors (Baranek et al., 2006; Bhat et al., 2011; Fournier et al., 2010; Matson and Nebel-Schwalm, 2007; Rogers and Ozonoff, 2005).

Clearly, ASD is a multisystem disorder and demands special attention due to several reasons. Firstly, the multisystem impairments of ASD have negative implications on the overall functioning of children including adaptive functioning, cognitive and academic competence, and social engagement (Hobson and Lee, 1998; Jacobson and Ackerman, 1990; Mayes and Calhoun, 2003; Sigman and Ruskin, 1999). Further, the negative outcomes of the disorder are clearly evident in adults with ASD such that majority of the adults with ASD live in assisted homes and lack paid employment (Gray et al., 2014; Howlin et al., 2000). Secondly, ASD is a highly prevalent disorder with Centers for Disease Control and Prevention (CDC) reporting a current prevalence of 1 in every 68 children (CDC, 2014). Thirdly, the lifetime healthcare costs for an individual with autism are estimated at $3.2 million, and are three-fold compared to children with other psychiatric or physical disorders (Croen et al., 2006; Ganz, 2007). Lastly, ASD is associated with greater psychological burden for the caregivers such that caregivers of children with ASD report high levels of stress and anxiety compared to caregivers of TD children (Davis and Carter, 2008; Lecavalier et al., 2006). Overall, ASD is a highly prevalent, multisystem disorder with impairments in the social communication, behavior,
and sensory motor skills of children. These impairments have direct implications for the overall development and learning of children as well as indirect implications for the emotional and psychological well-being of the caregivers.

1.2 Motor Impairments in ASD

In the recent years, there is an ever increasing evidence for the presence of motor impairments in children with ASD including deficits in gross and fine motor skills, and poor motor coordination (Bhat et al., 2011; Fournier et al., 2010; Glazebrook et al, 2011; Green et al., 2009; Isenhower et al., 2012). Motor deficits are reported in at least 50% of the ASD population (Ghaziuddin and Butler, 1998; McPhillips et al., 2014), with some studies reporting a prevalence rate of up to 80 to 85% (Green et al., 2009; Liu, 2013; Miyahara et al., 1997). In fact, motor delays including poor grasping and unstable sitting postures have been reported as early as the first year of life in infants who were later diagnosed with ASD (Kaur et al., 2015; Koterba et al., 2012; Ozonoff et al., 2008; Teitelbaum et al., 1998), with the magnitude of delays increasing with development (Lloyd et al., 2013). Specifically, a cross-sectional study in infants and toddlers with ASD between the ages of 12 and 36 months suggested fine and motor delays across all age groups, but the magnitude of impairments were more pronounced at later ages compared to the earlier ages (Lloyd et al., 2013). Below is a brief discussion of the literature comparing the gross and fine motor skills, and coordination skills between TD individuals and those with ASD.
1.2.1 Gross and Fine Motor Performance in ASD

Children with ASD show impaired gross motor skills such as poor balance and gait control, and fine motor skills such as poor handwriting and object control compared to TD children on various standardized and functional tests of motor performance (Ament et al., 2015; Ghaziuddin and Butler, 1998; Green et al., 2009; Jansiewicz et al., 2006; Liu 2013; McPhillips et al., 2014; Provost et al., 2007). In terms of balance and postural control, children have difficulty performing simple balance tasks such as typical stance as well as challenging tasks such as one-legged stance or standing on a narrow beam (Graham et al., 2014; Memari et al., 2014; Travers et al., 2013). In terms of gait, children with ASD perform poorly during functional locomotor tasks such as running and galloping as well as non-functional locomotor tasks such as heel walking and toe walking (Jansiewicz et al., 2006; Staples and Reid, 2010). The kinematic analyses of gait in children with ASD also indicated atypical parameters and compensatory strategies including the use of a wider base of support, variable stride lengths, and atypical arm and trunk postures (Nayate et al., 2012; Rinehart et al., 2006; Vilensky et al., 1981). In terms of handwriting, children with ASD show poor handwriting especially in the quality of letter formation identified by greater shape distortions and reversals compared to TD children (Fuentes et al., 2009; Kushki et al., 2011). Lastly, children with ASD show poor object control such as ball throwing and catching, as well as poor reaching compared to TD children (Ament et al., 2015; Green et al., 2009; Mari et al., 2003; McPhillips et al., 2014).
1.2.2 Motor Coordination in ASD

Children with ASD show poor coordination as assessed by greater movement variability during simple and complex motor tasks compared to age-matched TD children (Fitzpatrick et al., 2013; Fleury et al., 2013; Isenhower et al., 2012). Specifically, children with ASD showed greater variability for bilateral drumming tasks compared to TD children, and the difficulty was greater for complex alternate drumming compared to simple symmetrical drumming (Isenhower et al., 2012). Moreover, some studies have attempted to examine the motor coordination of children with ASD in a social context, i.e. synchronizing movements with a social partner (Marsh et al., 2013). Moving in social contexts come with additional constraints including children’s motivation to move with others as well as their social monitoring skills to accurately match up their movements with others (Colombi et al., 2009; Fitzpatrick et al., 2013; Marsh et al., 2013). Marsh et al. (2013) reported that children with ASD were less likely to synchronize their movements with their caregivers during a rocking chair experiment compared to TD children. Additionally, our past work on motor deficits in children with ASD suggested poor movement synchronization of children with ASD with an adult tester during simple and complex actions such as clapping, and simultaneous clapping and marching compared to age-matched TD children (Kaur et al., 2016, in preparation). To summarize, the current literature suggests that children with ASD have significant difficulty in motor skills such as gross and fine motor tasks as well as difficulty coordinating their body on their own or with a social partner.
1.3 Traditional Interventions for ASD

The majority of the intervention approaches for children with ASD follow principles of Applied Behavioral Analysis (ABA), a behavioral science aimed at improving the socially significant behaviors of children and adults with and without disabilities (Baer et al., 1968; Foxx, 2008; Matson et al., 2012). The primary focus of ABA therapies in children with ASD is to improve the social communication skills and facilitate positive behaviors in children. The ABA principles are similar to operant conditioning, which states that each behavior is influenced by the events that precede it (antecedents) and by the events that follow it (consequences). Hence, the frequency of a target behavior can be modified by altering the nature and type of antecedents and consequences related to the behavior. For example, reinforcements such as rewards and social praise can increase the frequency of positive behaviors and punishments such as time outs and reprimands can reduce the frequency of negative behaviors. Similarly, new behaviors could be taught using imitation (copy the teacher), shaping (reinforcing behavior approximations until the desired behavior is achieved), and chaining (teaching behavior in multiple steps). Various teaching techniques/methods have been developed using the aforementioned ABA principles including the Discrete Trial Training (DTT), Incidental Teaching (IT), Picture Exchange Communication System (PECS), and Treatment and Education of Autistic and Communication Handicapped Children (TEACCH).

a) Discrete Trial Training (DTT) involved use of highly-structured adult-led training. Children are taught new behaviors providing massed practice trials of the desired
behavior in multiple steps (Smith, 2001). The major limitation of this teaching method is lack of generalization of learned behavior to different settings and places, as well as lack of reinforcement for child-initiated behaviors.

b) **Incidental teaching** is comparatively contemporary teaching technique which overcomes the limitations of discrete trial teaching by encouraging child-initiated skills and behaviors. Incidental teaching is a child-led teaching approach as it capitalizes on the interests and desires of the child while teaching them new skills and behaviors, along with use of natural settings and people (Vismara and Rogers, 2010).

c) **Picture Exchange Communication System (PECS)** is another ABA-led intervention protocol focused on improving the communication of children with minimal to no verbal skills (Bondy and Frost, 2003). Children are prompted to use pictures to initiate requests, respond to questions, as well as describe their environment.

d) **Treatment and Education of Autistic and Communication Handicapped Children (TEACCH)** is another popular intervention implemented in children with ASD. TEACCH focuses on use of structured and consistent environment, predictable routines, and visual prompts and activity schedules to teach new skills and behaviors to the child (Mesibov et al., 2004). Additionally, TEACCH emphasizes the involvement of caregivers and parents as well as all the professionals working with the child such as psychologist, teachers, physical therapist, and occupational therapist in the treatment protocol.

Overall, several approaches targeting the social communication and behavioral skills
of children with ASD exist, however there is limited research on facilitating the motor skills of children. Given, the overwhelming evidence for motor impairments in children with ASD, we believe that socially-embedded movement interventions could improve the motor as well as the social communication skills of children with ASD. In the current study, we explored the effects of a movement-based yoga intervention on the motor, social communication, and behavioral skills of school-going children with ASD. Below is a brief discussion of the evidence suggesting positive effects of yoga intervention on the overall motor and behavioral skills of children with ASD.

1.4 Yoga Intervention for ASD

Yoga is gaining popularity as a recreational and alternative therapy for pediatric population and could potentially be an effective intervention for children with ASD due to several reasons. Firstly, yoga is a cost-effective intervention and does not require any expensive props and instruments. It is easy to learn and does not require intensive training and expertise before administering to the children. Secondly, yoga is a multidisciplinary approach with positive effects on the motor, social, behavioral, and cognitive skills of children. Various systematic reviews in the pediatric population suggested improvements in the motor speed, strength and flexibility, aerobic fitness, attentional focus, and spatial memory of children following yoga intervention (Birdee et al., 2009; Galantino et al., 2008; Jeter et al., 2014; Kaley-Isley et al., 2010; Serwacki and Cook-Cottone, 2012). Thirdly, yoga could be an effective alternative to the currently popular pharmacological treatments in ASD. Specifically, almost 50% of the subjects with autism receive
pharmacological treatments for maladaptive behaviors such as aggression, hyperactivity, and irritability; which sometimes lead to adverse side effects such as insomnia and weight gain (Broadstock et al., 2007; Gibbs, 2010). In contrast, yoga is a natural treatment approach, devoid of any side effects and is documented to positively address the behavioral deficits of children including attentional problems, stress and anxiety, as well as aggression and irritability (Beauchemin et al., 2008; Jensen et al., 2012; Khalsa et al., 2013; Peck et al., 2005; Powell et al., 2008; White, 2012). Overall, yoga could potentially be a cost-effective, multidisciplinary treatment approach which can remediate the core diagnostic impairments as well as the additional motor impairments in children with ASD.

1.4.1 Literature Review

There is some anecdotal evidence for the use of yoga in children with ASD to improve the social participation, increase on-task behaviors, and reduce maladaptive and negative behaviors (Ehlinger et al., 2010; Kenny 2002; Koenig et al., 2012; Rosenblatt et al., 2011; Radhakrishna et al, 2010). Specifically, in terms of behavioral skills, four studies including three published and one unpublished have reported positive effects of yoga intervention on reducing the maladaptive behaviors and increasing the attentional focus of children with ASD (Koenig et al., 2012; Rosenblatt et al., 2011; Goldberg, 2004; Behar, 2006). Koenig et al. (2012) reported reductions in the maladaptive behaviors such as irritability, lethargy, and hyperactivity in children with ASD in the yoga group compared to the control group as measured by a teacher-rated behavior checklist.
Aberrant Behavior Checklist (ABC). Although, this study is superior in terms of design and methodology, the results should be interpreted with caution as the teachers were not blinded to the grouping of children. Moreover, there were no differences between the two groups on the parent-rated ABC as well as the frequency of off-task and teacher redirections following the intervention (Koenig et al., 2012; Table 1.1).

Rosenblatt et al. (2011) examined the effects of an integrated intervention approach including yoga, music, and dance in children with ASD between 3 and 16 years using two parent-rated behavior checklists, Behavioral Assessment System for Children (BASC) and Aberrant Behavior Checklist (ABC). The results indicated positive effects of the intervention on various subscales of the questionnaires including Atypicality, Depression, and Irritability subscales. In this study, the direct effects of yoga intervention cannot be teased apart from the other strategies used during the intervention including the music and dance. Additionally, there was high variability among children in terms of session compliance such that only 10 out of total 24 children in the study completed all the sessions (Rosenblatt et al., 2011; Table 1.1). Goldberg (2004) encouraged use of Creative Relaxation, a yoga-based program to promote relaxation and reduce stress in children with ASD showing overt signs of stress and anxiety. Eight weeks of creative relaxation program improved the breathing patterns of children with ASD as measured by their reduced pulse rates, as well as reduced levels of stress and anxiety as measured by parent and teacher reports. In addition, qualitative parent reports suggested improved ability of children to cope with stressful situations and initiate self-relaxation techniques.
such as deep breathing during similar situations (Goldberg, 2004; Table 1.1). Lastly, an unpublished study in children with ASD reported parent observations of longer focused attention, easy transition to other task, and self-calming by children post 9 weeks of yoga training (Behar, 2006; Table 1.1).

In terms of social and motor skills, a single group of researchers examined the effects of yoga in children with ASD between 8 and 14 years following 10 months and 20 months of intervention. The investigators suggested improved motor imitation of warm up actions such as jogging and running, yoga poses, oro-facial movements of tongue and lips, breathing exercises as well as vocalizations following 10 months of yoga training (Radhakrishnan, 2010; Table 1.1). The same group also suggested improved eye-to-eye gazes and sitting tolerance, along with reduction in restricted and repetitive behaviors of children following 20 months of yoga intervention (Radhakrishnan et al., 2010, Table 1.1). In addition, the yoga trainers reported increased spontaneous attempts for socialization such as increased social proximity, smiling, and vocalizations by children with ASD in the later sessions compared to initial sessions. However, poor description of the testing methods and statistical analysis makes it difficult to generalize the study results (Radhakrishnan et al., 2010). Overall, there is some preliminary evidence to suggest the positive impact of yoga on the motor imitation and behavioral skills of children with ASD.
1.4.2 Rationale for the Current Study

Although, a yoga intervention seems to be a promising intervention tool for children with ASD, the research to date is limited in many respects. Firstly, there is a clear lack of empirical studies exploring the effects of yoga intervention in children with ASD. To date, there are only five research groups which have attempted to experimentally quantify the effects of yoga intervention in children with ASD (Table 1.1). Secondly, a majority of the studies evaluated performance on qualitative reports or questionnaires versus use of standardized testing measures. Additionally, most of the studies fail to provide a clear description of the training protocol including the fidelity or adherence to training protocol, expertise of the yoga trainers, and layout of the different yoga sessions. Lastly, in spite of the direct effects of yoga intervention on the motor skills, there are no studies evaluating the effects of yoga on balance, strength, flexibility, and endurance of children with ASD. Therefore, the rationale for the current study lies in addressing the limitations in the current literature by systematically examining the effects of yoga on the social communication, motor, and behavioral skills of children with ASD. We have used standardized assessments and detailed behavioral coding schemes to evaluate the effects of intervention. Additionally, we monitored the training via use of training logs, fidelity checklist, as well as exit questionnaires.
Table 1.1: Literature Review of Yoga Intervention in ASD.

<table>
<thead>
<tr>
<th>Study</th>
<th>Study design</th>
<th>Participants</th>
<th>Testing measures</th>
<th>Training</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Studies on Behavioral Skills</strong></td>
<td></td>
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<tr>
<td>Koeing et al., 2012</td>
<td>Pre-posttest, control group design</td>
<td>n = 46 (24 in yoga and 22 in control group), age = 5-12 years</td>
<td>Teacher- and parent-rated ABC, Behavior coding of time off task and teacher redirections</td>
<td>F = 7 sessions/ week, I = 16 weeks, T = 15-20 min/ session</td>
<td>Improved performance on teacher-rated ABC in the yoga group compared to the control group in the posttest session. No other group differences were observed.</td>
</tr>
<tr>
<td>Rosenblatt et al., 2011</td>
<td>Pre-posttest single group design</td>
<td>n = 24, age = 3-16 years</td>
<td>Parent-rated BACS and ABC</td>
<td>F = 1 session/ week, I = 8 weeks, T = 45 min/ session</td>
<td>Improved performance on the Atypicality, Depression, and Irritability subscale of BASC and ABC in the posttest session.</td>
</tr>
<tr>
<td>Goldberg 2004</td>
<td>Single subject design</td>
<td>n = 6, age = NS</td>
<td>Pulse rate measurements, Parent- and teacher-observations of child’s stress levels, breathing patterns, and muscle tone</td>
<td>F = 3 sessions/ week, I = 8 weeks, T = 30 min/ session</td>
<td>Reduced pulse rate post yoga session, as well as better coping of stress, deep breathing, and muscle tone as reported by the teachers and parents.</td>
</tr>
<tr>
<td>Study on Social Skills</td>
<td>Study on Motor Skills</td>
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<tr>
<td><strong>Behar 2006</strong></td>
<td><strong>Radhakrishna et al., 2010</strong></td>
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<tr>
<td>Single subject design</td>
<td>Single group design</td>
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<tr>
<td>n = 6, age = NS</td>
<td>n = 6, age = 8-14 years</td>
<td></td>
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</tr>
<tr>
<td>Parent reports of child’s attentional focus and transition between activities</td>
<td>Autism Research Institute’s Form- including items such as eye-to-eye gaze, depth perception, sitting tolerance, balance, and repetitive and self-injurious behaviors</td>
<td></td>
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<tr>
<td>F = NS, I = 9 weeks, T = NS, T = Breathing, poses, relaxation</td>
<td>F = 5 sessions/week, I = 82 weeks, T = Warm up, breathing, poses, relaxation</td>
<td></td>
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<tr>
<td>Improved attention span and easy transition between activities as reported by parents following intervention.</td>
<td>Children improved eye-to-eye gazes, depth perception, sitting tolerance and balance, and reduced repetitive behaviors during the late training session.</td>
<td></td>
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</tbody>
</table>

n = number of participants, F = Frequency, I = Intensity, T = Time, T = Type, ABC = Aberrant Behavior Checklist, BASC = Behavioral Assessment System for Children, NS = Not Specified in the study
1.5 Aims and Hypotheses

The primary aim of the current study was to examine the effects of a socially-embedded, yoga intervention on the motor, social communication, and behavioral skills of children with ASD between 5 and 12 years of age. Additionally, we were interested in comparing the effects of yoga intervention to two previously delivered movement interventions in our lab, i.e. music and robot intervention in children with ASD. All interventions included 8 weeks of whole-body activities performed within a social context to promote the motor skills such as bilateral coordination and balance, social skills such as eye contact and cooperation, communication skills such as greetings and commenting, as well as behavioral skills such as alertness and positive engagement. We assessed the training-related changes in 1) motor imitation, 2) verbalization/vocalization, 3) maladaptive behaviors, and 4) affective states of children with ASD by coding the entire duration of an early (session 1), mid (session 8), and late (session 16) training session. We also administered three standardized assessments, Bruniniks Oseretsky Test of Motor Proficiency (BOT-2), Sensory Integration and Praxis Tests (SIPT), and Joint Attention Test (JTAT) during the pretest and posttest session in the first and last week of the study. The standardized assessments measured the changes in the 1) fine and gross motor, 2) imitation, and 3) joint attention skills of children with ASD following the intervention.

The aims and hypotheses of the study are listed below.

Aim 1: To examine the effects of 8-week of yoga intervention on the motor and imitation skills of children with ASD between 5 and 12 years of age.
Hypothesis 1a: Motor Skills: We hypothesized that children with ASD would improve their gross motor skills on a standardized test of motor performance, BOT-2 in the posttest session compared to the pretest session.

Hypothesis 1b: Imitation Skills: Children would improve their imitation skills on a standardized subtest of SIPT during the posttest compared to the session as well as a Yoga Pose test administered during the late training session compared to the mid and early session.

Aim 2: To examine the effects of 8-weeks of yoga intervention on the communication, joint attention, maladaptive behaviors, and affective states of children with ASD between 5 and 12 years of age.

Hypothesis 2a: Communication Skills: Children with ASD would increase the total time spent in verbalizing/ vocalizing with the trainer and reduce the time spent in echolalia or self-talk in the late training compared to mid and the early training session. Within each training session, we expected children to show greater percent duration of verbalization during activities promoting social interactions such as hello and bye songs and fewer percent duration of verbalization during activities promoting whole body movements such as poses and partner poses.

Hypothesis 2b: Joint Attention Skills: We hypothesized that children with ASD would show increased response to the joint attention bids initiated by a tester using a standardized test, JTAT during the posttest compared to the pretest session.
**Hypothesis 2c: Maladaptive Behaviors**: We hypothesized that children with ASD would reduce the frequency of maladaptive behaviors such as body stereotypies, sensory behaviors, and non-compliance during the late compared to the mid and early session. Within each training session, we expected children to show fewer maladaptive behaviors during seated activities such as breathing and relaxation, and greater frequency of maladaptive behaviors during mobile activities such as poses and eye-gaze training activities.

**Hypothesis 2d: Affective States**: Children with ASD would show increased or similar percent duration of interested and positive affect during the late compared to the mid and early training session. Within each training session, we expected children to show greater interested and positive affect for easier activities such as hello/bye songs and relaxation, and greater negative affect for challenging activities such as poses and eye-gaze training activities.

**Aim 3**: To compare the effects of three movement interventions, i.e. music, robot, and yoga on the motor, communication, and affective states of children with ASD between 5 and 12 years of age.

**Hypothesis 3a: Motor Skills**: We hypothesized that children would improve their gross motor skills in the BOT-2 test during the posttest compared to the pretest session. In terms of group differences, we expected children to show similar improvements in the gross motor skills following the music, robot, and yoga training.
Hypothesis 3b: Communication Skills: We expected children to increase the percent duration of social verbalization and reduce self-verbalization or echolalia in the late compared to the mid and early training session. In terms of group differences, children would show similar levels of social and self-verbalization irrespective of the group type, i.e. music, robot, or yoga

Hypothesis 3c: Affective States: We expected children to show increased or similar percent duration of positive and interested affect in the late compared to the mid and early training sessions. In terms of group differences, we expected all three groups to show greater percent duration of interested affect compared to positive and negative affect. However, children in the music group could show greater percent duration of positive affect compared to the robot and yoga group as musical activities are extremely enjoyable and fun for children.
Chapter 2

EFFECTS OF YOGA INTERVENTION ON THE MOTOR AND IMITATION SKILLS OF CHILDREN WITH AUTISM SPECTRUM DISORDER (ASD)

2.1 Introduction

Autism Spectrum Disorder (ASD) is a highly prevalent neurological disorder with a current prevalence of 1 in every 68 children (Centers for Disease Control and Prevention (CDC), 2014). ASD is characterized by impairments in the social communication skills such as reduced eye contact, lack of reciprocity during social interactions, reduced use of communicative gestures, and a complete lack of or delay in language development, as well as by the presence of restricted and repetitive behaviors such as hand flapping, preoccupation with objects, and inflexible routines (American Psychiatric Association, 2013; Eigsti et al., 2011; Landa, 2007; Leekam et al., 2011; Lewis and Bodfish, 1998; Tager-Flusberg et al., 2005; Turner, 1999). Apart from the primary social communication and behavior deficits, there is increasing evidence of motor deficits in children with ASD with a prevalence rate ranging from 50 - 85 % of children (Bhat et al., 2011; Chukoskie et al., 2013; Dowd et al., 2010; Downey and Rapport, 2012; Fournier et al., 2010; McPhillips et al., 2014; Liu, 2013). In fact, motor delays such as poor grasping, sitting, and walking have been reported as early as the first year of life in infants who later developed ASD and the magnitude of such delays appears to increase with development
(Bhat et al., 2012; Kaur et al., 2015; Koterba et al., 2012; Ozonoff et al., 2008; Teitelbaum et al., 1998; Lloyd et al., 2013). Additionally, fine and gross motor performance in children with ASD correlated significantly with impairments in social skills (MacDonald et al., 2013a; 2014; Sipes et al., 2011), daily living skills (MacDonald et al., 2013b), speech fluency (Gernsbacher et al., 2008), and the frequency and severity of restricted and repetitive behaviors (Radonovich et al., 2013). Below, we have provided a brief review of the literature comparing the motor and imitation skills of children with ASD and healthy, typically developing (TD) children.

2.1.1 Motor Impairments in ASD

Children with ASD show impaired performance of gross motor skills such as jumping and walking, and fine motor skills such as reaching and handwriting compared to TD children on various standardized and functional tests of motor performance (Ament et al., 2015; Fuentes et al., 2009; Graham et al., 2014; Green et al., 2009; Jansiewicz et al., 2006; Kushki et al., 2011; Mari et al., 2003; McPhillips et al., 2014; Memari et al., 2014; Nayate et al., 2012; Staples and Reid, 2010; Travers et al., 2013). In terms of a standardized gross motor test, Test of Gross Motor Development (TGMD), children with ASD between 9 and 12 years performed poorly compared to age-matched TD children, with ASD children performing at the level of TD children half their ages (Staples and Reid, 2010). Similarly, on a standardized fine motor handwriting test, Minnesota Handwriting Assessment, children with ASD had poor legibility of their writing samples especially due to the poor quality of letter formation compared to TD children (Fuentes et al., 2009). In terms of
functional gross and fine motor movements such as gait and reaching, children with ASD demonstrated poor quality of movement compared to TD children (Glazebrook et al., 2006; Mari et al., 2003; Nayate et al., 2012; Rinehart et al., 2006; Vilensky et al., 1981). Specifically, kinematic gait analyses indicate atypical postures and strategies in children with ASD compared to TD children such as the use of a wider base of support, variable stride lengths, and atypical arm and trunk postures (Nayate et al., 2012; Rinehart et al., 2006). Similarly, kinematic analysis of reaching indicated that low functioning children with ASD between 9 and 12 years had poor planning and execution of reaching and grasping movements including delayed onset and greater duration of movements (Mari et al., 2003). Taken together, children with ASD show significant deficits in gross and fine motor performance compared to age-matched TD children on various standardized motor measures as well as functional motor tasks.

2.1.2 Praxis/ Imitation Impairments in ASD

Imitation impairments are universally reported in children with ASD and are usually discussed as part of a generalized disorder in praxis. Praxis is the ability to perform simple and complex actions or gestures on imitation, on verbal command, or during tool use (Dewey, 1993; 1995; Mostofsky et al., 2006). Praxis skills are important for learning new motor sequences, (e.g. a child learning to tie shoelaces while imitating his/her caregiver), engaging in social interactions (e.g. waving hands to say goodbye), and during daily functional activities (e.g. using a hammer on a nail). There is overwhelming evidence for impaired praxis/ imitation performance in children with ASD compared to age-matched...
TD children on standardized tests as well as non-standardized actions or gestures (Carmo et al., 2013; Dewey et al., 2007; Dowell et al., 2009; Mostofsky et al., 2006; Rogers et al., 1996; Salowitz et al., 2013; Vanvuchelen et al., 2007; Williams et al., 2004).

In terms of a standardized test, Florida Apraxia Battery, children with ASD between 8 and 13 years showed poor production of actions on imitation, verbal command, and tool use compared to age-matched TD children (Dowell et al., 2009). Similarly, on a non-standardized test, children with ASD between 5 and 11 years showed poor imitation of meaningless gestures involving hands, feet, and trunk compared to age-matched TD children (Carmo et al., 2013). The common praxis/imitation errors reported in children with ASD are spatial errors (e.g. incorrect positioning of the moving limb in space), reversal errors (e.g. waving with palm facing inwards), and body-part-for-tool errors (e.g. cutting with scissors by moving the index and middle fingers). Overall, there is considerable evidence for praxis/imitation deficits in children with ASD compared to age-matched TD children.

2.1.3 Impact of Motor Impairments on ASD

Motor skills are essential for children to perform functional daily living skills such as grooming and feeding, as well as participate in recreational and competitive sports with peers. There is evidence to suggest that poor motor skills in children with ASD have serious implications on the core diagnostic impairments of ASD including the social, communication, and behavioral skills (Bhat et al., 2012; Gernsbacher et al., 2008; MacDonald et al., 2013a; 2014; Radonovich et al., 2013; Sipes et al., 2011). To elaborate,
early gross motor skills such as crawling and walking allow infants to physically move to another person and form social connections with their caregivers or other social partners (MacDonald et al., 2013a; Sipes et al., 2011). In fact, the motor performance of young toddlers with ASD correlated with their social skills such that toddlers with poor gross motor skills had greater impairments in sharing interests or enjoyment with others (Sipes et al., 2011). Similarly, early motor skills form the foundation for non-verbal communication such as pointing and gestures as well as verbal communication such as babbling and early words (Bhat et al., 2012; Gernsbacher et al., 2008; Iverson and Wozniak, 2007). Early impairments in the oral-motor skills such as blowing bubbles and puffing cheeks as well as the fine motor skills such as reaching, clapping, and pointing strongly predicted the speech fluency of minimally verbal children and adolescents with ASD (Gernsbacher et al., 2008). Lastly, in terms of behavioral skills, children with ASD with poor postural control showed greater frequency and intensity of restricted/ repetitive behaviors such as body rocking, hand flapping, inflexible routines, and preoccupations with specific objects (Radonovich et al., 2013; Ravizza et al., 2013). Overall, motor impairments in children with ASD could have cascading effects on the social communication and restricted/ repetitive behaviors of children. Therefore, efforts should be directed towards identifying the motor impairments through adequate assessments as well as remediating them through effective intervention and treatment plans.
2.1.4 Motor and Imitation Interventions for ASD

In the past few years, there has been a relatively increased focus on promoting the physical/motor activity in children with ASD and exploring the effects of therapeutic exercise in children. A majority of the physical exercise interventions included aerobic training such as jogging and running, and recreational or competitive sports such as table tennis, ice skating, horse-back riding, and swimming (Bremer et al., 2016; Kunzi, 2015; Lang et al., 2010; Lee et al., 2016; Sowa and Meulenbroek, 2012). However, the focus of these interventions is repetitive/stereotypical behaviors (Anderson-Hanley et al., 2011; Elliott et al., 1994; Neely et al., 2014), social skills (Kunzi, 2015; Movahedi et al., 2013; Pan, 2010), and academic performance (Neely et al., 2014; Oriel et al., 2011) of children with ASD. A systematic review of 13 studies suggested improvements in behavioral skills such as reduction in stereotypical behaviors, and improvements in social-emotional, and cognitive functioning of children with ASD following exercise interventions, with moderate to large effect sizes for interventions involving horse-back riding and martial arts training (Bremer et al., 2016).

Surprisingly, fewer studies monitored the changes in the motor skills such as balance, strength, and flexibility of children with ASD following exercise training (Bremer et al., 2015; Hilton et al., 2014; MacDonald et al., 2012; Pan et al., 2016; Wuang et al., 2010). For example, a randomized control trial in children with ASD between 6 and 12 years indicated improved body coordination and strength scores on a standardized motor test following 12-weeks of table tennis training compared to no improvements in the control
group. Additionally, the training group sustained the improvements over a 12-week follow-up period (Pan et al., 2016). Similarly, Bremer et al. (2015) examined the effects of a 12-week motor training including locomotor skills such as running and jogging, and object control skills such as throwing and catching balls on the motor, adaptive behaviors, and social skills of 4-year old children with ASD. The results indicated improved object control and total motor scores on a standardized test of motor performance but no improvements on the parent-reported adaptive behavior and social skill questionnaires (Bremer et al., 2015). Overall, there is some preliminary evidence to suggest the positive effects of therapeutic exercise interventions on the motor skills of children with ASD. However, the evidence is clearly limited due to lack of studies as well as weak study designs such as small sample sizes, heterogeneous study samples, and lack of detailed testing measures. The current study has attempted to address these limitations by systematically examining the effects of a movement-based, yoga intervention in 12 children with ASD using standardized assessments as well as detailed behavioral coding schemes.

In terms of imitation, two popular treatment approaches exist, Reciprocal Imitation Training and Video Modeling. Reciprocal Imitation Training are adult- or peer-delivered interventions in a naturalistic and socially interactive environment to promote the spontaneous imitation of children with ASD (Ingersoll, 2010; Ingersoll and Gergans, 2007; Ingersoll and Schreibman, 2006; Walton and Ingersoll, 2012). The training protocol gradually progresses to generalizing the imitation skills to novel settings and
people. A 10-week randomized controlled trial using reciprocal imitation techniques in young toddlers with ASD indicated improvements in the spontaneous and responsive imitation of objects and gestures in the treatment group compared to the no-treatment control group (Ingersoll 2010). On the other hand, Video Modeling, includes watching the video clips of target behaviors along with opportunities to copy the televised behaviors (Bellini and Akullian, 2007; Charlop-Christy and Daneshvar, 2003; Charlop-Christy et al., 2000; MacDonald et al., 2005). Video Modeling interventions are considered beneficial as they are less distracting due to a restricted field of focus, self-motivating, as well as socially non-intimidating, especially for children with ASD. Two children with ASD undergoing the Video Modeling intervention indicated improvements in imitation of the televised play behaviors, with improvements maintained at the follow-up period (MacDonald et al., 2005). A comparison of the Video Modeling and Reciprocal Imitation Training techniques in children with ASD suggested that both the techniques are equally effective for teaching object imitation in children. However, the improvements could be seen rapidly following the Video Modeling techniques compared to the steady increase in skill level following the Reciprocal Imitation Training techniques (Cardon and Wilcox, 2011). Overall, there are several interventions which specifically target the imitation skills of children with ASD. In the current study, we were interested to explore the effects of a movement-based yoga intervention, delivered within an imitation context on the motor as well as the imitation skills of children with ASD.
2.1.5 Yoga Intervention for ASD

Yoga is gaining popularity as a complementary and alternative therapy due to its cost-effectiveness as well as multiple effects on the physical and the mental well-being of children with and without special needs (Barnes et al., 2008; Birdee et al., 2009; Galantino et al., Serwacki and Cook-Cottone, 2012). In terms of physical health, yoga could improve the muscle strength, flexibility, and balance as well as the aerobic fitness/cardiorespiratory endurance of children (Dash and Telles, 1999; D'souza and Avadhany, 2014; Hotkar, 2009; Jeter et al., 2014; Madanmohan et al., 2003; Manjunath and Telles, 2001; Raghuraj and Telles, 1997; Tran et al., 2001). In terms of mental health, yoga helps in overcoming stress, promoting positive thoughts, and reducing disruptive behaviors in children (Beauchemin et al., 2008; Bernardi et al., 2001; Ehlinger et al., 2010; Harrison et al., 2004; Kenny 2002; Khalsa et al., 2013; Koszycka et al., 2007; Peck et al., 2005; Powell et al., 2008; White, 2012).

Additionally, yoga-based activities are easy to learn, modifiable based on the age and level of functioning of the child, and could be made fun and creative for children. There is some anecdotal evidence for the use of yoga in children with ASD to improve the social participation, and reduce the maladaptive and negative behaviors (Goldberg, 2004; Koenig et al., 2012; Rosenblatt et al., 2011; Radhakrishna et al., 2010). To our knowledge, there is a single study examining the effects of yoga on the motor imitation of children with ASD (Radhakrishna, 2010). Specifically, children with ASD between 8 and 14 years improved imitation of yoga poses and breathing exercises, as well as gross motor actions.
such as jogging and running, and oro-facial movements of lips and tongue following 10 months of yoga training (Radhakrishnan, 2010).

Although, the current literature on yoga intervention for promoting the motor skills of children with ASD is limited, there is overwhelming evidence from TD children suggesting positive effects of yoga on the balance, strength, flexibility, and motor speed of children (Dash and Telles, 1999; D'souza and Avadhany, 2014; Hotkar, 2009; Jeter et al., 2014; Madanmohan et al., 2003; Manjunath and Telles, 2001; Raghuraj and Telles, 1997; Tran et al., 2001). Specifically, a yoga intervention primarily including poses, breathing exercises, and relaxation improved the strength of hand and respiratory muscles (Madanmohan et al., 2003), reduced the motor planning and execution time for a problem-solving task (Manjunath and Telles, 2001), and improved the motor speed for a repetitive finger tapping task in TD children in the yoga group compared to the no intervention or physical exercise control group (Dash and Telles, 1999). Similarly, a 6-week randomized controlled trial using yoga intervention in TD children between 11 and 14 years suggested improvements in the static balance of children compared to no changes in the control group (Hotkar, 2009). Given the current evidence in TD children, yoga-based interventions could be a promising tool to improve the balance, strength, and flexibility of children. Clearly, the evidence for yoga intervention in children with ASD is limited and needs further investigation. Additionally, there is lack of comprehensive or holistic movement interventions targeting the motor as well as the core social communication and behavioral skills of children with ASD. Hence, the current study
systematically explored the effects of a socially-embedded, yoga intervention on the motor, imitation, social communication, and behavioral skills of children with ASD.

2.1.6 Aims and Hypotheses of the Study

The primary aim of the current study was to examine the training-related changes in the motor and imitation skills of children with ASD between 5 and 12 years of age following 8-weeks of yoga intervention. The specific aims of the study were:

Aim 1: To examine the changes in the gross and fine motor skills of children with ASD using a standardized motor test, Bruininks-Oseretsky Test of Motor Proficiency (BOT-2) administered during the posttest and the pretest sessions.

Hypothesis 1: We hypothesized that children with ASD would improve their gross motor skills on the BOT-2 during the posttest session compared to the pretest sessions.

Aim 2: To examine the changes in the imitation of novel actions using a standardized subtest of Sensory Integration and Praxis Test (SIPT) administered during the testing sessions, as well as the imitation of training-specific actions using a Yoga Pose test delivered during the early (session 1), mid (session 8), and late (session 16) in children with ASD.

Hypothesis 2: Children would improve the imitation of novel actions on the standardized subtest of SIPT during the posttest session compared to the pretest session. Additionally, children would improve the imitation of training-specific actions of the Yoga Pose Test.
during the late compared to the mid and the early training session.

**Aim 3**: To determine the social validity of the yoga intervention using a parent measure, exit questionnaire completed at the end of the study.

**Hypothesis 3**: Parents may or may not find the intervention useful and beneficial for their child with ASD.

### 2.2 Methods

#### 2.2.1 Research Design and Study Timeline

We used a single group pre-posttest study design to assess the efficacy of 8-week yoga intervention on the motor, social communication, and behavioral skills of children with ASD. We improvised the study design in order to address the internal validity threats associated with a single group study design such as the testing threat (Dimitrov and Rumrill, 2003). Specifically, we introduced a repeat pretest session, where children participated in two pretest sessions repeated within a 2-week period (Table 2.1). The repeat pretest session would monitor the changes in child’s performance due to simple repetition or familiarization with the testing activities. Ideally, true intervention effects would be indicated by similar performance across the two pretest sessions, whereas improved performance from both the pretest sessions to the posttest session.

The study lasted for 12 weeks including two pretest sessions repeated within a 2-week period followed by 8-weeks of yoga intervention, and a posttest session in the last week
The testing sessions included a standardized test of motor performance, Bruininks-Oseretsky Test as well as a standardized test of imitation, Sensory Integration and Praxis Test. The intervention included 16 yoga sessions with two sessions delivered each week for an 8-week period. In addition, parents were asked to deliver two yoga sessions at home each week. We also assessed the training-specific changes in imitation of children from the first to the last training sessions.

Table 2.1: Study Timeline.

<table>
<thead>
<tr>
<th>Pretest (Week 1)</th>
<th>Repeat Pretest (Week 3)</th>
<th>Intervention (Week 4-11)</th>
<th>Posttest (Week 12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Sensory Integration &amp; Praxis Test</td>
<td>2. Sensory Integration &amp; Praxis Test</td>
<td>Training-specific imitation test: Yoga Pose Test</td>
<td>2. Sensory Integration &amp; Praxis Test</td>
</tr>
</tbody>
</table>

2.2.2 Participants

Twelve children with ASD (11 boys and 1 girl) between 5 and 12 years (Mean ± SE = 7.77 ± 0.49 years) received the intervention (Table 2.2). The greater number of boys in the study is not surprising as ASD is 5 times more prevalent in males compared to females (CDC, 2014). The sample size was finalized by conducting power analysis from the preliminary results of two children with ASD who underwent the yoga intervention. Participants were recruited from the Delaware and Maryland areas by distributing fliers in the local schools and online postings on the autism websites. The eligibility for the
study was determined by the following criteria:

a) Social Communication Questionnaire (SCQ): SCQ is a parent-reported, 40-item questionnaire that screens for autism-specific social communication impairments (Rutter et al., 2003). A cut-off score of 15 or greater was reported in 8 out of the 12 children indicating significant impairments in social communication skills (Table 2.2). The eligibility for the remaining four children was confirmed after administrating the Autism Diagnostic Observation Schedule- Second Edition (see below).

b) Autism Diagnostic Observation Schedule- Second Edition (ADOS-2): ADOS-2 is a gold standard assessment for autism diagnosis and involves a semi-structured play for assessing social interaction, and repetitive/ restricted behaviors of children (Lord et al., 2012). The scoring of ADOS-2 provides a comparison score of 1-10 to gauge the severity of disorder with higher score indicating greater severity of disorder. Autism diagnosis was confirmed for all 12 children with comparison score ranging from 5 to 10 indicating moderate to high severity of disorder (Table 2.2).
Our exclusion criteria included children with additional impairments such as hearing/vision impairments, orthopedic/neurological cardiopulmonary conditions, or significant developmental delays. Additionally, the children had to demonstrate the ability to engage in the testing and training activities, hence children with challenging behaviors such as aggression, non-compliance, temper tantrums, or attentional problems were also excluded. Four additional children were excluded from the study based on the above-mentioned exclusion criteria. All parents signed the consent form and children signed the assent form approved by the Institutional Review Board at the University of Delaware before participating in the study. Based on the socioeconomic scores (Mean ± SE = 56.54 ± 2.20; Table 2.2), the families belonged to the middle (n = 1), upper-middle (n = 9), or upper class (n = 2) with Asian (n = 5) or Caucasian (n = 7) ethnicity (Hollingshead, 1975). The comparatively higher proportion of Asian families in the current study could be attributed to the greater familiarity and popularity of yoga among Asian families.

### Table 2.2: Participant Demographics

<table>
<thead>
<tr>
<th>Participant</th>
<th>Age: Gender</th>
<th>SCQ</th>
<th>ADOS-2 Score</th>
<th>Severity</th>
<th>SES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child 1</td>
<td>10.46: M</td>
<td>21</td>
<td>10</td>
<td>High</td>
<td>50.50</td>
</tr>
<tr>
<td>Child 2</td>
<td>6.29: M</td>
<td>5</td>
<td>6</td>
<td>Moderate</td>
<td>66</td>
</tr>
<tr>
<td>Child 3</td>
<td>8.07: M</td>
<td>17</td>
<td>9</td>
<td>High</td>
<td>61</td>
</tr>
<tr>
<td>Child 4</td>
<td>9.52: M</td>
<td>16</td>
<td>10</td>
<td>High</td>
<td>40</td>
</tr>
<tr>
<td>Child 5</td>
<td>7.23: M</td>
<td>7</td>
<td>8</td>
<td>High</td>
<td>61</td>
</tr>
<tr>
<td>Child 6</td>
<td>6.95: M</td>
<td>11</td>
<td>10</td>
<td>High</td>
<td>66</td>
</tr>
<tr>
<td>Child 7</td>
<td>7.66: M</td>
<td>16</td>
<td>8</td>
<td>High</td>
<td>53</td>
</tr>
<tr>
<td>Child 8</td>
<td>5.48: F</td>
<td>11</td>
<td>8</td>
<td>High</td>
<td>57</td>
</tr>
<tr>
<td>Child 9</td>
<td>7.22: M</td>
<td>16</td>
<td>8</td>
<td>High</td>
<td>50</td>
</tr>
<tr>
<td>Child 10</td>
<td>11.01: M</td>
<td>19</td>
<td>5</td>
<td>Moderate</td>
<td>53</td>
</tr>
<tr>
<td>Child 11</td>
<td>7.03: M</td>
<td>23</td>
<td>10</td>
<td>High</td>
<td>63</td>
</tr>
<tr>
<td>Child 12</td>
<td>6.36: M</td>
<td>22</td>
<td>9</td>
<td>High</td>
<td>58</td>
</tr>
</tbody>
</table>

M = Male, F = Female, SCQ = Social Communication Questionnaire, SES = Socio-Economic Status, N/A = Not Available
2.2.3 Training Protocol

We delivered 8-weeks of a yoga intervention with 2 sessions per week (total 16 sessions) and each session lasting 50-60 minutes. The training sessions involved a triadic context, i.e. a child with ASD, an expert trainer, and an adult model (Figure 2.1). The expert trainer is a pediatric physical therapist and a graduate student at University of Delaware. She was responsible for conducting the session and guiding the child through the activities. The adult models are undergraduates at University of Delaware and their role was to act as a buddy for the child with ASD as well as help the expert trainer in delivering the sessions. All models received at least 6 hours of training in the form of instructional manuals and videos before participating in the intervention. Additionally, to ensure training fidelity, a novel coder coded three randomly-picked sessions for each child to monitor the trainers’ adherence to the protocol as well as completion of all the critical activities of the session (Appendix A for Fidelity checklist). The results indicated that the trainers followed the protocol and completed the critical activities for majority of the training sessions (Mean $\pm$ SE = 94.63 $\pm$ 0.74 %).

The parents were provided with instructional CDs and manuals to deliver two additional sessions at home each week. Additionally, the expert trainer provided a brief training to the parents regarding the home sessions and provided all the necessary materials such as yoga mats and props required to conduct the sessions. The expert trainers and parents maintained a log of the total number of sessions completed for the child. All children completed the 16 expert training sessions, except one child who
completed 8 sessions. In terms of parent sessions, 10 out of the 12 parents the training logs and the number of home sessions ranged from 4 to 16 sessions child.

**Yoga Training Session**

![Figure 2.1: Yoga training session indicating a triadic context between an expert trainer, model, and a child with ASD.](image)

2.2.3.1 Training Principles and Goals

We based our training on the principles of autism interventions including Applied Behavioral Analysis (ABA; Lovaas, 1987), Teaching and Education of Autistic and Related Communication Handicapped Children (TEACHH; Mesibov et al., 2004), and Picture Exchange Communication System (PECS; Bondy and Frost, 2003), and motor learning principles (Luft and Buitrago, 2005; Schmidt and Lee, 1988). Specifically, we ensured consistency in session location and people involved, used picture schedules to facilitate transitions between activities and offer choice between activities, provided graded prompting from low-level (visual or verbal) to high-level prompts (hand-on-hand assistance), repeated activities to ensure learning, and lastly provided positive
reinforcement such as gestural or verbal praise. Our goal was to facilitate the gross motor skills such as balance, flexibility, strength, and imitation, social skills such as social proximity, eye gaze, and co-operative play, communication skills including verbal (commenting, responding, singing) and non-verbal gestural use (showing, pointing), and lastly, behavioral skills such as alertness, attention, and relaxation.

2.2.3.2 Training Activities

We included traditional yoga activities such as breathing, poses, partner poses, and relaxation, as well as activities specifically catering to the needs of children with ASD such as greetings, contact, and looking games. The order of activities followed during each session was- Hello song, Contact, Breathing, Looking, Poses and Partner poses, Relaxation, and lastly Bye song (Table 2.3). We made several attempts to make the yoga training activities fun and creative for children, i.e. by incorporating music-based songs, stories, and games within the sessions. Musical activities are inherently enjoyable for children, especially for children with ASD who have better understanding of musical notes and pitch perception (Heaton, 2003; Heaton et al., 1999). Additionally, we used various props during the to provide an appropriate context to the child such as straws and thermo balls during the breathing activities.
Table 2.3: Activities Practiced within Yoga Session.

<table>
<thead>
<tr>
<th>Activities</th>
<th>Description</th>
<th>Goals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hello</td>
<td>Greeting by singing a song together.</td>
<td>Prepares child for the session and promotes social verbalization and verbal synchrony with trainers.</td>
</tr>
<tr>
<td>Contact</td>
<td>Social games such as passing a ball, forming shapes together, or trusting games.</td>
<td>Facilitates social bond or connection between the child and the trainers by promoting social proximity and safe social distance.</td>
</tr>
<tr>
<td>Breathing</td>
<td>Breathing exercises such as sucking through a straw, nostril breathing, bee sound breathing.</td>
<td>Facilitates rhythmic and slow breathing patterns for promoting alertness, relaxation, and self-regulation during stressful conditions.</td>
</tr>
<tr>
<td>Looking</td>
<td>Eye-gaze training through isolated eye or head turns on trainer’s command such as look at the moving hand/ball.</td>
<td>Improves social attention of the child towards stationary and moving, social and non-social stimuli.</td>
</tr>
<tr>
<td>Poses</td>
<td>Postures varying in starting positions (lying, sitting, standing), complexity (simple, complex).</td>
<td>Improves balance, strength, flexibility, and coordination between body segments.</td>
</tr>
<tr>
<td>Partner poses</td>
<td>Child and trainer perform the poses together.</td>
<td>Improves social synchrony, and trust on the social partner.</td>
</tr>
<tr>
<td>Relaxation</td>
<td>Still lying with pre-recorded verbal imagery in the background.</td>
<td>Promotes relaxation, calming, and improve the attentional focus of the child.</td>
</tr>
<tr>
<td>Bye</td>
<td>Bidding farewell by singing a song together.</td>
<td>Promotes social verbalization and verbal synchrony with trainers.</td>
</tr>
</tbody>
</table>

2.2.4 Testing Protocol

2.2.4.1 Testing Measures

We included two standardized measures, Bruininks-Oseretsky Test and Sensory Integration and Praxis Test to assess the generalized changes in gross motor, fine motor, and imitation skills following the intervention. The standardized measures were
administered by a novel tester during the pretest, repeat pretest, and the posttest session. Additionally, we included a training-specific imitation measure, *Yoga Pose Test* to assess changes in imitation of yoga poses with the expert trainer during the intervention. Lastly, we asked the parents to fill an *Exit Questionnaire* at the completion of the study to indicate their overall experience and satisfaction with the intervention. In terms of missing data, 1 child was unable to participate in the posttest session, hence we are reporting on the BOT-2 and SIPT-PP data for 11 children.

**a) Bruininks-Oseretsky Test of Motor Proficiency- Second Edition (BOT-2):** BOT-2 is a reliable and valid measure of fine and gross motor performance in individuals between 4 and 21 years of age (Bruininks and Bruininks, 2005). A novel tester administered three gross motor and three fine motor subtests, including the Bilateral Coordination, Balance, Strength, Fine Motor Precision, Fine Motor Integration, and Manual Dexterity subtests. The Bilateral Coordination subtest assessed children’s ability to synchronize their upper and lower limbs, the Balance subtest assessed children’s postural control in standing and walking in the presence/absence of visual input, and the Strength subtest assessed upper-, lower-limb, and core muscle strength. The Fine Motor Precision subtest assessed the precise hand and finger control, the Fine Motor Integration subtest assessed the ability to integrate visual stimuli during motor control, and lastly, the Manual Dexterity measured the ability to manipulate small objects using one or both hands (see Appendix B for pictures of BOT-2 items).

**b) Sensory Integration and Praxis Testing (SIPT):** SIPT is a comprehensive
assessment tool consisting of 17 subtests that evaluate praxis, sensory integration, and motor accuracy in children between 4 and 8 years of age (Ayres, 1988). We used the Postural Praxis subtest of SIPT (SIPT-PP) to evaluate the generalized changes in imitation abilities of children with ASD following the intervention. SIPT-PP has 17 novel, non-functional actions and the child was instructed to copy the tester’s actions (see Appendix C for pictures of SIPT-PP actions).

c) Yoga Pose Test: Yoga pose test included six poses varying in complexity and starting positions (see Appendix D for pictures of poses). The test was repeated during the training session 1 (early), 8 (mid), and 16 (late) to evaluate the changes in the imitation skills of children over the training.

d) Exit Questionnaire: The exit questionnaire was based on a 5-point Likert-scale with total five questions on parent’s satisfaction and perceived efficacy of the intervention. The responses could range from 1 (do not agree) to 5 (strongly agree) (see Appendix E) and the questionnaire was completed by the parents at the end of the study.

2.2.4.2 Behavioral Coding

All testing and training sessions were videotaped for behavioral coding. Following are the details for the behavioral coding of the testing measures. Pearson’s correlations were conducted to establish intra-rater reliability of > 90% and inter-rater reliability of > 80% for 25% of the dataset for all the study variables.
a) **Scaled Scores for BOT-2**: The BOT-2 manual provides scaled scores, age equivalents, and a qualitative description for each of the subtest raw scores. We have reported on the training effects using the scaled scores, with greater scores indicating better performance.

b) **Imitation Errors for SIPT-PP**: We coded each action for spatio-temporal errors including Movement Modulation, Movement Directness, Body Part, and Overflow errors based on the error classification by Dewey (1993). The Movement Modulation error indicated insufficient or exaggerated effort by the child while copying the action, Movement Directness indicated indirect/hesitated movements by the child along with following an inefficient path of motion, Body Part error involved use of incorrect body parts during the action, and lastly Overflow error indicated extra movements by the child beyond what the tester performed. Each child received a 0 (no error) or 1 (error) score based on the absence/presence of an error. We have reported on the total Modulation, Directness, Body Part, and Overflow errors by summing the child’s error scores across all the action sequences along with the Total error score by summing all the error types. We also coded the prompts, i.e. verbal, visual, and physical required by the child to perform the action sequences of SIPT-PP. A verbal prompt indicated any additional statements by the tester to help the child focus on the activity such as “Please pay attention” or help perform the action such as “Use your right hand”. A visual prompt indicated that the child required a repeat demonstration of the action. Physical prompt indicated that the child required hand-on-hand assistance to complete
the action sequence. We are reporting on the total number of prompts by summing the verbal, visual, and physical prompts across all the SIPT-PP actions.

c) *Imitation Errors for Yoga Test:* Similar to the SIPT-PP, we coded the yoga test for various appropriate imitation errors including the Pose Element, Balance Strategy, and Spatial errors. The Pose Element error indicated inability of the child to copy all the necessary elements of the pose, Balance Strategies indicated the additional movements by the child to maintain balance during the pose, and lastly Spatial error indicated poses performed in different plane of motion compared to the tester. We have reported on the total Pose Element, Balance Strategy, and Spatial errors by summing the child’s error scores across the six poses along with the Total errors by summing all the error types. Additionally, we have reported on the total number of prompts by summing the verbal, visual, and physical prompts required by the child to perform the poses (see description above).

d) *Percentage for Exit Questionnaire:* We grouped the Likert-scale responses into three levels—do not agree (score 1 on Likert-scale), agree (score 2 or 3), and strongly agree (score 4 or 5). Further, we calculated the percentage of parents whose responses fell under the above-mentioned agreement levels for all the five questions.

2.2.4.3 Statistical Analysis

To examine the training effects, we conducted three separate Repeated Measures Analysis of Variance (ANOVA) for our testing measures, i.e. the BOT-2, the SIPT-PP,
and the Yoga test with testing/training session (Testing session: pretest, repeat pretest, posttest; Training session: early, mid, late) and subtest/error type (BOT-2 subtest types: Bilateral Coordination, Balance, Strength, Fine Motor Precision, Fine Motor Integration, and Manual Dexterity; SIPT-PP error types: Movement Modulation, Movement Directness, Body Part, Overflow, Total errors; Yoga test error types: Pose Element, Balance Strategy, Spatial, Total errors) as the within-subjects factor. Additionally, we conducted two separate dependent t-tests for the number of prompts during the SIPT-PP and the Yoga test. We checked our data for parametric assumptions using the Mauchly’s Test of Sphericity and Greenhouse-Geisser corrections were applied in case of violations. The significance was set at $p \leq 0.05$ and the training effects were further examined using post-hoc, dependent t-tests with Bonferroni corrections applied for multiple comparisons. In the case of Bonferroni corrections, we considered $p$-values $\leq 0.05$ as statistical trends. Additionally, we have reported on the individual data of children for each of the testing measure (see Results for details).

2.3 Results

2.3.1 Training-Related Changes in BOT-2

We examined the generalized effects of yoga intervention in children with ASD using a standardized motor test, BOT-2 across three testing sessions—i.e. the pretest, the repeat pretest, and the posttest session. The Repeated measures ANOVA for BOT-2 revealed a significant main effect of testing session ($F (2, 20) = 14.25, p < 0.01$, partial $\eta^2 = 0.59$) and subtest type ($F (5, 50) = 14.08, p < 0.01$, partial $\eta^2 = 0.59$), as well as significant 2-
way testing session x subtest interaction (F (10, 100) = 2.68, \( p < 0.01 \), partial \( \eta^2 = 0.21 \)). We further analyzed the 2-way interaction using post-hoc t-tests which indicated that the children improved their performance for two gross motor subtests, i.e. the Bilateral Coordination and the Strength subtest following the intervention. Specifically, children improved their Bilateral Coordination and Strength scores from both the pretest to the posttest sessions, with similar performance across the two pretest sessions (\( p \)-values between 0.003 and 0.05, Figure 2.2).

Surprisingly, Balance, which was one of the targeted skill of the intervention showed no changes following the intervention. Therefore, to better understand these results, we divided the items of Balance subtest into 2 sub groups based on their complexity, i.e. (a) eyes open and (b) eyes closed items. The dependent t-tests for the two subgroups of Balance indicated that children were performing at the ceiling level for the comparatively easier eyes open items across all three testing sessions (Figure 2.3). On the other hand, for the eyes closed items, children increased their raw scores from both the pretest to the posttest session, with similar performance across the two pretest sessions (\( p \)-values < 0.05, Figure 2.3). Lastly, in terms of the fine motor subtests, children performed similarly across the three testing sessions. We also examined the individual data to confirm the group trends: 6-10 out of 11 children increased their gross motor scores following the yoga intervention.
**Training-Related Changes in BOT-2**

![Graph showing training-related changes in BOT-2.

**Figure 2.2**: Effects of yoga intervention on the standardized motor test, BOT-2. * indicates \( p < 0.003 \), † indicates \( p < 0.05 \)

**Training-Related Changes in Balance of BOT-2**

![Graph showing training-related changes in Balance of BOT-2.

**Figure 2.3**: Effects of yoga intervention on the Balance subtest of BOT-2. * indicates \( p \leq 0.05 \)
2.3.2 Training-Related Changes in SIPT-PP

We examined the generalized effects of yoga intervention on the imitation skills of children by administrating a standardized subtest of SIPT across three testing sessions - i.e. the pretest, the repeat pretest, and the posttest session. Repeated measures ANOVA for SIPT-PP errors revealed a significant main effect of testing session (F (2, 20) = 6.95, \( p < 0.01 \), partial \( \eta^2 = 0.41 \)) and error type (F (4, 40) = 31.68, \( p < 0.01 \), partial \( \eta^2 = 0.76 \)). Post-hoc t-tests for the main effect of testing session indicated that children reduced their errors during the posttest session compared to the two pretest sessions, with similar performance across the two pretest sessions (\( p < 0.02 \) after Bonferroni corrections, Figure 2.4). In terms of individual data, 8-10 out of 11 children reduced their total imitation errors in the posttest session compared to the two pretest sessions.

**Figure 2.4:** Effects of yoga intervention on the imitation errors for SIPT-PP. * indicates \( p \leq 0.02 \)
We also coded the number of prompts (verbal, visual, and physical) required by the child to complete the action sequences. The dependent t-tests for the prompts indicated that the children required fewer number of prompts in the posttest session compared to the first pretest session (p < 0.02 after Bonferroni corrections, Figure 2.5). No other differences were observed in the number of prompts between the testing sessions. In terms of individual data, 10 out of 11 children required fewer prompts in the posttest session compared to the first pretest session.

**Figure 2.5:** Effects of yoga intervention on the number of prompts for the SIPT-PP actions.
* indicates $p \leq 0.02$
2.3.3 Training-Related Changes in Yoga Pose Test

We examined the training-specific changes in the imitation of yoga poses across the training sessions—i.e. early (session 1), mid (8), and late (16) session. The repeated measures ANOVA indicated a significant main effect of training session ($F(2, 22) = 14.31, p < 0.01$, partial $\eta^2 = 0.57$), and error types ($F(3, 33) = 172.86, p < 0.01$, partial $\eta^2 = 0.94$), as well as a significant 2-way training session x error type interaction ($F(6, 66) = 5.57, p < 0.01$, partial $\eta^2 = 0.34$). The post-hoc tests for the 2-way interaction indicated that the children with ASD reduced their total errors, pose element, and spatial errors from the early to the mid and late training session ($p$-values between 0.004 and 0.05, Figure 2.6). We did not observe any changes in imitation errors from the mid to the late training session. The individual data suggested that 6-12 out of the 12 children reduced their total and pose element errors during the mid and late training session compared to the early session.

Training-Related Changes in Yoga Test

Figure 2.6: Effects of yoga intervention on the imitation errors during the yoga test.
* indicates $p < 0.004$, † indicates $p \leq 0.05$
In terms of number of prompts, children required fewer prompts to perform the yoga poses in the mid and the late training sessions compared to the early training session ($p < 0.02$ after Bonferroni corrections, Figure 2.7), with no changes between the mid and the late training session. Individual data suggested that 8-12 out of 12 children followed the group trends.

**Training-related Changes in Prompts of Yoga test**

*Figure 2.7: Effects of yoga intervention on the number of prompts for the Yoga test. * indicates $p \leq 0.02$*

### 2.3.4 Parent Reports on Exit Questionnaire

The exit questionnaire was filled by 11 out of the 12 parents at the completion of the study. We have reported on the percentage of parent responses falling under 3 categories - do not agree, agree, and strongly agree. Majority of the parents, around 78-82% found the intervention useful, innovative, and satisfactory (Table 2.4). They suggested
continuing yoga with their child after the study completion, as well as recommending it to other parents (Table 2.4).

**Table 2.4: Parent Reports on Exit Questionnaire.**

<table>
<thead>
<tr>
<th>Question</th>
<th>Parent Responses (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Do not agree</td>
</tr>
<tr>
<td>I found the intervention very useful for my child.</td>
<td>0</td>
</tr>
<tr>
<td>I found the intervention highly innovative.</td>
<td>0</td>
</tr>
<tr>
<td>I am satisfied with the intervention.</td>
<td>0</td>
</tr>
<tr>
<td>I would recommend the intervention to other parents.</td>
<td>0</td>
</tr>
<tr>
<td>I would continue yoga with my child after the study.</td>
<td>11</td>
</tr>
</tbody>
</table>

**2.4 Discussion**

**2.4.1 Summary of Results**

The current study compared the effects of an 8-week yoga intervention on the motor and imitation skills of children with ASD between 5 and 12 years of age. In terms of the standardized motor test, BOT-2, children showed improvements in the gross motor subtests of BOT-2 including the Strength, Bilateral Coordination, and eyes closed items of the Balance subtest; whereas no changes in the fine motor subtests during the posttest session compared to the two pretest sessions. In terms of the standardized imitation subtest, SIPT-PP, children with ASD reduced the number of imitation errors as well as required fewer number of prompts while copying the actions of a novel tester during the posttest session compared to the two pretest sessions. To be clear, children showed no
changes in their performance for both the standardized tests across the two pretest sessions, i.e. the first pretest and the repeat pretest session indicating that simple repetition or familiarization with the testing activities did not impact the overall motor and imitation performance of children with ASD. In terms of the training-specific imitation measure, Yoga Pose Test, children reduced their total imitation errors, pose element, and spatial errors, as well as required fewer prompts while copying the yoga poses of the expert trainer during the mid and late training sessions compared to the early training session. Lastly, in terms of the exit questionnaire, majority of the parents provided social validity for the intervention and believed the intervention was useful and beneficial for their child.

2.4.2 Effects of Yoga Intervention on the Motor and Imitation Skills of ASD

Children with ASD improved their Balance, Strength, and Bilateral Coordination on a standardized motor test- BOT-2, administered by a novel tester during the testing sessions. The activities within the yoga session, especially the poses and the partner poses heavily focused on promoting the whole body movements of children. Specifically, we included simple and complex postures in lying, sitting, and standing, requiring good balance control, core strength, as well as coordination between the two sides of the body. Hence, the improvements in gross motor subtests of BOT-2 are consistent with the training demands. It was especially encouraging to see that children generalized their motor skills to a standardized test of motor performance, following the yoga intervention. Our findings fit with the current literature in TD children, where yoga-based interventions improved the balance, strength, and flexibility of TD children (Dash and Telles, 1999;
D’souza and Avadhany, 2014; Hotkar, 2009; Jeter et al., 2014; Madanmohan et al., 2003; Manjunath and Telles, 2001; Raghuraj and Telles, 1997; Tran et al., 2001). A systematic review of yoga intervention on the balancing abilities of healthy individuals suggested moderate to strong effect sizes for improvements in both the static and dynamic balance of TD children and adults following the intervention (Jeter et al., 2014). Similarly, a 6-month randomized controlled trial in TD children between 12 and 15 years suggested improvements in the strength of hand and respiratory muscles along with improvements in the lung capacities such as Forced Expiratory Volume compared to no changes in the strength and endurance of the control, no training group (Madanmohan et al., 2003). Overall, this is the first study documenting improvements in the gross motor skills of children with ASD on a standardized test of motor performance following an 8-week, movement-based yoga intervention.

Children with ASD reduced their imitation errors and number of prompts for both the, novel actions of a standardized imitation subtest as well as a training-specific test involving the yoga poses. The improvements in the imitation skills of children following the yoga intervention could be attributed to the improvements in the motor skills and social monitoring of children during the training. Motor performance is an essential prerequisite of imitation such that the imitation impairment in autism are strongly associated with the level of motor ability of children with ASD assessed on standardized tests (Dziuk et al., 2007; Vanvuchelen et al., 2007). Children in the current study improved their gross motor skills following the yoga training, which could have allowed
them to move their body efficiently and hence, better imitate the actions of the adult during the testing and the training sessions. Another essential determinant of imitation performance in children is social monitoring, i.e. visually monitoring the actions of the social partner. Children with ASD are documented to show reduced eye contact and monitoring of others actions (Dawson et al., 2004; Mundy et al., 1986; Senju and Johnson, 2009), which further impacts their ability to observe and copy actions of others. We delivered the yoga intervention within an imitation context, i.e. children were required to observe and copy the actions of the trainer. Additionally, the trainers would continuously monitor the child throughout the session and give explicit instructions to the child to look at her and copy her actions. Hence, the inherent imitation-context of our training might have improved the social monitoring and turn taking abilities of children resulting in improved imitation of novel as well as training-specific actions following the training. Similar to our study, Radhakrishna (2010) reported better imitation of the yoga poses, breathing exercises, vocalizations, and oro-facial movements as well as increased eye-to-eye gazes with the social partners following an intensive 10- to 20-month yoga intervention. Lastly, our analysis of the affective states of children indicated that children showed high levels of interest throughout the training sessions indicating that the training activities were age-appropriate and highly engaging for children. Additionally, the trainers were friendly, and they ensured a motivating and encouraging environment for the child. So, we believe that this inherently enjoyable training context further motivated the children to continue practicing the training activities without losing focus and eventually getting better at it. In all, movement-based interventions delivered within an
imitation context are equally effective as the traditional interventions in improving the imitation skills of children with ASD for familiar and unfamiliar actions.

2.4.3 Limitations of the Study

One of the main limitations of the current study is the lack of a control group. We have attempted to address this limitation by monitoring the performance of children on standardized tests during the course of a brief, 2-week no-intervention period. Our results indicated that there were no significant changes in the performance of children during the course of the no-intervention period. However, we would like to acknowledge that we noticed slight improvements in the performance after the 2-week period which could be argued to multiply over the course of 8 weeks. At this stage, we are unable to address this limitation and would suggest future investigations in this area. Secondly, we were unable to determine the maintenance of gains in the motor and imitation skills of children following the intervention due of lack of a follow-up session after the completion of the study. Thirdly, our sample size was relatively small with a mix of high and low functioning children resulting in a comparatively heterogeneous study sample. Lastly, our training duration was relatively shorter compared to other intensive yoga interventions. We tried to address this limitation by increasing the intensity of training sessions, i.e. 4 sessions/ each week (2 expert and 2 parent sessions). However, we were unable to control the variability in the number of home sessions received by each child.
2.5 Conclusions

The current study explored the effects of a movement-based, yoga intervention on the motor and imitation skills of children with ASD between 5 and 12 years of age. Our study indicated that an 8-week yoga intervention could lead to generalized and training-specific improvements in the gross motor and the imitation skills of children. Additionally, the current study provided social validity of the intervention from the parents participating in the study. To our best knowledge, this is the first study systematically examining the effects of yoga intervention on the motor and imitation skills of children with ASD using standardized and training-specific measures. Overall, we suggest that whole-body motor interventions could be promising tools to improve the motor skills of children with ASD, which are unequivocally impaired in this population.
Chapter 3

EFFECTS OF YOGA INTERVENTION ON COMMUNICATION, JOINT ATTENTION, AND BEHAVIORAL SKILLS OF CHILDREN WITH AUTISM SPECTRUM DISORDER (ASD)

3.1 Introduction

According to the Diagnostic and Statistical Manual of Mental Disorders (DSM- V), the two core diagnostic impairments of Autism Spectrum Disorder (ASD) include impaired social communication skills and presence of restricted and repetitive behaviors (American Psychiatric Association (APA), 2013). Specifically, the communication impairments include delayed acquisition of language, difficulty understanding and responding to conversations with others, as well as engagement in self- or one-sided conversations (Eigsti et al., 2011; Landa, 2007; Lord et al., 2000; Loukusa and Moilanen, 2009; Tager-Flusberg et al., 2005). The social impairments in ASD include reduced eye contact and gaze monitoring, as well as reduced sharing of interests and enjoyment with others through joint attention (Dawson et al., 2004; Leekam et al., 1998; Mundy et al., 1986; Senju and Johnson, 2009). Specifically, Joint Attention is the ability to share attention with others through eye contact and gestures and is among the core social deficits in children with ASD (Charman, 2003; Mundy and Newell, 2007; Sullivan et al., 2007). Restricted and repetitive behaviors include stereotypical/ repetitive body movements with and without objects, as well as desire for sameness by resisting any
changes in their routines and schedules (Leekam et al., 2011; Lewis and Bodfish, 1998; Turner, 1999). Below, we have provided a detailed discussion of the communication, joint attention, and restricted and repetitive behaviors of children with ASD.

3.1.1 Communication Impairments in ASD

Communication impairments are universal in children with ASD, but the severity varies tremendously from non-verbal to highly fluent children (Eigsti et al., 2011; Tager-Flusberg et al., 2005; Tager-Flusberg and Caronna, 2005). Specifically, around 25% of children with ASD never achieve functional speech, whereas on the other hand, few children develop fluent speech comparable to age-matched typically developing (TD) children (Luyster et al., 2008; Tager-Flusberg et al., 2005; Thurm et al., 2007). Communication impairments in ASD could broadly be discussed under 2 categories- 1) impairments in receptive language (i.e. difficulty comprehending speech) and 2) impairments in expressive language (i.e. difficulty producing speech), with evidence suggesting greater deficits in the receptive compared to the expressive language of children with ASD (Charman et al., 2003; Hudry et al., 2010). To elaborate, preschoolers with ASD between 2 and 5 years showed greater deficits in the receptive language compared to the expressive language as assessed through direct clinical observations as well as through parent-reported measures of communication skills (Hudry et al., 2010). Further, the expressive language impairments of children with ASD, are observed in both initiating the speech, i.e. spontaneous language, and responding to the questions and comments of others, i.e. responsive language (Capps et al., 1998; Condouris et al., 2003;
Specifically, in terms of spontaneous language, children with ASD showed a very low frequency of self-initiated communicative acts ranging from 3 to 4 times / hour during a usual classroom setting (Stone and Caro-Martinez, 1990). Additionally, majority of the spontaneous communicative acts of children in the study were directed to the teacher compared to the peers, with almost half of the children never initiating a speech towards their peer (Stone and Caro-Martinez, 1990). In terms of responsive language, children with ASD responded less frequently to the questions and comments of an examiner compared to the language age and IQ-matched children with other disabilities such as Developmental Delays (Capps et al., 1998). Another peculiar communication, commonly observed in children with ASD is echolalia, i.e. the repetition of words and phrases of others. It could be immediate echolalia, i.e. repeating words just spoken by others, or delayed echolalia, i.e. repeating words from a TV show or past conversation (Prizant et al., 1981; Prizant and Rydell, 1984; Tager-Flusberg and Caronna, 2005). Previously, echolalia was considered as a highly non-functional speech of children, however, current literature suggests that echolalia in some children help convey requests, comments, or gives time to process language (Prizant et al., 1981; Prizant and Rydell, 1984). Overall, children with ASD show significant deficits in various aspects of verbal communication skills, including impaired receptive and expressive language, as well as presence of echolalia or repetition of others speech.
3.1.2 Joint Attention in ASD

Joint attention is the ability to share attention with others regarding any objects or events in the environment through eye gaze or pointing, e.g. a child directing the parents’ attention towards a toy in the shop by pointing towards the toy (Mundy and Newell, 2007). Joint attention is an essential developmental skill emerging during the first year of life and has significant effect on the future social learning and language skills of children (Charman, 2003; Loveland and Landry, 1986; Mundy et al., 1990). There is overwhelming evidence of impaired joint attention in ASD such that poor joint attention such as inability to follow the eye gaze or pointing gestures of others could easily differentiate young toddlers and children with ASD from mental-age matched developmental delay and TD children (Bean and Eigsti, 2012; Dawson et al., 2004; Leekam et al., 1998; MacDonald et al., 2006; Sullivan et al., 2007). Joint Attention is usually categorized as, 1) spontaneous, which involves initiating an attentional bid by directing the attention of others towards an object or event, e.g. a child saying ‘look at that picture’ to a peer, and 2) responsive, which involves acknowledging to the attentional bid initiated by others, e.g. peer looks at the picture (Mundy and Newell, 2007). Children with ASD show impairments in both spontaneous and responsive joint attention, such that young preschoolers of 3.5 years with ASD made fewer attempts to initiate the bids as well as responded less frequently to the bids initiated by the examiner during a standardized test of joint attention skills (Dawson et al., 2004). Similarly, children with ASD between 7 and 17 years responded less frequently to the bids initiated by the
examiner on a standardized test of responsive joint attention compared to age and IQ-matched TD children (Bean and Eigsti, 2012). Further, clinical research suggests that children with ASD have greater difficulties in spontaneous or self-initiated joint attention compared to responsive joint attention (MacDonald et al., 2006; Mundy and Newell, 2007). Specifically, 2 to 4 years old children with ASD showed fewer deficits while responding to an examiner’s pointing bid, whereas on the other hand, they were severely impaired in initiating a bid through pointing or eye gaze (MacDonald et al., 2006). Lastly, joint attention bids could be labeled as, i.e. 1) gestural bids if initiated using gestures or eye contact, e.g. pointing to a picture on the wall, and 2) verbal bids if initiated by providing a verbal label, e.g. look at that painting on the wall. Children with ASD are documented to perform poorly on both the gestural and verbal joint bids initiated by a tester compared to age-matched TD children on a standardized test of joint attention (Bean and Eigsti, 2012). Overall, children with ASD show significant impairments in initiating and responding to the verbal and gestural joint attention bids compared to age-matched TD children.

3.1.3 Restricted and Repetitive Behaviors in ASD

Restricted and repetitive behaviors (RB’s) including repetitive body movements, inflexible routines, and desire for sameness are among the hallmark impairments in children with ASD (Bodfish et al., 2000; Lam et al., 2008; Leekam et al., 2011; Lewis and Bodfish, 1998; Richler et al., 2007; Turner, 1999). These behaviors are especially debilitating for the child as they impede opportunities to learn from the environment and
impact the overall social, communication, and adaptive functioning of children (Bopp et al., 2009; Gabriels et al., 2005; Honey et al., 2007). In fact, atypical RB’s could be observed as early as 12 months in infants who are later diagnosed with ASD (Elison et al., 2014; Damiano et al., 2013; Ozonoff et al., 2008; Wolff et al., 2014). Specifically, parents indicated high rates of RB’s on Repetitive Behavior Scale- Revised (RBS-R) for their infants at 12 months who were later diagnosed with ASD at 24 months. Further, high rates of RB’s in children diagnosed with ASD at 24 months negatively correlated with their adaptive behaviors and socialization skills (Wolff et al., 2014). Similarly, children with ASD showed repetitive exploration of objects at 12 months including greater spinning, rotating, and visual exploration compared to age-matched TD infants (Ozonoff et al., 2008). RB’s in children with ASD encompasses a broad range of behaviors and some studies have categorized RB’s into, 1) restricted interests and inflexible routines (or high level behaviors), and 2) repetitive motor mannerisms (or low level behaviors) (Leekam et al., 2011; Richler et al., 2007; Turner, 1999; South et al., 2005). Specifically, the restricted or high level behaviors include interest in certain activities or topics such as recycling or angry bird cartoons, and inflexible routines such as wearing certain cloth or eating certain food. On the other hand, the repetitive or low level behaviors include repetitive motor mannerisms such as finger flicking and body rocking, and/ or repetitive object use such as spinning wheels or banging rattle. Further, apart from the above mentioned RB’s, children with ASD exhibit various other challenging and negative behaviors such as self-injurious behaviors, aggression towards others, non-compliance, and temper tantrums (Hartley et al., 2008; Matson and Nebel-
Schwalm, 2007). There is evidence to suggest that RB’s in subjects with ASD varies with the age and the IQ of subjects (Bishop et al., 2006; Esbensen et al., 2009; Moore and Goodson, 2003; Richler et al., 2010). A large cross-sectional study of RB’s across the life span of individuals with ASD between 2 and 62 years indicated that both the frequency and severity of RBs including stereotyped movements, self-injurious behaviors, restricted interests, and compulsive behaviors is fewer in older individuals compared to younger individuals with ASD (Esbensen et al., 2009). Similarly, another study examining the role of IQ on RB’s, indicated that the frequency of RB’s did not vary with the non-verbal IQ for young toddlers with ASD under 36 months of age, whereas for older children with ASD between 3 and 12 years, the frequency of RBs strongly correlated with the non-verbal IQ such that children with low IQ showed greater RB’s including the repetitive use of objects (Bishop et al., 2006). Overall, restricted and repetitive behaviors are prevalent among children with ASD but the frequency and severity of behaviors varies among children based on the age, level of functioning, and IQ of children.

3.1.4 Traditional Interventions for ASD

The majority of the intervention approaches for children with ASD follow principles of Applied Behavioral Analysis (ABA), a behavioral science aimed at improving the socially significant behaviors of children and adults with and without disabilities (Baer et al., 1968; Foxx, 2008; Matson et al., 2012). The primary focus of ABA therapies in children with ASD is to improve the social communication skills and facilitate positive behaviors in children. Various teaching techniques have been developed using the aforementioned ABA principles including a very traditional Discrete Trial Training
which focuses on highly-structured adult-led training, and on another hand, a comparatively contemporary Incidental teaching focusing on promoting child-initiated skills and behaviors (Lovaas, 1987; Smith, 2001; Vismara and Rogers, 2010). Two other popular ABA-led interventions include Picture Exchange Communication System which focuses on improving the communication of children using pictures and Treatment and Education of Autistic and Communication Handicapped Children which focuses on use of structured environment, and routines to teach new skills to children (Bondy and Frost, 2003; Mesibov et al., 2004). Overall, several approaches targeting the social communication and behavioral skills of children with ASD exist, however there is limited research on facilitating the motor skills of children. Given, the overwhelming evidence for motor impairments in children with ASD, we believe that socially-embedded movement interventions could improve the motor as well as the social communication skills of children with ASD. In the current study, we explored the effects of a movement-based, yoga intervention on the core social communication and behavioral skills of children with ASD.

3.1.5 Yoga Intervention for ASD

Yoga, also referred to as mind-body intervention has gained popularity in the recent years as a complementary and alternative therapy for children with and without special needs (Barnes et al., 2008). Yoga is increasingly being implemented in various school settings due to its cost-effectiveness and multiple effects on the physical and mental health of children (Beauchemin et al., 2008; Birdee et al., 2009; Galantino et al., 2008;
Peck et al., 2005; Powell et al., 2008; Serwacki and Cook-Cottone, 2012; White, 2012). Specifically, for children with ASD, there is some anecdotal evidence for the positive effects of yoga intervention on reducing the maladaptive behaviors of children (Goldberg, 2004; Koenig et al., 2012; Rosenblatt et al., 2011). Specifically, 16 weeks of classroom yoga including breathing, poses, relaxation, and chanting reduced the maladaptive behaviors such as irritability, lethargy, and hyperactivity in children with ASD as measured by a teacher-rated behavior checklist, Aberrant Behavior Checklist (ABC), with no improvements in the control group involved in the usual morning class routine (Koenig et al., 2012). Similarly, 8-weeks of integrated intervention including yoga, music, and dance in children with ASD indicated positive effects on various subscales of two parent-rated behavior checklists including the Atypicality, Depression, and Irritability subscales (Rosenblatt et al., 2011). Although, the evidence is limited for children with ASD, there is overwhelming evidence from TD children and children with attentional or learning disorders suggesting positive effects of yoga on improving the attentional focus, reducing the disruptive and negative behaviors, overcoming stress and social anxiety, as well as improving the spatial memory of children (Beauchemin et al., 2008; Bernardi et al., 2001; Ehlinger et al., 2010; Harrison et al., 2004; Kenny 2002; Khalsa et al., 2013; Koszyckia et al., 2007; Peck et al., 2005; Powell et al., 2008; White, 2012).

In terms of social and communication skills, there is no evidence to suggest the direct effects of yoga on the social communication of children with and without ASD. However,
there is evidence to suggest that behavioral changes following yoga such as reduction in anxiety and stress can reduce social phobias and promote engagement in social interactions for healthy, TD children or children with attentional deficits (Koszyckia et al., 2012). In addition, relaxed and calm children are less likely to strain their interpersonal relationships; which could improve their social functioning or relationships with others (child-parent, child-friend relationships) (Beauchemin et al., 2008; Harrison et al., 2004). Further, qualitative reports of yoga teachers working with children with ASD suggested that yoga training increased the spontaneous attempts for socialization such as increased social proximity, smiling, and vocalizations by children with ASD (Ehlinger et al., 2010; Kenny 2002; Radhakrishna et al., 2010). Taken together, yoga could be an effective tool for improving the behavioral and social communication skills of children. However, clear lack of empirical studies limits the use of yoga in children with ASD. Moreover, majority of the yoga studies in children with ASD evaluated the behavioral skills of children using parent- or teacher-rated questionnaires versus use of standardized clinical measures and detailed behavioral coding schemes. Therefore, the primary goal of the current study was to systematically examine the effects of socially-embedded, yoga intervention on the social communication, maladaptive behaviors, and motor skills of children with ASD. We have used standardized assessments and detailed behavioral coding schemes to evaluate the performance of children following the intervention. Additionally, we monitored the training via use of training logs, fidelity checklist, as well as exit questionnaires (see Methods section for details).
3.1.6 Aims and Hypotheses of the Study

The primary goal of the current study was to examine the training-related changes in the communication, joint attention, maladaptive behaviors, and affective states of children with ASD between 5 and 12 years of age following 8-weeks of socially-embedded yoga intervention. The training-related changes were determined by comparing the child’s performance between the pretest and posttest session conducted before and after the study, as well as between the first and last training sessions. The secondary goal of the study was to examine the training activity-related changes in the communication, maladaptive behaviors, and affective states of children with ASD between 5 and 12 years of age. The activity-related changes were assessed by comparing the child’s performance across the different training activities performed within a session.

The specific aims of the study are listed below:

**Aim 1**: To examine the changes in the responsive joint attention bids of children with ASD using a standardized assessment, Joint Attention Test (JTAT) during the pretest and the posttest sessions.

**Hypothesis 1**: Training-related changes: We hypothesized that children with ASD would show increased response to the joint attention bids initiated by the tester during the posttest compared to the pretest sessions.

**Aim 2**: To examine the changes in the communication skills of children with ASD during the early (session 1), mid (8), and late (16) training session.
**Hypothesis 2a: Training-related changes:** Children with ASD would increase the total time spent in verbalizing/vocalizing with the trainer and reduce the time spent in echolalia or self-talk in the late training compared to mid and the early training session.

**Hypothesis 2b: Activity-related changes:** Within each training session, children would show greater percent duration of verbalizations/vocalizations during activities promoting social interactions such as hello and bye songs and fewer percent duration of verbalization during activities promoting whole body movements such as poses and partner poses.

**Aim 3:** To examine the changes in the maladaptive behaviors of children with ASD during the early, mid, and late training session.

**Hypothesis 3a: Training-related changes:** We hypothesized that children with ASD would reduce the frequency of maladaptive behaviors such as body stereotypies, sensory behaviors, and non-compliance during the late compared to the mid and early session.

**Hypothesis 3b: Activity-related changes:** Within each training session, we expected children to show fewer maladaptive behaviors during seated activities such as breathing and relaxation, and greater frequency of maladaptive behaviors during mobile activities such as poses and eye-gaze training activities.

**Aim 4:** To examine the changes in the affective state of children of ASD during the early, mid, and late training session.
Hypothesis 4a: Training-related changes: Children with ASD would show increased or similar percent duration of interested and positive affect during the late compared to the mid and early training session.

Hypothesis 3b: Activity-related changes: Within each training session, we expected children to show greater interested and positive affect for easier activities such as hello/bye songs and relaxation, and greater negative affect for challenging activities such as poses and eye gaze training activities.

3.2 Methods

3.2.1 Research Design and Study Timeline

We used a single group pre-posttest study design to assess the efficacy of yoga intervention on the motor, social communication, and behavioral skills of children with ASD. We improvised the study design in order to address the internal validity threats associated with a single group study design such as the testing threat (Dimitrov and Rumrill, 2003). Specifically, we introduced a repeat pretest session in the study, i.e. children participated in two pretest sessions within a 2-week period (Table 3.1). The repeat pretest session was introduced to monitor the changes in child’s performance due to repetition or familiarization with the testing activities, in the absence of intervention. Ideally, true intervention effects would be indicated by similar performance across the two pretest sessions, whereas improved performance from both the pretest sessions to the posttest session.
The study lasted for 12 weeks including two pretest sessions repeated within a 2-week period followed by 8-weeks of yoga intervention, and a posttest session in the last week (Table 3.1). The testing session included a standardized test of Joint Attention. The intervention included 16 yoga sessions with two sessions each week over an 8-week period. In addition, parents were asked to deliver two yoga sessions at home each week. Additionally, we included three training-specific measures, i.e. verbalization, affect, and maladaptive behaviors during the first, mid, and late training sessions.

**Table 3.1: Study Timeline.**

<table>
<thead>
<tr>
<th>Pretest</th>
<th>Repeat Pretest</th>
<th>Intervention</th>
<th>Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Week 1)</td>
<td>(Week 3)</td>
<td>(Week 4-11)</td>
<td>(Week 12)</td>
</tr>
<tr>
<td>Joint Attention Test</td>
<td>Joint Attention Test</td>
<td>8-weeks of yoga intervention</td>
<td>Joint Attention Test</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Training-specific measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Verbalization/ vocalization</td>
</tr>
<tr>
<td>2. Affective States</td>
</tr>
<tr>
<td>3. Maladaptive Behaviors</td>
</tr>
</tbody>
</table>

### 3.2.2 Participants

Twelve children with ASD (11 boys and 1 girl) between 5 and 12 years (Mean ± SE = 7.77 ± 0.49 years) received the intervention (Table 3.2). The greater number of boys in the study is not surprising as the prevalence rate of ASD is 5 times greater in males than females (CDC, 2014). The sample size was finalized by conducting power analysis from the preliminary results of two children with ASD who underwent the yoga intervention. Participants were recruited from the Delaware and Maryland areas distributing fliers in
the local schools and online postings on the autism websites. The eligibility for the study was determined by the following criteria:

\textit{a) Social Communication Questionnaire (SCQ):} SCQ is a parent-reported, 40-item questionnaire that screens for autism-specific social communication impairments (Rutter et al., 2003). A cut-off score of 15 or greater was reported in 8 out of the 12 children indicating significant impairments in social communication skills (Table 3.2). The eligibility for the remaining four children was confirmed after administrating the Autism Diagnostic Observation Schedule- Second Edition (see below).

\textit{b) Autism Diagnostic Observation Schedule- Second Edition (ADOS-2):} ADOS-2 is a gold standard assessment for autism diagnosis and involves a semi-structured play for assessing social interaction, and repetitive/ restricted behaviors of children (Lord et al., 2012). The scoring of ADOS-2 provides a comparison score of 1-10 to gauge the severity of disorder with higher score indicating greater severity of disorder. Autism diagnosis was confirmed for all 12 children with comparison score ranging from 5 to 10 indicating moderate to high severity of disorder (Table 3.2).

Our exclusion criteria included children with additional impairments such as hearing/ vision impairments, orthopedic/ neurological/ cardiopulmonary conditions, or significant developmental delays. Additionally, the children had to demonstrate the ability to engage in the testing and training activities, hence children with challenging behaviors such as aggression, non-compliance, temper tantrums, or attentional deficits were excluded as it
affected their ability to complete the sessions. Four additional children were excluded from the study based on the above-mentioned exclusion criteria. All parents signed the consent form and children signed the assent form approved by the Institutional Review Board at the University of Delaware before participating in the study. Based on the socioeconomic scores (Mean ± SE = 56.54 ± 2.20; Table 3.2), the families belonged to the middle (n = 1), upper-middle (n = 9), or upper class (n = 2) with Asian (n = 5) or Caucasian (n = 7) ethnicity (Hollingshead, 1975). The comparatively higher proportion of Asian families in the current study could be attributed to the greater familiarity and popularity of yoga among Asian families.

Table 3.2: Participant Demographics.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Age: Gender</th>
<th>SCQ</th>
<th>ADOS-2</th>
<th>SES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Score</td>
<td>Severity</td>
</tr>
<tr>
<td>Child 1</td>
<td>10.46: M</td>
<td>21</td>
<td>10</td>
<td>High</td>
</tr>
<tr>
<td>Child 2</td>
<td>6.29: M</td>
<td>5</td>
<td>6</td>
<td>Moderate</td>
</tr>
<tr>
<td>Child 3</td>
<td>8.07: M</td>
<td>17</td>
<td>9</td>
<td>High</td>
</tr>
<tr>
<td>Child 4</td>
<td>9.52: M</td>
<td>16</td>
<td>10</td>
<td>High</td>
</tr>
<tr>
<td>Child 5</td>
<td>7.23: M</td>
<td>7</td>
<td>8</td>
<td>High</td>
</tr>
<tr>
<td>Child 6</td>
<td>6.95: M</td>
<td>11</td>
<td>10</td>
<td>High</td>
</tr>
<tr>
<td>Child 7</td>
<td>7.66: M</td>
<td>16</td>
<td>8</td>
<td>High</td>
</tr>
<tr>
<td>Child 8</td>
<td>5.48: F</td>
<td>11</td>
<td>8</td>
<td>High</td>
</tr>
<tr>
<td>Child 9</td>
<td>7.22: M</td>
<td>16</td>
<td>8</td>
<td>High</td>
</tr>
<tr>
<td>Child 10</td>
<td>11.01: M</td>
<td>19</td>
<td>5</td>
<td>Moderate</td>
</tr>
<tr>
<td>Child 11</td>
<td>7.03: M</td>
<td>23</td>
<td>10</td>
<td>High</td>
</tr>
<tr>
<td>Child 12</td>
<td>6.36: M</td>
<td>22</td>
<td>9</td>
<td>High</td>
</tr>
</tbody>
</table>

M = Male, F = Female, SCQ = Social Communication Questionnaire, ADOS-2 = Autism Diagnostic Observation Schedule- 2nd Edition, SES = Socioeconomic Status
3.2.3 Training Protocol

We delivered 8-weeks of yoga intervention with 2 sessions per week (total 16 sessions) and each session lasting 50-60 minutes. The training sessions involved a triadic context, i.e. a child with ASD, an expert trainer, and an adult model (Figure 3.1). The expert trainer is a pediatric physical therapist and a graduate student at University of Delaware. She was responsible for conducting the session and guiding the child through the activities. The adult models are undergraduates at University of Delaware and their role was to act as a buddy for the child with ASD as well as help the expert trainer in delivering the sessions. All models received at least 6 hours of training in the form of instructional manuals and videos before participating in the intervention. Additionally, to ensure training fidelity, a novel coder coded three randomly-picked sessions for each child to monitor the trainers’ adherence to the protocol as well as completion of all the critical activities of the session (see Appendix A for Fidelity Checklist). The results indicated that the trainers followed the protocol and completed the critical activities for majority of the training sessions (Mean ± SE = 94.63 ± 0.74 %).

The parents were provided with instructional cds and manuals to deliver two additional sessions at home each week. Additionally, the expert trainer provided a brief training to the parents regarding the home sessions and provided all the necessary materials such as yoga mats and props required to conduct the sessions. The expert trainers and parents maintained a log of the total number of sessions completed for the child. All children completed the 16 expert training sessions, except one child who
completed 8 sessions. In terms of parent sessions, 10 out of total 12 parents filled the training logs and the number of home sessions ranged from 4 to 16 sessions.

3.2.3.1 Training Principles and Goals

We based our training on the principles of autism interventions including Applied Behavioral Analysis (ABA; Lovaas, 1987), Teaching and Education of Autistic and Related Communication Handicapped Children (TEACHH; Mesibov et al., 2004), and Picture Exchange Communication System (PECS; Bondy & Frost, 2003), and motor learning principles (Luft and Buitrago, 2005; Schmidt and Lee, 1988). Specifically, we ensured consistency in session location and people involved, used picture schedules to facilitate transitions between activities and offer choice between activities, provided graded prompting from low-level (visual or verbal) to high-level prompts (hand-on-hand assistance), repeated activities to ensure learning, and lastly provided positive

![Figure 3.1: Yoga training session indicating a triadic context between an expert trainer, model, and a child with ASD.](image)

3.2.3.1 Training Principles and Goals

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reinforcement such as gestural or verbal praise. Our goal was to facilitate the gross motor skills such as balance, flexibility, strength, and imitation, social skills such as social proximity, eye gaze, and co-operative play, communication skills including verbal (commenting, responding, singing) and non-verbal gestural use (showing, pointing), and lastly, behavioral skills such as alertness, attention, and relaxation.

3.2.3.2 Training Activities

We included traditional yoga activities such as breathing, poses, partner poses, and relaxation, as well as activities specifically catering to the needs of children with ASD such as greetings, contact, and looking games. The order of activities followed during each session was- Hello song, Contact, Breathing, Looking, Poses and Partner poses, Relaxation, and lastly Bye song (Table 3.3). We made several attempts to make the yoga training activities fun and creative for children, i.e. by incorporating music-based songs, stories, and games within the sessions. Musical activities are inherently enjoyable for children, especially for children with ASD who have better understanding of musical notes and pitch perception (Heaton, 2003; Heaton et al., 1999). Additionally, we used various props during the to provide an appropriate context to the child such as straws and thermo balls during the breathing activities.
Table 3.3: Activities Practiced within Yoga Session.

<table>
<thead>
<tr>
<th>Activities</th>
<th>Description</th>
<th>Goals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hello</td>
<td>Greeting by singing a song together.</td>
<td>Prepares child for the session and promotes social verbalization and verbal synchrony with trainers.</td>
</tr>
<tr>
<td>Contact</td>
<td>Social games such as passing a ball, forming shapes together, or trusting games.</td>
<td>Facilitates social bond or connection between the child and the trainers by promoting social proximity and safe social distance.</td>
</tr>
<tr>
<td>Breathing</td>
<td>Breathing exercises such as sucking through a straw, nostril breathing, bee sound breathing.</td>
<td>Facilitates rhythmic and slow breathing patterns for promoting alertness, relaxation, and self-regulation during stressful conditions.</td>
</tr>
<tr>
<td>Looking</td>
<td>Eye-gaze training through isolated eye or head turns on trainer’s command such as look at the moving hand/ball.</td>
<td>Improves social attention of the child towards stationary and moving, social and non-social stimuli.</td>
</tr>
<tr>
<td>Poses</td>
<td>Postures varying in starting positions (lying, sitting, standing), complexity (simple, complex).</td>
<td>Improves balance, strength, flexibility, and coordination between body segments.</td>
</tr>
<tr>
<td>Partner poses</td>
<td>Child and trainer perform the poses together.</td>
<td>Improves social synchrony, and trust on the social partner.</td>
</tr>
<tr>
<td>Relaxation</td>
<td>Still lying with pre-recorded verbal imagery in the background.</td>
<td>Promotes relaxation, calming, and improve the attentional focus of the child.</td>
</tr>
<tr>
<td>Bye</td>
<td>Bidding farewell by singing a song together.</td>
<td>Promotes social verbalization and verbal synchrony with trainers.</td>
</tr>
</tbody>
</table>

3.2.4 Testing Protocol

3.2.4.1 Testing Measures

We included a standardized test, *Joint Attention Test (JTAT)* to assess the generalized changes in the responsive joint attention following the intervention (Bean and
Eigsti, 2012). JTAT is used for individuals between 7 and 17 years to assess the responsive joint attention skills for naturalistic bids initiated by the tester. The test was administered by a novel tester during the pretest, repeat pretest, and the posttest session. The child was seated across the tester and the tester initiated 9 different naturalistic bids, including 4 verbal (e.g. Look at that!) and 5 gestural (e.g. waving hand to say bye) to elicit the child’s attention. Each bid was offered at three different levels of cue, 1) Level 1 Cue- bid initiated with minimal cues, e.g. ‘Look at that!’ , 2) Level 2 Cue- bid initiated after explicitly calling the child’s name, e.g. ‘Hey Joey! Look at that!’ , 3) Level 3 Cue- bid initiated after explicitly calling the child’s name and labeling the object of tester’s attentional focus, e.g. ‘Hey Joey! Look at painting! (see Appendix F). A higher cue level (Level 2 or 3) was offered only if the child was unable to respond to the lower level cue. In terms of missing data, 1 child was unable to participate in the posttest session, hence we are reporting on the JTAT data for 11 children.

We included three training-specific measures, Verbalization/vocalizations, affective states, and maladaptive behaviors to assess the training-related and activity-related changes in the social communication and behavioral skills of children during the intervention. We coded the full duration of early (session 1), mid (8), and the late (16) training session for all the training-specific measures. In terms of missing data, 1 child was non-verbal, so we are reporting on 11 children for the verbalization data, and 12 children for the affective states and maladaptive behaviors.
3.2.4.2 Behavioral Coding

All testing and training sessions were videotaped for behavioral coding. Following are the details for the behavioral coding and the reliability of the testing measures. Pearson’s correlations were conducted to establish intra-rater reliability of > 90% and inter-rater reliability of > 80% for 25% of the dataset for all the study variables.

**a) Raw Score for JTAT:** Each verbal and gestural JTAT bid was scored based on the following criteria, 1) correct action- if the child accurately responded to the bid, e.g. for ‘waving bye’, child raises his/her hand to wave bye to the tester, 2) looking at the face/ appropriate direction- child looked at the direction of tester’s attentional focus, e.g. if the tester looked at a painting on the wall while verbalizing ‘look at that’, child responded by looking at the painting, 3) eye contact- child made an eye contact with the tester while responding to the bid, and 4) verbal response- child responded to the tester by producing verbiage related to the bid. Child was given a score for each of the above mentioned criteria and then we calculate the total verbal and gestural score by summing the raw scores across all the verbal and gestural bids. Greater scores would indicate better performance.

We also coded the cue level at which the child responded to the JTAT bids, i.e. Level 1, 2, or 3, with higher score assigned to a lower level of cue. We have summed the level of cue across the verbal and gestural bids to obtain a total verbal and gestural cue level, with higher score indicating better performance.
b) Percent Duration of Verbalization/Vocalizations: We coded the entire duration of the early, mid, and late training session to assess the time spent by the child in verbalizing/ vocalizing. A behavioral coding software, Datavyu was used to code the start and stop time for each verbalization/ vocalization bout produced by the child during the training session (Datavyu Team, 2014). Specifically, we coded for social verbalizations/ vocalizations by the child, i.e. words, phrases, sentences, and vocalizations (e.g. humming, breathing, and laughing sounds) directed towards the social partners i.e. the trainer, the model, or the parent. It was further characterized as spontaneous (i.e. initiated by the child) or responsive (i.e. in response to the social partners in the session). We also coded for self-directed speech, i.e. verbalization/ vocalization initiated without any prompts from the social partners. It also included bouts of immediate or delayed echolalia, where children repeated the words of the social partners or remembered something from a different context. The Datavyu coded files were run through a custom made Matlab program to calculate the percent duration of spontaneous social, responsive social, and self-directed verbalization/ vocalization within the training sessions.

c) Percent Duration of Affective States: We examined the child’s affect, i.e. positive, negative, and interested affect during the early, mid, and late session using the Datavyu software. Specifically, the positive affect included time spent smiling, negative affect indicated time spent pouting, frowning, yelling, and the interested affect indicated time spent on-task without expressing positive or negative affect. The
Datavyu coded files were run through a custom made Matlab program to calculate the percent duration of positive, negative, and interested affect.

**d) Frequency of Maladaptive Behaviors:** We coded the frequency of maladaptive behaviors including the stereotyped, sensory, and negative behaviors demonstrated by the child during the early, mid, and late training session. Specifically, the stereotyped behaviors included repetitive and stereotypical body movements (e.g. hand flapping, body rocking, shaking, bouncing), the sensory behaviors included behaviors demonstrated to seek or avoid visual, auditory, oral, and tactile sensations (e.g. chewing objects, smelling or sniffing, covering ears), and lastly, the negative behaviors included behaviors which interfered with child's participation during the session such as bouts of non-compliance (e.g. outbursts, crying, yelling, meltdowns), self-injurious and aggressive behaviors (e.g. hitting, biting, kicking), inappropriate social conduct/ distance, as well as repetitive use of language.

**3.2.4.3 Statistical Analysis**

To examine the effects of training on JTAT, we conducted two separate Repeated Measures Analysis of Variance (ANOVA), one for JTAT scores and another for JTAT cue level with bid type (Verbal, Gestural) and testing session (Pretest, Repeat Pretest, Posttest) as the within-subjects factor. For the training-specific measures, we conducted three separate Repeated Measures ANOVA with behavior type (*Verbalization/vocalization types: spontaneous social, responsive social, self; Affect types: positive, negative, interested; Maladaptive behavior types: stereotyped, sensory, negative*),
training activity (greetings which included the hello and bye, contact, breathing, looking, poses, relaxation), and training session (early, mid, late) as the within subjects’ factors. We checked our data for parametric assumptions using the Mauchly’s Test of Sphericity and Greenhouse-Geisser corrections were applied in case of violations. The significance was set at $p \leq 0.05$ and the training effects were further examined using post-hoc, dependent $t$-tests with Bonferroni corrections applied for multiple comparisons. In case of Bonferroni corrections, we considered $p$-values $\leq 0.05$ as statistical trends. Additionally, we are reporting on the individual data for all the dependent measures of the study.

### 3.3 Results

#### 3.3.1 Training-Related Changes in JTAT

We examined the generalized effects of yoga intervention on the responsive social attention of children with ASD across three testing sessions- i.e. the pretest, the repeat pretest, and the posttest session. The Repeated measures ANOVA for JTAT raw scores was not significant and indicated that children responded similarly to the verbal (pretest $= 11.73 \pm 0.94$, repeat pretest $= 10.36 \pm 1.22$, posttest $= 11.91 \pm 1.25$) and the gestural bids (pretest $= 11.09 \pm 0.67$, repeat pretest $= 11.09 \pm 0.58$, posttest $= 11.46 \pm 0.89$) initiated by the tester during the three testing sessions.

However, the ANOVA for the JTAT cue level indicated a significant main effect of testing session ($F(2, 20) = 4.50, p < 0.05$, partial $\eta^2 = 0.31$) and bid type ($F(1, 10) =$...
67.12, \( p < 0.01 \), partial \( \eta^2 = 0.87 \). The post-hoc t-tests for the main effect of testing session showed that children with ASD responded at a lower cue level during the posttest session compared to the two pretest sessions, with no differences between the two pretest sessions (\( p \)-values < 0.02 after Bonferroni corrections, Figure 3.2). Similarly, the post-hoc tests for the main effect of bid type indicated that children responded accurately to the gestural bids at a lower cue level compared to the verbal bids (\( p < 0.05 \), Figure 3.3). In terms of individual data, 6-9 out of total 11 children responded to the JTAT bids at a lower cue level in the posttest compared to the two pretest sessions, and 8 out of 11 children required lower cue level to respond to the gestural bids compared to the verbal bids.

**Training-Related Changes in Cue Level of JTAT**

![Graph showing training-related changes in cue level of JTAT bids](image_url)

*Figure 3.2: Effects of yoga intervention on the cue level of JTAT bids. * indicates \( p < 0.02 \)
3.3.2 Training-Related and Activity-Related Changes in Verbalization/ Vocalization

The ANOVA for the verbalization/ vocalization revealed a significant main effect of training session (F (2, 20) = 16.68, \( p < 0.01 \), partial \( \eta^2 = 0.63 \)), verbalization type (F (2, 20) = 34.58, \( p < 0.01 \), partial \( \eta^2 = 0.78 \)), and activity type (F (5, 50) = 30.72, \( p < 0.01 \), partial \( \eta^2 = 0.75 \)), significant 2-way interaction for training session x verbalization type (F (4, 40) = 7.16, \( p < 0.01 \), partial \( \eta^2 = 0.42 \)), training session x activity type (F (10, 100) = 4.09, \( p < 0.01 \), partial \( \eta^2 = 0.29 \)), and verbalization type x activity type (F (10, 100) = 19.69, \( p < 0.01 \), partial \( \eta^2 = 0.66 \)), as well as a significant 3-way training session x

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**Figure 3.3:** The cue level for the verbal and gestural JTAT bids.
* indicates \( p < 0.05 \)
verbalization x activity type interaction (F (20, 200) = 4.06, p < 0.01, partial η² = 0.29).

We further analyzed the two 2-way interactions using post-hoc t-tests, i.e. training session x verbalization type to assess the training-related changes and training session x activity type to assess the activity-related changes in verbalization.

a) **Training-Related Changes**: The post-hoc for training session x verbalization type indicated that the children with ASD increased their responsive verbalization/vocalization towards the social partners during the late compared to the mid and early session (p < 0.05, Figure 3.4). Similarly, children increased their spontaneous verbalization towards the social partners in the late and mid compared to the early session (p between 0.005 and 0.05, Figure 3.4). In terms of individual data, 9-10 out of total 11 children followed the group trend of increased social responsive and spontaneous verbalization following the intervention.

![Training-Related Changes in Verbalization/vocalization](image)

**Figure 3.4**: Effects of yoga intervention on the verbalization/vocalization of children with ASD.
* indicates $p < 0.005$, † indicates $p < 0.05$
b) **Activity-Related Changes:** The post-hoc tests for training session x activity type indicated that children increased their verbalization/ vocalization during the mid and late training session for the contact, breathing, looking, and pose activities, with no changes for the greetings and relaxation activity (Figure 3.5). Specifically, for the contact activities, children with ASD increased their verbalization in the late compared to the early and the mid training session ($p < 0.05$, Figure 3.5). For the breathing activities, children increased their verbalization in the late compared to the early session ($p < 0.05$, Figure 3.5). Lastly, for the looking and pose activities, children increased their verbalization in the mid and late session compared to the early training session ($p$ between 0.003 and 0.05, Figure 3.5). Individual data suggested that 10-11 children followed the group trend of increased verbalization during the contact, breathing, looking, and pose activities.

![Activity-Related Changes in Verbalization/Vocalization](image)

**Figure 3.5:** Effects of yoga intervention on activity-related verbalization of children with ASD.

* indicates $p < 0.003$, † indicates $p < 0.05$
3.3.3 Training-Related and Activity-Related Changes in Affective States

The Repeated Measures ANOVA for the affective states revealed a significant main effect of affect type (F (2, 22) = 2756.59, \( p < 0.01 \), partial \( \eta^2 = 0.99 \)) and activity type (F (5, 55) = 6.13, \( p < 0.01 \), partial \( \eta^2 = 0.36 \)), as well as a significant 2-way affect x activity type interaction (F (10, 110) = 4.47, \( p = 0.01 \), partial \( \eta^2 = 0.29 \)).

a) Training-Related Changes: There were no effects of the training session indicating that children with ASD showed no changes in the positive, negative, and interested affect during the early, mid, and late session (Figure 3.6). However, it was encouraging to see that children showed greater percent duration of interested affect throughout the training with negligible amounts of negative affect (Figure 3.6).

![Affective States Diagram](image)

**Figure 3.6**: Percent duration of affect, i.e. interested, positive, and negative affect shown by children during the training sessions.
b) **Activity-Related Changes:** We analyzed the 2-way affect x activity type interaction using post-hoc t-tests to assess the activity-related changes in the affective states within the training sessions. In terms of the interested affect, children showed relatively greater interested affect for three activities, i.e. relaxation, breathing, and poses. Specifically, children showed greater interested affect for the relaxation compared to the poses, looking, and contact game, as well as greater interested affect for the poses compared to the contact, and lastly, greater interested affect for the breathing compared to the contact activities ($p < 0.001$ after Bonferroni corrections, Figure 3.7). In terms of positive affect, children showed greater positive affect for the contact and the looking compared to the relaxation activities ($p < 0.001$, Figure 3.8). Lastly, for the negative affect, we observed no significant differences in the percent duration of negative affect across the different training activities (Figure 3.9). Individual data suggested 10-12 out of 12 children had similar trends for activity-specific interested and positive affect as the average group trends.
Figure 3.7: Activity-related differences in the interested affect shown by children with ASD during the training sessions.

**Activity-Related Differences in Interested Affect**

Figure 3.8: Activity-related differences in the positive affect shown by children with ASD during the training sessions.

* indicates $p < 0.001$
3.3.4 Training-Related and Activity-Related Changes in Maladaptive Behaviors

The Repeated Measures ANOVA for the maladaptive behaviors indicated a significant main effect of behavior type ($F (2, 22) = 4.72, p < 0.05$, partial $\eta^2 = 0.30$) and activity type ($F (5, 55) = 8.59, p < 0.01$, partial $\eta^2 = 0.44$).

a) Training-Related Changes: There were no significant main or interaction effects of the training session on the maladaptive behaviors of children. In general, children showed greater frequency of sensory behaviors followed by the stereotypical and negative behaviors throughout the training (Figure 3.10).
b) **Activity-Related Changes**: We analyzed the main effect of training activities using the post-hoc t-tests to assess the activity-related changes in the maladaptive behaviors. The t-tests revealed two groups of training activities—1) training activities associated with low frequency of maladaptive behaviors, i.e. greetings, breathing, and relaxation activities, and 2) training activities associated with high frequency of maladaptive behaviors, i.e. contact, looking, and pose activities (Figure 3.11). Specifically, children showed low frequency of maladaptive behaviors in the greeting, breathing, and relaxation compared to the contact and looking activity, as well as low frequency of maladaptive behaviors in the breathing and relaxation compared to the pose activities ($p < 0.003$ after

![Figure 3.10: Frequency of maladaptive behaviors, i.e. sensory, stereotypical, and negative behaviors shown by children during the training sessions.](image)
Bonferroni corrections, Table 3.4). In terms of individual data, 10 out of 12 children followed the group trends.

**Activity-Related Differences in Maladaptive Behaviors**

![Activity-related differences in maladaptive behaviors](Diagram)

*Figure 3.11*: Activity-related differences in the maladaptive behaviors shown by children with ASD during the training sessions.

**Table 3.4**: *P*-values of Activity-Related Comparisons for the Maladaptive Behaviors.

<table>
<thead>
<tr>
<th>Low frequency</th>
<th>High Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Contact</td>
</tr>
<tr>
<td>Greeting</td>
<td>&lt; 0.003</td>
</tr>
<tr>
<td>Breath</td>
<td>&lt; 0.003</td>
</tr>
<tr>
<td>Relax</td>
<td>&lt; 0.003</td>
</tr>
</tbody>
</table>
3.4 Discussion

3.4.1 Summary of Results

The current study compared the effects of an 8-week yoga intervention on the joint attention, communication, affective states, and maladaptive behaviors of children with ASD between 5 and 12 years of age. For joint attention skills, the children with ASD correctly responded at a lower cue level to the attentional bids initiated by a tester on a standardized test, JTAT during the posttest session compared to the two pretest sessions, with no differences between the two pretest sessions. Additionally, in terms of bid type, children responded to the gestural bids at a lower cue level compared to the verbal bids of JTAT. For verbalization/vocalization, children with ASD increased the percent duration of responsive and spontaneous verbalization/vocalization towards the social partners during the late training session. Specifically, the social responsive verbalization increased during the late compared to the mid and early session, and the social spontaneous verbalization increased in the late and mid compared to the early session. In terms of activity-related verbalization/vocalization, children increased their verbalization bouts during the contact, breathing, looking, and pose activities, whereas no changes were observed during the hello, bye, and relaxation activities. For affective states, children showed greater percent duration of interested affect for majority of the early, mid, and late session, with no changes in the affective states of children following the training. In terms of activity-specific affective states, children showed greater interested affect for the relaxation compared to the poses, looking, and contact game, as well as greater interested
affect for the poses compared to the contact, and greater interested affect for the breathing compared to the contact activities. Moreover, the children showed greater positive affect for the contact and the looking compared to the relaxation, with no changes in the negative affect across the different training activities. For maladaptive behaviors, children showed greater frequency of sensory behaviors followed by the stereotypical and negative behaviors, with no changes in the frequency of maladaptive behaviors during the training.

In terms of activity-specific maladaptive behaviors, two groups of training activities emerged 1) training activities associated with low frequency of maladaptive behaviors, i.e. greetings, breathing, and relaxation activities, and 2) training activities associated with high frequency of maladaptive behaviors, i.e. contact, looking, and pose activities. Specifically, children showed low frequency of maladaptive behaviors in the greeting, breathing, and relaxation compared to the contact and looking activity, as well as low frequency of maladaptive behaviors in the breathing and relaxation compared to the pose activities.

3.4.2 Effects of Yoga Intervention on the Joint Attention and Communication Skills of ASD

Children with ASD in the current study responded at a lower cue level to the gestural and verbal bids of a novel tester for a standardized test of joint attention, JTAT. These improvements could be attributed to improvements in the social monitoring and attentional focus of children following the yoga training. Specifically, children were engaged in various social activities requiring responding as well as following the attentional cues of the social partners, especially the activities of the looking game were
designed to teach eye gaze monitoring through isolated eye or head turns on trainer’s command. Overall, we provided ample opportunities to the child to share the focus of attention with their social partners and to engage in joint attention episodes, which might have helped the child improve his/ her joint attention skills with a novel tester and a novel assessment.

To date, one single study in children with ASD has reported improvements in the social eye-to-eye gazes of children following an intensive 20 months of yoga intervention. Additionally, the yoga trainers reported qualitative improvements in the social skill such as social proximity in children following the training (Radhakrishna et al., 2010). Although the evidence is limited in children with ASD, studies in children with attentional deficits and learning disorders suggest that yoga can improve the attentional focus of children (Abadi et al., 2008; Jensen and Kenny, 2004; Lawson, 2012; Peck et al., 2005). Children aged 6-10 years with attentional deficits increased the percentage of eye contacts with their teacher as well as increased focus on the class tasks after 3-weeks of yoga intervention delivered twice a week (Peck et al., 2005). Similarly, Lawson suggested improvements in on-task behaviors of children with attentional problems following 5 weeks of yoga therapy compared to the no intervention, control group (Lawson, 2012). Our study results also indicated that children with ASD responded at a lower cue level to the gestural bids of the tester compared to the verbal bids. This result could be explained by the complexity of bids included within each category, i.e. the gestural bids of JTAT such as hi-fi, low-hi were simpler and easier to respond, whereas the verbal bids such as
“Wow! That is beautiful! were comparatively more complex and hence, children required greater cues to respond to the verbal bids compared to the gestural bids of the JTAT.

Children with ASD in the current study increased their responsive and spontaneous verbalizations/ vocalizations directed towards the social partners during the latter part of the yoga training. Ours is the first study reporting the positive effects of yoga intervention on the communication skills of children with ASD. Similar to the current study, our past work in movement-based interventions using robots also suggested improvements in the verbalization skills of healthy TD children as well as a child with ASD following a brief 6-week intervention period (Srinivasan and Bhat, 2013).

We observed that across the training sessions, children became more familiar and comfortable working with the trainers, and hence they started talking more to the trainers in the late training session compared to the early session. It was especially encouraging to see that children were spending greater time in spontaneous or self-initiated communication compared to responsive communication. Children would initiate general conversation topics about their day or would ask specific questions regarding the different training activities practiced during the training sessions. In addition, our results indicated that children increased their verbalizations/ vocalizations for the contact, breathing, looking, and pose games, whereas no changes were observed during the greetings and relaxation. This selective increase of verbalizations during the contact, breathing, looking, and pose games could be due to the nature of activities involved within these game. The primary focus of the contact, breathing, looking, and poses was to teach whole-body movements, breathing patterns, and eye gaze training. During the initial training
sessions, children might have found the dual task of simultaneously performing the games and verbalizing with the trainers challenging. However, over training, children got better at these tasks and thus, were able to verbalize as well as perform the task at the same time. In contrast, greetings involved singing a hello and bye song and relaxation involved still lying, hence we did not see any changes in verbalization for these two games.

3.4.3 Effects of Yoga Intervention on the Affective States and Maladaptive Behaviors of ASD

Children with ASD showed interested affect for majority of the training session, with no changes in the affective states over the training. It was encouraging to see high proportion of interested affect throughout the training sessions as it indicates that children enjoyed the activities practiced within the sessions and complied with the trainer’s requests. We based the training activities around highly engaging, and age-appropriate themes such as stories, songs, and games, which clearly motivated the children to perform the activities with the adult trainers. Additionally, our results indicated that children showed maximum positive affect for the contact compared to the other activities. The contact activities included various social games and promoted social proximity and social touch. We believe that some children might have enjoyed these social games resulting in greater smiling in the contact game.

Children in the current study showed no significant changes in the maladaptive behaviors following the yoga training. This was surprising as there is evidence to suggest that yoga-based interventions could reduce the maladaptive and disruptive behaviors of
children with ASD (Goldberg, 2004; Koenig et al., 2012; Rosenblatt et al., 2011). Specifically, 16 weeks of yoga reduced the maladaptive behaviors such as irritability, lethargy, and hyperactivity in children with ASD in the intervention group, compared to the no-intervention, control group (Koenig et al., 2012). However, these improvements were observed on a teacher-rated behavior checklist, Aberrant Behavior Checklist (ABC), with teachers not blinded to the grouping of children. Moreover, there were no differences between the two groups on the behavioral coding of off-task and teacher redirections following the intervention (Koenig et al., 2012). One possible explanation of our study results could be the variability among children in terms of maladaptive and disruptive behaviors shown during the training sessions.

Few children in the study had negligible frequency of the maladaptive behaviors throughout the training sessions, which could have diluted the overall results of the study, as a visual inspection of our data suggests slight reduction in the maladaptive behaviors of children in the mid and late training session compared to the early session (see Figure 3.10). Alternatively, the comparatively smaller duration of our intervention period might be insufficient in evoking significant changes in the behavioral skills of children. Another result of the study included activity-related changes in maladaptive behaviors such that the greetings, breathing, and relaxation were associated with fewer maladaptive behaviors compared to the contact, looking, and poses. The former activities were performed in seated or still lying positions, hence there was limited opportunities for the child to freely move his/her body in repetitive or stereotypical ways or engage in any negative or
disruptive behaviors such as running away. On the other hand, the later games offered more freedom to the child to run away or throw temper tantrums, as well as move his/her body in various stereotypical/ repetitive way.

3.4.4 Limitations of the Study

One of the main limitations of the current study is the lack of a control group. We have attempted to address this limitation by monitoring the performance of children on standardized tests during the course of a brief, 2-week no-intervention period. Our results indicated that there were no significant changes in the performance of children during the course of the no-intervention period. However, we would like to acknowledge that we noticed slight improvements in the performance after the 2-week period which could be argued to multiply over the course of 8 weeks. At this stage, we are unable to address this limitation and would suggest future investigations in this area. Secondly, we were unable to determine the sustenance of gains in the communication and joint attention skills of children following the intervention due of lack of a follow-up session after the completion of the study. Thirdly, we did not administer any standardized tests to assess the generalized changes in the communication skills and maladaptive behaviors of children following the intervention. Fourthly, our sample size was relatively small with a mix of high and low functioning children resulting in a comparatively heterogeneous study sample. Lastly, our training duration was relatively shorter compared to other intensive yoga interventions. We tried to address this limitation by increasing the intensity of training sessions, i.e. 4 sessions/ each week (2 expert and 2 parent sessions). However,
we were unable to control the variability in the number of home sessions delivered by the parents.

### 3.5 Conclusions

The current study explored the effects of a socially-embedded, yoga intervention on the joint attention, communication, affect, and maladaptive behaviors of children with ASD between 5 and 12 years of age. Our study indicated that an 8-week yoga intervention could lead to generalized improvements in responsive joint attention skills as well as training-specific improvements in the social verbalization/vocalization of children with ASD following the training. We did not observe any changes in the affective states and the maladaptive behaviors of children following the training, however children showed interested affect for majority of the training sessions. Overall, we suggest that whole-body motor interventions delivered within a socially rich environment could improve the social communication as well as the motor skills of children with ASD, and hence should be included in the standard-of-care treatment for children with ASD.
Chapter 4

COMPARISON OF THE EFFECTS OF MOVEMENT-BASED MUSIC, ROBOT, AND YOGA INTERVENTION IN CHILDREN WITH AUTISM SPECTRUM DISORDER (ASD)

4.1. Introduction

4.1.1 Multisystem Impairments of ASD

Autism Spectrum Disorder (ASD) is a multisystem neurological disorder identified by impairments in social communication skills and presence of restricted and repetitive behaviors (American Psychiatric Association (APA), 2013). Social communication impairments include reduced eye contacts, lack of social and emotional reciprocity, delays in acquiring language, and difficulty initiating and sustaining social interactions (Eigsti et al., 2011; Landa, 2007; Lord et al., 2000; Tager-Flusberg et al., 2005). Restricted and repetitive behaviors include stereotypical body mannerisms such as hand flapping, preoccupation with non-functional parts of objects such as spinning wheels of a car, as well as desire for sameness such as insisting on wearing the same clothes and eating the same food (Leekam et al., 2011; Lewis and Bodfish, 1998; Turner, 1999). In addition, motor impairments such as postural instability, unstable gait, poor handwriting, and poor bilateral coordination are prevalent in children diagnosed with ASD (Bhat et al., 2011; Chukoskie et al., 2013; Dowd et al., 2010; Downey and Rapport, 2012; Fournier et
Further, motor impairments have serious cascading effects on the overall social, communication, adaptive behavior, and cognitive skill of children in ASD (Bhat et al., 2012; Gernsbacher et al., 2008; Iverson and Wozniak, 2007; MacDonald et al., 2013a; 2013b, 2014; Radonovich et al., 2013; Sipes et al., 2011). A large sample size study including 159 young children with ASD between 14 and 33 months indicated that children with poor fine and gross motor have greater severity of autism diagnosis (MacDonald et al., 2014). Another study indicated that the motor skills of children with ASD at 2 years of age is one of the most predictive factor for optimal outcomes at 4 years of age (Sutera et al., 2007). Clearly, ASD is a multisystem disorder with diagnostic impairments in the social communication and restricted and repetitive behavior domains, as well as significant impairments in the gross and fine motor skills.

Note: Please see chapter 2 and 3 for detailed discussion of the diagnostic and motor impairments of ASD.

4.1.2 Traditional Interventions and Need of Multisystem Interventions for ASD

The majority of the intervention approaches for children with ASD follow principles of Applied Behavioral Analysis (ABA), a behavioral science aimed at improving the socially significant behaviors of children and adults with and without disabilities (Baer et al., 1968; Foxx, 2008; Matson et al., 2012). The primary focus of ABA therapies in children with ASD is to improve the social communication skills and facilitate positive behaviors in children. Various teaching techniques have been developed using the aforementioned ABA principles including a very traditional Discrete Trial Training
which focuses on highly-structured adult-led training, and a comparatively contemporary Incidental teaching focusing on promoting child-initiated skills and behaviors (Lovaas, 1987; Smith, 2001; Vismara and Rogers, 2010). Two other popular ABA-led interventions include Picture Exchange Communication System which focuses on improving the communication of children using pictures and Treatment and Education of Autistic and Communication Handicapped Children which focuses on use of structured environment, and routines to teach new skills to children (Bondy and Frost, 2003; Mesibov et al., 2004). Overall, several approaches targeting the social communication and behavioral skills of children with ASD exist, however there is limited research on facilitating the motor skills of children. Given, the overwhelming evidence for motor impairments in children with ASD, we believe that socially-embedded movement interventions could improve the motor as well as the social communication skills of children with ASD. Additionally, most of the interventions are time-consuming, require expert trainers, and are driven by external factors such as providing reinforcements, prompting to achieve desirable behavioral outcomes. Hence, there is a need of novel, comprehensive interventions which can address the multisystem impairments, are engaging and easy to administer, and are driven by internal factors i.e. inherent interest and engagement in the task.
4.1.3 Novel Multisystem Interventions for ASD

Given the above-mentioned limitations in the traditional ASD interventions, there has been increasing focus on examining the effects of novel ideas and contexts to target the primary social communication and behavioral skills, as well as the secondary motor impairments of children with ASD. In our lab, we were interested in exploring the effects of music-, robot-, and yoga-based movement intervention on the overall functioning of school-going children with ASD. Below, we have provided the current evidence for these interventions on the social communication, behavior, and motor skills of children with ASD.

Music interventions are enjoyable and highly engaging for children with ASD probably due to their superior ability for understanding the musical tones and chords, as well as enhanced pitch memory and labeling compared to age-matched, typically developing (TD) children (Heaton, 2003; Heaton et al., 1999). Musical interventions have primarily been used to promote the communication and behavioral skills of children with ASD (Brownell, 2002; Buday, 1995; Farmer, 2003; Gattino et al., 2011; Gold et al., 2006; Katagiri, 2009; Kim et al., 2008; 2009; Lim, 2010). In terms of communication skills, musical training including listening to music, playing instruments such as drums and guitars, and singing songs could facilitate the communication skills of children with ASD (Buday, 1995; Farmer, 2003; Gattino et al., 2011; Gold et al., 2006; Kim et al., 2008; Lim, 2010). Specifically, a randomized controlled trial in children with ASD suggested improvements in the non-verbal communication such as signing or motion gestures as
well as the verbal communication such as responding to the trainers in the musical group compared to the control, no music group (Farmer, 2003). Similarly, children with ASD between 3 and 5 years improved verbal production of target words after watching the musical videos of songs incorporating the target words (Lim, 2010). In terms of behavioral skills, music interventions are documented to reduce the negative and disruptive as well as improve the understanding of emotional or affective states in children with ASD (Brownell, 2002; Katagiri, 2009; Kim et al., 2009). Children with ASD between 6 and 9 years showed improvements in the problem behaviors such as TV talk and inability to follow teacher’s directions after listening to the musical stories created around the targeted problem behaviors (Brownell, 2002). Additionally, children with ASD showed better understanding of emotional/ affective states such as happiness, sadness, anger, and fear taught in a musical context compared to the no music condition (Katagiri, 2009). Lastly, in terms of motor skills, there are no studies exploring the effects of musical interventions on the gross and fine motor skills of children with ASD. In contrast, TD literature suggest that movements practiced within a musical context can improve the gross motor skills such as jumping and balance of TD children (Deli et al., 2006; Zachopoulou et al., 2004). Similarly, playing musical instruments such as piano can lead to improvements in the fine motor skills of TD children (Costa-Giomi, 2005). Overall, there is evidence to suggest that music-based interventions could be highly engaging for children with ASD, and movements performed within a musical context can positively impact the communication, behavior, and motor skills of children with ASD.
Children with ASD find technology such as robots extremely enticing and engaging. In addition, children find it easier to interact with robots as they are non-intimidating, predictable entities compared to human interactions (Dautenhahn, 2003; Dautenhahn and Werry, 2004; Diehl et al., 2011). There is some anecdotal evidence for the use of robots to target the communication, social attention, and imitation skills of children with ASD (Duquette et al., 2008; Kozima et al., 2007; Robins et al., 2004; 2005; 2006; 2009). In terms of communication skills, children with autism showed some improvements in social interactions and communication following an extended protocol involving imitation games with a humanoid robot, Robota (Robins et al., 2004). In terms of social skills, children with autism paired with the mobile robot, Tito showed greater shared attention including eye contact and physical approach towards the robot compared to children with autism paired with an adult experimenter (Duquette et al., 2008). In terms of motor skills, robotic arms are better at facilitating simple reaching motions in children with ASD compared to human models which are better at facilitating reaches in typically developing children (Pierno et al., 2008). This could indicate that children with ASD may have an easier time perceiving and responding to the simple, predictable, and repeatable movement patterns of a robot compared to humans (Dautenhahn and Werry, 2004). Our past work also suggested that repeated practice of whole body karate and dance moves with a small humanoid robot, Isobot can improve the bilateral coordination of a child with autism (Kaur et al., 2013). Taken together, there is anecdotal evidence to suggest that robots could be a promising intervention tool to promote the social, communication, and motor skills of children with ASD.
Yoga has gained popularity in the recent years due to its cost effectiveness as well as multiple effects on the motor and behavioral skills of children. Moreover, yoga activities could be easily modified and adjusted according to the needs and level of functioning of children. In terms of behavioral skills, there is anecdotal evidence for the use of yoga intervention in children with ASD to reduce the maladaptive and negative behaviors (Koenig et al., 2012; Rosenblatt et al., 2011; Goldberg, 2004; Behar, 2006). Specifically, children with ASD showed reduced maladaptive behaviors such as irritability, lethargy, social withdrawal, hyperactivity, and non-compliance on a teacher-reported behavior checklist following 16 weeks of classroom yoga training compared to no changes in the control group involved in usual classroom routines (Koenig et al., 2012). Similarly, 8-weeks of creative relaxation, a yoga-based program to promote relaxation and reduce stress in children with ASD improved the breathing patterns of children with ASD as measured by their reduced pulse rates, as well as reduced levels of stress and anxiety as measured by parent and teacher reports (Goldberg, 2004). In terms of motor skills, a single study in children with ASD suggested improvements in the motor imitation, sitting balance, and posture of six children with ASD after an intensive 10- to 20-month yoga intervention primarily including poses, breathing, and relaxation exercises (Radhakrishna et al., 2010a; 2010b). In contrast, there is ample evidence for the positive effects of yoga on the balance, strength, flexibility, as well as the cardiopulmonary endurance of TD children (Birdee et al., 2009; Dash and Telles, 1999; D'souza and Avadhany, 2014; Galantino et al., 2008; Hotkar, 2009; Madanmohan et al., 2003; Manjunath and Telles, 2001; Raghuraj and Telles, 1997; Serwacki and Cook-Cottone, 2012). A systematic
review in TD subjects suggested that yoga can improve the static balance and dynamic balance of TD children and adults with moderate to strong effect size (Jeter et al., 2014). Similarly, a systematic review of yoga interventions in the pediatric population suggested positive effect on the cardiopulmonary health including lowering of blood pressure, heart rate, and breathing rate, and improvements in the lung functions such as Forced Expiratory Volumes (Birdee et al., 2009). Overall, novel intervention contexts including, music, robot, and yoga could be promising tools to improve the non-verbal and verbal communication skills, reduce negative and stereotypical behaviors, improve joint attention, as well as facilitate positive affect in children with ASD. However, there is clear lack of evidence to support the use of these interventions to improve the motor skills of children. Hence, our primary aim was to deliver movement-based interventions based on music, robot, and yoga theme to improve the motor performance, as well as the communication, and affective states of children with ASD.

4.1.4 Aims and Hypotheses of the Study

The primary aim of the current study was to examine the training-related and group-related changes in the motor, communication, and affective states of children with ASD following movement-based music, robot, and yoga intervention. The specific aims of the study were:

Aim 1: To compare the effects of music, robot, and yoga intervention on the gross and fine motor skills of children with ASD using a standardized motor test, Bruininks-
Oseretsky Test of Motor Proficiency (BOT-2) delivered during the pretest and posttest session.

**Hypothesis 1a: Training-related changes:** We hypothesized that children in all three movement groups would improve their gross motor skills with no improvements in the fine motor skills in the posttest session compared to the pretest session.

**Hypothesis 1a: Group-related differences:** We expected no group differences as children would show similar levels of motor skills before the intervention as well as similar improvements in the motor skills after the intervention.

**Aim 2:** To compare the effects of movement interventions, i.e. music, robot, and yoga on the communication skills of children with ASD during the early (session 1), mid (8), and late (16) training session.

**Hypothesis 2a: Training-related changes:** We expected children to increase percent duration of social verbalization and reduce self-verbalization or echolalia in the late training session compared to the mid and early session for all three movement groups.

**Hypothesis 2b: Group-related differences:** We expected similar changes in the social and self-verbalization following training in the three movement groups.

**Aim 3:** To compare the changes in affective states during the early, mid, and late training session of children with ASD in the music, robot, and yoga group.

**Hypothesis 3a: Training-related changes:** We expected children to show increased or similar percent duration of positive and interested affect in the late compared to the mid and early training sessions for all three movement groups.
Hypothesis 3b: Group-related differences: In general, we expected all three groups to show greater percent duration of interested affect compared to positive and negative affect throughout the training sessions. However, children in the music group could show greater percent duration of positive affect compared to the robot and yoga group as musical activities are extremely enjoyable and fun for children with ASD.

4.2 Methods

4.2.1 Research Design and Study Timeline

The music and robot interventions were implemented using a randomized controlled trial design between 2012-2014 at University of Connecticut. Children were matched based on their age, IQ, and level of functioning and were randomly divided into the music and robot group. The intervention lasted for 10 weeks including 8 weeks of intervention and a pre and posttest session before and after the intervention (Table 4.1).

The yoga intervention was implemented using a single group pre-posttest study design between 2015-2016 at University of Delaware. The study timeline was slightly longer, i.e. 12 weeks due to a repeat pretest session conducted 2-weeks after the initial pretest session (see chapter 2 or 3 for details). Our analysis indicated that children performed similarly across the two pretest session, hence we have pooled the data across the two pretest sessions for the purposes of the current study (Table 4.1).
Table 4.1: Study Timeline.

<table>
<thead>
<tr>
<th>Pretest (Week 1)</th>
<th>Intervention (Music, Robot, Yoga)</th>
<th>Posttest (Week 10/12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bruininks-Oseretsky Test of Motor Proficiency (BOT-2)</td>
<td>8 week of intervention Training-specific measures 1. Verbalization/ vocalization 2. Affective States</td>
<td>Bruininks-Oseretsky Test of Motor Proficiency (BOT-2)</td>
</tr>
</tbody>
</table>

4.2.2 Participants

Thirty-six children with ASD between 5 and 12 years with 12 children each in the music (Mean ± SE = 8.22 ± 0.72 years), robot (Mean ± SE = 7.30 ± 0.65 years), and yoga group (Mean ± SE = 7.77 ± 0.49 years) were recruited to participate in the study. Children were recruited from the Connecticut, Massachusetts, and New Jersey Delaware for the music and the robot group, and from the Delaware and Maryland for the yoga group by distributing fliers in the local schools and online postings on the autism websites. The eligibility for the study was determined by the following criteria:

*a) Social Communication Questionnaire (SCQ):* SCQ is a parent-reported, 40-item questionnaire that screens for autism-specific social communication impairments (Rutter et al., 2003). A cut-off score of 15 or greater was reported in 24 out of the 36 children indicating significant impairments in social communication skills. The eligibility for the remaining 8 children was confirmed after administrating the Autism Diagnostic Observation Schedule- Second Edition (see below).
b) Autism Diagnostic Observation Schedule- Second Edition (ADOS-2): ADOS-2 is a gold standard assessment for autism diagnosis and involves a semi-structured play for assessing social interaction, and repetitive/ restricted behaviors of children (Lord et al., 2012). The scoring of ADOS-2 provides a comparison score of 1-10 to gauge the severity of disorder with higher score indicating greater severity of disorder. ADOS-2 assessment was conducted for 32 out of total 36 children with comparison score ranging from 5 to 10 indicating moderate to high severity of disorder. The diagnosis for the remaining four children was confirmed by medical/ school records provided by parents before participating in the study.

Our exclusion criteria included children with additional impairments such as hearing/ vision impairments, orthopedic/ neurological/ cardiopulmonary conditions, or significant developmental delays. Additionally, children had to demonstrate the ability to engage in the testing and the training activities, hence the children with challenging and negative behaviors such as aggression, non-compliance, temper tantrums, or attentional deficits were excluded as it affected their ability to complete the sessions. All parents signed the consent form and children signed the assent form approved by the Institutional Review Board at the University of Connecticut and University of Delaware before participating in the study. Based on the socioeconomic scores, 34 families belonged to middle class and 2 families belonged to upper class. Out of the 36 families, 20 families were Caucasian, 4 were African-American, 8 were Asian, 2 Hispanic, and 3 were biracial (Hollingshead, 1975).
Children in the three groups were matched based on age, gender, and level of functioning obtained from a parent questionnaire and subjective clinical assessment (Table 4.2). Specifically, we used a parent-reported questionnaire, Vineland Adaptive Behavior Scales- 2nd Edition (VABS) to assess the level of functioning of each child. VABS is a standardized assessment for the adaptive functioning of children from birth to 80 years of age and includes five domains, communication, daily living skills, socialization, motor, and problem behaviors (Sparrow et al., 2005). Additionally, we assessed the level of functioning of children through subjective assessment of social communication and motor performance during the pretest session. The expert tester rated the child’s motor and social communication skills on a scale from 1- 4 (1 – extremely low, 2 – low, 3 – moderate, 4 – high). As indicated in Table 4.2, children in all three groups were matched on the age, gender, VABS, and subjective motor, and social communication skills.

Table 4.2: Group demographics.

<table>
<thead>
<tr>
<th>Group</th>
<th>Age</th>
<th>Gender</th>
<th>Level of Functioning</th>
<th>VABS</th>
<th>Subjective-Motor</th>
<th>Subjective-Social Communication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Music</td>
<td>8.22±0.72</td>
<td>10M, 2F</td>
<td>71.46±3.54</td>
<td>2.40±0.22</td>
<td>2.57±0.23</td>
<td></td>
</tr>
<tr>
<td>Robot</td>
<td>7.30±0.65</td>
<td>11M, 1F</td>
<td>67.91±4.53</td>
<td>2.51±0.24</td>
<td>2.63±0.25</td>
<td></td>
</tr>
<tr>
<td>Yoga</td>
<td>7.77±0.49</td>
<td>11M, 1F</td>
<td>81.18±4.82</td>
<td>2.99±0.18</td>
<td>2.97±0.23</td>
<td></td>
</tr>
<tr>
<td>p-values</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Music vs Robot</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>Music vs Yoga</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>Robot vs Yoga</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td></td>
</tr>
</tbody>
</table>
4.2.3 Training Protocol

We delivered 8-weeks of intervention with two sessions per week (total 16 sessions) and each session lasting 50-60 minutes. The training sessions involved a triadic context, i.e. a child with ASD, an expert trainer, and an adult model (Figure 4.1, 4.2, 4.3). The expert trainers were pediatric physical therapists and/or Kinesiology graduate students, and were responsible for conducting the session and guiding the child through the activities. The adult models were university undergraduates and their role was to act as a buddy for the child with ASD as well as help the expert trainer in delivering the sessions. All models received at least 6 hours of training in the form of instructional manuals and videos before participating in the intervention. Additionally, to ensure training fidelity, a novel coder coded three randomly-picked sessions for each child to monitor the trainers’ adherence to the protocol as well as completion of all the critical activities of the session. The results indicated that the trainers followed the protocol and completed the critical activities for majority of the training sessions (Mean ± SE: Music = 92.16 ± 1.52 %; Robot = 90.73 ± 2.96 %; Yoga = 94.63 ± 0.74 %). The parents were provided with instructional CDs and manuals to deliver 2 additional sessions at home each week. Additionally, the expert trainer provided a brief training to the parents regarding the home sessions and provided all the necessary materials such as yoga mats and props required to conduct the sessions.
The activities included within each intervention group are listed below.

\textit{a) Music group:} The music group involved singing and rhythmic whole body actions performed to the beat of the music. Each session’s music was based on a theme such as start and stop, moving on a steady beat, slow and fast, moving on a count, turn taking, and small and large movements. Children performed seven different activities within each session:

- \textit{Hello song} where child, trainer, and model sang a song together
- \textit{Action song} included performing gestures along the lyrics of the song
- \textit{Beat keeping} included performing whole body actions on the beats of the music
- \textit{Music making} involved playing with different musical instruments such as xylophones and maracas
- \textit{Moving game} involved whole body walking activities on music
- \textit{Calming song} included relaxing on music
- \textit{Goodbye song} where child, trainer, and model sang a goodbye song to end the session
b) Robot group: The robot group involved rhythmic whole body actions, drumming, and walking activities performed with a highly sophisticated 23” humanoid robot, Nao (Aldebran) and small pet robot, Rovio (WowWee®). The robots were controlled using a laptop-based software by the expert trainer. Parents/ caregivers were provided three small toy robots to conduct the home sessions- ‘Isobot’ programmed to perform karate and dance actions, ‘Bioloid’ programmed to perform yoga poses, and lastly ‘iRobot’ programmed for walking activities. Similar to the music group, the training activities were built on various themes such as start and stop, moving on a steady beat, slow and fast, moving on a count, turn taking, and small and large movements. The specific activities practiced within each session were:

- **Hello** where the robot introduces itself and says hi to the child
• **Warm up** included whole body stretching exercises

• **Action game** included various rhythmic gross motor actions varying in type and complexity

• **Drumming game** included various simple and complex drumming actions

• **Walking game** involved following ‘Rovio’ which was programmed to trace various shapes and letters on the floor

• **Goodbye** where children bid farewell to the robot.

**Robot Training Session**

**Figure 4.2:** Robot group- child and model imitating the robot. The expert trainer (not visible in the picture) sits next to the robot.

c)*Yoga group:* The yoga group was engaged in whole body postures, breathing exercises, as well as relaxation. The training activities were performed on various age-appropriate themes such as songs, stories, and games. Additionally, we used
various props during the games to provide an appropriate context to the child such as straws and thermo balls during the breathing game. The training activities practiced within each session are listed below:

- **Hello song** included the child, trainer, and model singing a song together
- **Contact** included social games such as passing a ball or forming shapes together
- **Breathing** included various simple and complex breathing activities such as sucking through a straw, nostril breathing, bee sound breathing
- **Looking** included eye-gaze training through isolated eye or head turns
- **Poses and partner poses** involved whole body postures in sitting, standing, and lying
- **Relaxation** involved still lying with pre-recorded verbal imagery in the background
- **Bye song** included the child, trainer, and model singing a song to bid farewell
Although, the intervention groups were based on three different themes, i.e., music, robot, and yoga, there were various similarities among the groups such as intervention duration, number of participants, training principles as well as training goals (Table 4.3).

**Table 4.3: Similarities in the Movement Groups.**

<table>
<thead>
<tr>
<th>COMPONENTS</th>
<th>MUSIC</th>
<th>ROBOT</th>
<th>YOGA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Duration</strong></td>
<td>8 weeks (2 expert + 2 parent sessions/week)</td>
<td>8 weeks (2 expert + 2 parent sessions/week)</td>
<td>8 weeks (2 expert + 2 parent sessions/week)</td>
</tr>
<tr>
<td><strong># of participants</strong></td>
<td>12</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td><strong>Standardized assessments</strong></td>
<td>BOT-2</td>
<td>BOT-2</td>
<td>BOT-2</td>
</tr>
<tr>
<td><strong>Training-specific assessments</strong></td>
<td>Verbalization/vocalization, Affective states</td>
<td>Verbalization/vocalization, Affective states</td>
<td>Verbalization/vocalization, Affective states</td>
</tr>
<tr>
<td><strong>Training principles</strong></td>
<td>Motor Training (imitating, joint action), Social skills (greeting, eye contact, turn)</td>
<td>Motor Training (imitating, joint action), Social skills (greeting, eye contact, turn)</td>
<td>Motor Training (imitating, joint action), Social skills (greeting, eye contact, turn)</td>
</tr>
</tbody>
</table>

*Figure 4.3: Yoga group-child, model, and trainer performing a pose together*
4.2.4 Testing Protocol

4.2.4.1 Testing Measures

We included a standardized test, *Bruininks-Oseretsky Test of Motor Proficiency-Second Edition (BOT-2)* to assess the generalized changes in gross and fine motor skills of children with ASD during the posttest and pretest session. BOT-2 is a reliable and valid measure of fine and gross motor performance in individuals between 4 and 21 years of age (Bruininks and Bruininks, 2005). A novel tester administered two gross motor and two fine motor subtests, including the Bilateral Coordination, Balance, Fine Motor Precision, and Fine Motor Integration subtests. The Bilateral Coordination subtest assessed children’s ability to synchronize their upper and lower limbs, and the Balance subtest assessed children’s postural control in standing and walking in the presence/absence of visual input. The Fine Motor Precision subtest assessed the precise hand and finger control, and the Fine Motor Integration subtest assessed the ability to integrate visual stimuli during motor control (see Appendix B for BOT-2 items). One child each in the music, robot, and yoga group was unable to complete the testing session.
due to scheduling conflicts or non-compliance with the tester, hence we are reporting on the BOT-2 results for 33 children, with 11 children in each group.

We included two training-specific measures, *Verbalization/ vocalizations* and *affective states* to assess the changes in communication and affective states of children following the music, robot, and yoga intervention. We coded the entire duration of early (session 1), mid (8), and the late (16) training session for all the training-specific measures. In terms of missing data, 1 child in the yoga study was non-verbal, so we are reporting on the verbalization data for 35 children.

4.2.4.2 Behavioral Coding

All testing and training sessions were videotaped for behavioral coding. Following are the details for the behavioral coding and the reliability of the testing measures. Pearson’s correlations were conducted to establish intra-rater reliability of > 90% and inter-rater reliability of > 80% for 25% of the dataset for all the study variables.

*a) Standard Scores for BOT-2*: The BOT-2 manual provides scaled scores for the individual subtests and standard scores for the composite domains, with greater scores indicating better performance. Specifically, the balance and bilateral coordination subtests contribute to the body coordination composite and the fine motor precision and fine motor integration subtests contribute to the fine manual control composite. We have reported on the standard scores for the body coordination composite and the fine manual control composite. Intraclass correlations were conducted to establish
intra-rater reliability of > 90% and inter-rater reliability of > 80% for 25% of the dataset.

b) Percent Duration of Verbalization/Vocalizations: We examined the changes in child’s verbalizations/ vocalizations from the early to the mid and the late training session. A behavioral coding software, Datavyu was used to code the start and stop time for each verbalization/ vocalization bout produced by the child during the entire training session (Datavyu Team, 2014). Specifically, we coded for social verbalizations/ vocalizations by the child, i.e. words, phrases, sentences, and vocalizations (e.g. humming, breathing, and laughing sounds) directed towards the social partners i.e. the trainer, the model, or the parent. It was further characterized as spontaneous (i.e. initiated by the child) or responsive (i.e. in response to the social partners in the session). We also coded for self-directed speech, i.e. verbalization/ vocalization initiated without any prompts from the social partners. It also included bouts of immediate or delayed echolalia, where children repeated the words of the social partners or remembered something from a different context. The coded files were run through a custom made Matlab program to calculate the percent duration of spontaneous social, responsive social, and self-directed verbalization/ vocalization within the training sessions.

c) Percent Duration of Affective States: We examined the child’s affect, i.e. positive, negative, and interested affect during the early, mid, and late session using the Datavyu software. Specifically, the positive affect included time spent smiling,
negative affect indicated time spent pouting, frowning, yelling, and the interested
affect indicated time spent on-task without expressing positive or negative affect. The
Datavyu coded files were run through a custom made Matlab program to calculate the
percent duration of positive, negative, and interested affect.

4.2.4.3 Statistical Analysis

To compare the three intervention groups, i.e. music, robot, and yoga, we conducted
three separate Repeated Measures Analysis of Variance (ANOVA) for BOT-2,
verbalization, and affective states with composite/ behavior type (BOT-2: Body
Coordination composite, Fine Manual Control composite; Verbalization type: Social
responsive, social spontaneous, self; Affect: Interested, Positive, Negative) and testing/
training session (Testing session: Pretest, Posttest; Training session: Early, mid, late) as
the within-subjects factor and the group (music, robot, yoga) as between subjects factor.
We checked our data for parametric assumptions using the Mauchly’s Test of Sphericity
and Greenhouse-Geisser corrections were applied in case of violations. The significance
was set at $p \leq 0.05$ and the training effects were further examined using post-hoc,
dependent $t$-tests with Bonferroni corrections applied for multiple comparisons. In case
of Bonferroni corrections, we considered $p$-values $\leq 0.05$ as statistical trends.
Additionally, we have reported on the individual data for the training-related changes of
the study.
4.3 Results

4.3.1 Effect of Movement Interventions on BOT-2

The Repeated measures ANOVA for BOT-2 composite scores indicated a main effect of testing session (F (1, 30) = 17.74, \( p < 0.01 \), partial \( \eta^2 = 0.37 \)) and composite type (F (1, 30) = 13.13, \( p < 0.01 \), partial \( \eta^2 = 0.30 \)), with no significant effect of group.

a) **Training-Related**: We further analyzed the main effect of testing session to identify the training-related changes following the intervention. Our analysis indicated that children improved their performance in the Body Coordination composite during the posttest session compared to the pretest session (\( p < 0.05 \), Figure 4.4), with no changes in the Fine Manual Control composite between the pretest and posttest session (Figure 4.4). In terms of individual data, 26 out of 33 children increased their Body Coordination scores in the posttest session compared to the pretest session.

b) **Group-Related**: In terms of group-related differences, there were no differences across the music, robot, and yoga group highlighting that all three movement groups led to similar improvements in the gross motor skills of children.
4.3.2 Effect of Movement Interventions on Verbalization/Vocalization

The Repeated measures ANOVA indicated main effect of training session ($F(2, 66) = 17.76, p < 0.01, \eta^2 = 0.35$), verbalization type ($F(2, 66) = 15.75, p < 0.01, \eta^2 = 0.32$), and significant 2-way verbalization type x group ($F(4) = 7.26, p < 0.01, \eta^2 = 0.31$) and verbalization type x training session ($F(4, 132) = 14.54, p < 0.01, \eta^2 = 0.31$) interactions.

a) **Training-Related:** We further analyzed the main effect of training session to examine the training-related changes in verbalization. The post-hoc t-tests indicated that children increased the total time spent in verbalization/vocalization.
in the mid and late training session compared to the early session ($p < 0.02$ after Bonferroni corrections, Figure 4.5). Individual data suggested that 27-30 out of total 35 children increased their verbalization during the mid and the late training sessions.

![Training-Related Changes in Verbalization/Vocalization](image)

**Figure 4.5:** Effect of movement interventions on the verbalization/vocalization of children with ASD. * indicates $p < 0.02$

b) **Group-Related:** We also analyzed the meaningful 2-way group interaction to identify the group-related differences in the music, robot, and yoga group for verbalization types. The results indicated that the yoga group produced greater social spontaneous verbalization than the robot group, greater social responsive
verbalization than the robot and the music group, as well as reduced self-verbalization than the robot and the music group ($p < 0.006$ after Bonferroni corrections, Figure 4.6). Additionally, the music group produced reduced self-verbalization than the robot group ($p < 0.006$ after Bonferroni corrections, Figure 4.6).

**Group-Related Differences in Verbalization/ Vocalization**

![Group-Related Differences in Verbalization/ Vocalization](image)

**Figure 4.6**: Differences in verbalization types across the training groups, i.e. music, robot, and yoga.

* indicates $p < 0.006$
4.3.3 Effect of Movement Interventions on Affective States

The Repeated measures ANOVA indicated main effect of affect type ($F (2, 66) = 444.29, p < 0.01$, partial $\eta^2 = 0.93$), and significant 2-way affect type x group interaction ($F (4) = 12.14, p < 0.01$, partial $\eta^2 = 0.42$).

a) **Training-Related**: There were no main or interaction effects for the training-related changes in the affective states of children during the early, mid, and late training session.

b) **Group-Related**: We further analyzed the meaningful 2-way group interaction to better understand the group-related differences in affective states across the music, robot, and the yoga group. The yoga group showed maximum interested and least negative affect compared to the music and the robot group ($p < 0.006$ after Bonferroni corrections, Figure 4.7). In addition, the music group showed maximum positive affect compared to the other two groups ($p < 0.006$ after Bonferroni corrections, Figure 4.7).
4.4 Discussion

4.4.1 Summary of Results

The primary aim of the current study was to compare the effects of three movement interventions based on music, robot, and yoga theme on the motor, communication, and affective states of children with ASD between 5 and 12 years of age. In terms of BOT-2 results, the children in all three groups improved their gross motor performance following training as indicated by greater Body coordination scores in the posttest session compared to the pretest session. We did not observe any group-related differences between the music, robot, and the yoga group in terms of BOT-2 scores. In terms of communication
skills, children with ASD in all three groups increased the percent duration of time spent verbalizing or vocalizing in the late and mid training session compared to the early session. In addition, the yoga group showed greater percent duration of spontaneous social verbalization compared to the robot group, as well as greater responsive social verbalization and less self-verbalization compared to the music and the robot group. The music group showed less percent duration of self-verbalization compared to the robot group. Lastly, in terms of affective states, we did not observe any changes in the affective states of children across the early, mid, and late training session for the music, robot, and yoga group. However, the yoga group showed maximum interested and least negative affect, and the music group showed maximum positive affect compared to the other two groups.

4.4.2 Effect of Movement Interventions on the Motor Skills of ASD

Children with ASD showed generalized improvements in the gross motor performance as assessed using the standardized test, BOT-2. This result is consistent with our training demands and the whole-body activities practiced within the three movement groups. Specifically, the music and robot group involved various dual and multilimb movements of the hands and legs. Similarly, the yoga group involved various simple and complex postures in lying, sitting, and standing. Hence, it is not surprising that children improved their gross motor performance following the training. To our knowledge, this is the first study examining the effects of movement based-interventions on the motor skills of children with ASD using a standardized test of motor performance. Although,
this is the first empirical study in children with ASD, there is evidence from the TD literature to support the results of our study (Birdee et al., 2009; Costa-Giomi, 2005; Deli et al., 2006; Galantino et al., 2008; Hotkar, 2009; Kaur et al, 2013; Madanmohan et al., 2003; Manjunath and Telles, 2001; Zachopoulou et al., 2004) TD children between 4 and 6 years showed greater improvements in the gross motor skills such as jumping and balance following 8-weeks of music and movement program compared to the control group engaged in a physical education program (Zachopoulou et al., 2004). Similarly, 6-weeks of whole body movements practiced with a small humanoid robot, Isobot led to improvements in the bilateral coordination of TD children as well as a child with ASD (Kaur et al., 2013). Lastly, a 6-week randomized controlled trial using yoga intervention in TD children between 11 and 14 years suggested improvements in the static balance of children compared to no changes in the control group (Hotkar, 2009).

4.4.3 Effect of Movement Interventions on the Communication Skills of ASD

Children with ASD produced greater verbalization/ vocalizations in the mid and late training sessions compared to the early session. We believe these improvements in the communication skills are directly related to the children’s increased familiarity with the trainers as well as the motivating training contexts. Over training, we observed children getting more familiar and comfortable with the training activities as well as the trainers. Children started talking about various topics such as their daily routine as well as specific questions about the training activities resulting in greater verbalization during the mid and the late training sessions. Additionally, our training contexts were highly engaging
and enjoyable, hence it might have motivated the children to engage/verbalize more with the trainers. These results fit with the previous literature in children with ASD on the efficacy of music and robot-based interventions (Buday, 1995; Duquette et al., 2008; Farmer, 2003; Gattino et al., 2011; Gold et al., 2006; Kim et al., 2008; Kozima et al., 2007; Lim, 2010; Robins et al., 2005; 2006; 2009). Specifically, a meta-analysis of music interventions in children with ASD suggested moderate effect sizes for improvements in the verbal and non-verbal communication skills of children following the intervention (Gold et al et al., 2006). Similarly, children with ASD between 2 and 4 years started initiating conversations with a robot ‘Keepon’ during the course of a 5-9-month intervention period (Kozima et al., 2007). To our best knowledge, this is the first study examining the effects of yoga intervention on the communication skills of children with ASD.

In terms of group differences, the yoga group showed greater social responsive verbalization and the robot group showed greater self-verbalization compared to the other two groups. This could be attributed to the differences in the verbal levels of children across the three groups. In spite of matching the children on age and level of functioning, the yoga group included comparatively greater number of high verbal children compared to the music and robot group, thus resulting in greater social responsive verbalization in the yoga group. On the other hand, greater self-verbalization in the robot group, could probably be attributed to the limitations in the verbal repertoire of the robot. Specifically, the robot’s speech was unclear and sometimes difficult for children to understand.
Moreover, child’s conversations with the robot lacked the typical dynamics of a to-and-fro conversations as there was usually a lag between the robot’s response to child’s questions and comments. Hence, children in the robot group might have chosen to indulge in greater self-verbalization compared to social verbalization. Similar to our study, another study reported reduction in the self-initiated interactions of first and sixth grade TD children with an interactive robot, Robovie over the course of a 2-week robot-child-interactions period (Kanda et al., 2004).

4.4.4 Effect of Movement Interventions on the Affective States of ASD

We did not observe any changes in the affective states of children from the early to the late training sessions, instead children showed greater interested affect throughout the training sessions validating our assumption that the movement contexts could be enjoyable and fun for children. In terms of group-related differences, the music group showed the maximum positive affect and the yoga group showed the maximum interested and least negative affect compared to the other two groups. The greater positive affect in the music group is not surprising as musical activities are usually engaging and enjoyable for children and are documented to promote positive affect such as smiling in children with ASD (Katagiri, 2009; Kim et al., 2009). Children with ASD in the improvisational music making therapy increased the frequency and duration of positive affect and joint attention after 12 weeks of intervention compared to the no music, toy play group (Kim et al., 2009). On the other hand, greater negative affect in the music and the robot group could probably be the result of difficulty encountered by children to perform the whole-
body activities incorporated during the training sessions. Specifically, there is
overwhelming literature to suggest the presence of motor impairments such as postural
instability, locomotor difficulties, as well as motor incoordination in children with ASD
(Bhat et al., 2011; Chukoskie et al., 2013; Fournier et al., 2010; Isenhower et al., 2012;
McPhillips et al., 2014; Staples and Reid, 2010). Hence, these motor impairments might
have made it difficult for children to perform the gross motor activities included within
the training session. We believe that the comparative low verbal children in the music
and robot group expressed this difficulty by getting frustrated, agitated, and angry,
whereas the high verbal children in the yoga group verbalized with the trainer regarding
their difficulty in performing the activities. There is literature to suggest that children with
ASD could increase their repetitive/ stereotypical and negative behaviors to express
frustration and agitation with challenging and unfamiliar activities (Cunningham and
Schreibman, 2008; Durand and Carr, 1987; Joosten et al., 2012). Specifically, the
stereotypical behaviors of children with ASD varied with the task difficulty such that
children showed greater stereotypical behaviors such as hand flapping and body rocking
during difficult tasks compared to simpler tasks (Durand and Carr, 1987). Interestingly,
functional communication training such as saying ‘Help me’ during difficult tasks
reduced the stereotypical behaviors of children (Durand and Carr, 1987).
4.4.5 Limitations of the Study

One of the main limitations of the current study is the comparatively smaller sample size with a mix of high and low functioning children. Secondly, the three groups were not perfectly matched as the yoga group had a comparatively higher proportion of high verbal children compared to the other two groups. In spite of matching the children on the age, gender, and level of functioning, we were unable to achieve a perfect match of children across the three groups. Thirdly, we were unable to determine the maintenance of gains in the communication and motor skills of children following the intervention due of lack of a follow-up session after the completion of the study.

4.5 Conclusions

The current study compared the efficacy of three movement interventions based on music, robot, and yoga theme on the motor, communication, and affective states of children with ASD between 5 and 12 years of age. Our results indicated that socially-embedded, movement interventions could be a promising tool to improve the motor as well as the communication skills of children with ASD. In terms of group-specific differences, the yoga group showed greater social responsive verbalization and interested affect, the robot group showed greater self-verbalization and negative affect, and the music group greater positive and negative affect compared to the other two groups. Given our study results, we argue that movement interventions could be highly beneficial for children with ASD and should be incorporated within the usual treatment protocols for children with ASD.
Chapter 5

CONCLUSIONS

Movement is an integral part of early childhood and helps children successfully explore their environment in several ways. A sound motor system not only offers functional independence, but also helps learn several vital skills including social, emotional, and cognitive skills. For example, onset of walking in infancy offers functional mobility, as well as several opportunities for social engagement and sharing with caregivers. Keeping this in mind, motor treatment or approaches become highly essential for children with movement disorders including Autism Spectrum Disorder (ASD). Although, the diagnostic impairments of ASD are within the social communication and restricted/repétitive behavior domain, children with ASD show significant gross motor deficits such as postural instability and unstable gait, fine motor deficits such as poor handwriting and object control, and bilateral incoordination such as variable reaching and drumming actions. The current treatment approaches for ASD primarily target the communication, academic, and positive behaviors of children, with limited to no focus on the motor skills of children. Moreover, the current approaches involve table-top, seated activities, which further limits the opportunities for children to explore their motor skills. Clearly, there is a need to change the current trend of treatment approaches in ASD to
include more holistic interventions targeting the motor as well as the core social communication skills of children with ASD.

5.1 Yoga Intervention for Children with ASD

Yoga-based interventions are documented to improve the motor skills such as balance, strength, flexibility, and the behavioral skills such as attention, spatial memory, and relaxation of children with and without special needs. The primary goal of the current project was to examine the effects of 8-week yoga intervention on the motor, social communication, and behavioral skills of children with ASD between 5 and 12 years of age. Specifically, we developed a socially-embedded, movement intervention including social games such as greetings and co-operative actions, motor games such as yoga postures, and relaxing games such as breathing and guided imagery. Moreover, we provided a highly engaging training context by including age-appropriate stories, songs, and games, as well as using fun props within the training activities. Our results indicated that socially-embedded, yoga activities improved the gross motor performance, imitation accuracy, joint attention, and communication skills of children with ASD, with no changes in the affective states and maladaptive behaviors of children. Specifically, in terms of the gross motor performance, children showed improvements in the strength, bilateral coordination, and balance subtests of a standardized motor test administered by a novel tester. In terms of imitation accuracy, children reduced their imitation errors and required fewer prompts while copying the standardized actions of a novel tester as well as the training-specific actions of the familiar trainer. In terms of joint attention, children
with ASD required fewer cues to respond to the attentional bids initiated by a novel tester on a standardized test. In terms of social communication, children increased the percent duration of responsive and spontaneous verbalizations/ vocalizations directed towards the trainers in the latter compared to the initial training sessions. In terms of affective states, children showed no changes in the affect over the training as they were showing ceiling levels of interested affect from the beginning to the end of the training. Lastly, in contrast to our expectations, children showed no changes in the frequency of maladaptive behaviors such as sensory, stereotypical, and negative behaviors over the training. Overall, we believe that whole-body movement-based interventions delivered within a socially rich environment could improve the motor, imitation, joint attention, and communication skills of children with ASD, and hence should be included in the standard-of-care treatment for children with ASD. Our training was fun and engaging for children as indicated by the high levels of interested affect. Moreover, the parents provided social validity for the intervention by reporting the intervention as useful and beneficial for their child.

5.2 Comparing Movement Interventions for Children with ASD

As indicated above, movement interventions are vital for children with motor deficits including children with ASD. In our lab, we have delivered movement interventions on various engaging themes including music, robot, and yoga in children with ASD. The secondary aim of the current project was to compare the efficacy of three different movement interventions in our lab, i.e. yoga-, music-, and robot-based intervention on
the motor, communication, and affective states of children with ASD between 5 and 12 years of age. Our results indicated that all three movement groups were equally effective in improving the gross motor performance and communication skills of children, with no changes in the affective states of children. Specifically, in terms of gross motor performance, children improved on the Body Coordination subtest of a standardized motor test administered by a novel tester. In terms of communication skills, children increased the percent duration of verbalizations/ vocalizations produced during the latter part of the training compared to the initial training sessions. The group differences were only observed for the different types of verbalization and affect shown by children throughout the training. Specifically, the yoga group offered greater opportunities for social responsive verbalization with the trainers, with children showing high levels of interested affect throughout the training. The robot group showed greater self-verbalization, with children showing high levels of negative affect during the training sessions. Lastly, the music group showed high levels of positive and negative affect throughout the training. Given our study results, we argue that movement-based interventions delivered within enjoyable contexts including musical, robotic, or yoga context could be highly beneficial for children with ASD by improving the motor and communication skills of children.
5.3 Limitations and Future Directions

The current study provided valuable insights for the use of movement-based interventions in children with ASD. However, due to several limitations in the study, we suggest further investigation of movement contexts in this population to make a stronger case for the inclusion of motor interventions in the standard-of-care treatment programs for ASD. Firstly, our study included a relatively smaller sample of 12 children with a mix of both high and low functioning children, for example, few children were highly fluent compared to others who were completely non-verbal. Hence, we suggest future studies with large sample size and homogenous population to investigate the role of movement interventions in ASD. Additionally, we recommend extending this work to younger age groups—i.e. 2 to 4 years old as early interventions could produce greater impact on the overall development of children. The second limitation of the yoga study was the lack of a no treatment, control group. Hence, our study results need to be replicated through future randomized controlled trials to ensure that improvements in children were related to the training and unrelated to the maturation or repeated testing of children. Additionally, we emphasized the importance of highly engaging treatment context for children by incorporating age-appropriate themes and context within the training session, however, it would be interesting to compare the efficacy of these interventions to the standard physical therapy approaches popular in the clinical practice. Thirdly, although, our training suggested improvements in the gross motor skills of children, we did not assess the sustenance of improvements using follow-up testing. Additionally, we did not
assess the carry-over effects to more functional tasks such as toileting, dressing, and other self-care activities. Hence, we would recommend future studies to include appropriate follow-up tests as well as create training context to target the functional skills of children. Next, we included a relatively smaller duration of training period, i.e. 8 weeks, with a relatively intense frequency, i.e. 2 expert and 2 parent sessions each week. However, there was variability in terms of total sessions delivered by parent for each child, and we were unable to tease apart the influence of parent adherence on the overall improvements in the child. Lastly, in addition to further investigating the role of yoga intervention, there is a need to explore other ideas of movement interventions including aquatic therapy, horse-back riding, and dance therapies. Currently, our lab is exploring the effects of dance-based movement intervention in children with ASD. Additionally, we will be examining the neural correlates of motor deficits and motor function in children with ASD using Functional Near Infrared Spectroscopy (fNIRS).
REFERENCES


### FIDELITY CHECKLIST

**Date of Entry:** ______  **ID#:** ________  **Session#:** ____  **(Expert/Parent):______**

<table>
<thead>
<tr>
<th>Fidelity Measures</th>
<th>Training Components</th>
<th>Max points (79)</th>
<th>Score</th>
<th>Feedback for Trainer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Introduction – 9 points</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Show PECS to the child.</td>
<td>Trainer shows the PECS and introduces all the activities for the day.</td>
<td>1 point</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Introduce condition using PECS</td>
<td>Trainer asks the child, “So what are we going to do first? Can you point to it?”</td>
<td>1 point</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Ready position & Ready response | - Trainer makes sure that the child is sitting on his/her mat with hands by the side. Model shows the ready position to the child.  
- Trainer asks the child, “Are you ready” or “Let’s get ready”? Give points if child is already attentive. | 1 point | | |
| Condition Instructions | Trainer says, “Today we are going to sing the hello song” | 1 point | | |
| Trials | - 1st trial – Trainer sings the whole song while saying hi to child.  
- 2nd trial – Trainer waits for child to fill in words during the song. | 2 points (1 point per trial) | | |
<p>| Social bid 1 (Not done for S1/8/16) | Model makes the social bid and waits for the child to answer and then makes the appropriate follow-up comment. | 1 point | | |
| Recall test (Only for even #ed sessions) | Trainer asks child to recall poses of the previous session. (Applicable only to even numbered sessions) | 1 point | | |
| Transition with PECS | Trainer prompts child to move the picture down on the board following completion of the condition. | 1 point | | |
| <strong>Contact game – 9 points</strong> | | | | |
| Introduce condition using PECS | Trainer asks the child, “So what are we going to do next? Can you point to it?” | 1 point | | |
| Ready position &amp; Ready response | Trainer ensures that the child is ready for the condition. Gets the child to come to his/her spot. Asks, “Are you ready for the contact game?” If the child is already in a ready position, give point. | 1 point | | |
| Condition Instructions | Trainer says, “Today we are going to play the ________game.” | 1 point | | |
| Trials | - 1st trial – Trainer leads the game. Score points if | 2 points (1 | | |</p>
<table>
<thead>
<tr>
<th><strong>Task</strong></th>
<th><strong>Instructions</strong></th>
<th><strong>Points</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Social praise – Gestural &amp; Verbal</strong></td>
<td>Child participates in the game.</td>
<td>point per trial</td>
</tr>
<tr>
<td></td>
<td>- 2nd trial – Child leads the game.</td>
<td></td>
</tr>
<tr>
<td><strong>Social bid 2</strong></td>
<td>Model makes the social bid and waits for the child to answer and then makes the appropriate follow-up comment.</td>
<td>1 point</td>
</tr>
<tr>
<td><strong>Transition with PECS</strong></td>
<td>Trainer prompts child to move the picture down on the board following completion of the condition.</td>
<td>1 point</td>
</tr>
<tr>
<td><strong>Breathing game – 12 points</strong></td>
<td><strong>Introduce condition using PECS</strong></td>
<td>1 point</td>
</tr>
<tr>
<td></td>
<td>Trainer asks the child, “So what are we going to do next? Can you point to it?”</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Ask for help</strong></td>
<td>1 point</td>
</tr>
<tr>
<td></td>
<td>Trainer asks child for help to get the props needed for the condition. (Applicable only if props are used for the condition)</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Ready position &amp; Ready response</strong></td>
<td>1 point</td>
</tr>
<tr>
<td></td>
<td>Trainer ensures that the child is ready for the condition. Gets the child to come to his/her spot and asks, “Are you ready to begin?” If the child is already in a ready position, give point.</td>
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</tr>
<tr>
<td></td>
<td><strong>Condition Instructions</strong></td>
<td>1 point</td>
</tr>
<tr>
<td></td>
<td>Trainer says, “Today we are going to do ______ breathing. Make sure to copy me.”</td>
<td></td>
</tr>
<tr>
<td><strong>Trials</strong></td>
<td><strong>Breathing game 1</strong></td>
<td>4 points (1 point per trial)</td>
</tr>
<tr>
<td></td>
<td>- 1st trial – Trainer shows the breathing exercises to the child. Score full points if child attempts the game.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 2nd trial – Child practices the game again.</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Breathing game 2</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 1st trial – Trainer shows the second breathing exercise to the child. Score points if child attempts the game.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 2nd trial – Child practices the game again.</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Social praise – Gestural &amp; Verbal</strong></td>
<td>2 points (1 point for trainer bid, 1 point for model bid)</td>
</tr>
<tr>
<td></td>
<td>Gestural: Model provides hi-fives, low-fives, fist bumps and waits for response (at least 1 bid). Verbal: Trainer provides verbal reinforcement (at least 1 bid).</td>
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<tr>
<td></td>
<td><strong>Help for cleanup</strong></td>
<td>1 point</td>
</tr>
<tr>
<td></td>
<td>Trainer asks the child for help with cleanup of all props. (Applicable only if props are used for the condition).</td>
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<tr>
<td></td>
<td><strong>Transition with PECS</strong></td>
<td>1 point</td>
</tr>
<tr>
<td></td>
<td>Trainer prompts child to move the picture down on the board following completion of the condition.</td>
<td></td>
</tr>
<tr>
<td><strong>Looking game – 10 points</strong></td>
<td><strong>Introduce condition using PECS</strong></td>
<td>1 point</td>
</tr>
<tr>
<td></td>
<td>Trainer asks the child, “So what are we going to do next? Can you point to it?”</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Ready position &amp; Ready response</strong></td>
<td>1 point</td>
</tr>
<tr>
<td></td>
<td>Trainer ensures that the child is ready for the condition. Gets the child to come to his/her spot. Asks, “Are you ready to play the looking game?” If the child is already in a ready position, give point.</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Condition Instructions</strong></td>
<td>1 point</td>
</tr>
<tr>
<td></td>
<td>Trainer says, “Today we are going to play ______ game. But let’s do some warm up first”.</td>
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<tr>
<td>Trials</td>
<td>Neck/eye exercises</td>
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<tr>
<td>--------</td>
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<tr>
<td></td>
<td>Trainer shows the child neck/body part exercises. Score points if child attempts the exercises.</td>
<td></td>
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<tr>
<td></td>
<td><strong>Looking game</strong></td>
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<tr>
<td></td>
<td>- 1st trial – Trainer leads the game and asks the child to follow trainer’s gaze. Score points if child attempts the game.</td>
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<tr>
<td></td>
<td>- 2nd trial: Child/model leads the game. (For charades, score points if 4 actions of dumb charades are attempted in the session).</td>
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<tr>
<td></td>
<td>3 points (1 point per trial)</td>
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</table>

<table>
<thead>
<tr>
<th>Social praise – Gestural &amp; Verbal</th>
<th>Gestural: Model provides hi-fives, low-fives, fist bumps, and waits for response (at least 1 bid). Verbal: Trainer provides verbal reinforcement (at least 1 bid).</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2 points (1 point for trainer bid and 1 point for model bid)</td>
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</table>

<table>
<thead>
<tr>
<th>Social bid 3</th>
<th>Model makes the social bid and waits for the child to answer and then makes the appropriate follow-up comment.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 point</td>
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<table>
<thead>
<tr>
<th>Transition with PECS</th>
<th>Trainer prompts child to move the picture down on the board following completion of the condition.</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>1 point</td>
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<table>
<thead>
<tr>
<th>Pose &amp; partner game – 15 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduce condition using PECS</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Ready position &amp; Ready response</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Condition Instructions</td>
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<tr>
<td></td>
</tr>
<tr>
<td>Session theme (asked during second trial of poses)</td>
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<tr>
<td></td>
</tr>
<tr>
<td>Trials</td>
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<tr>
<td></td>
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<td></td>
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<tr>
<td>Partner poses</td>
</tr>
<tr>
<td></td>
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<tr>
<td>Social praise – Gestural &amp; Verbal</td>
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<tr>
<td></td>
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<tr>
<td>Transition with PECS</td>
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<table>
<thead>
<tr>
<th>Relaxation game – 6 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduce condition using PECS</td>
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<tr>
<td></td>
</tr>
<tr>
<td>Condition Instructions</td>
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<tr>
<td>-------------------------</td>
</tr>
<tr>
<td><strong>Ready position</strong></td>
</tr>
<tr>
<td><strong>Guided Imagery</strong></td>
</tr>
<tr>
<td><strong>Thanking</strong></td>
</tr>
<tr>
<td><strong>Transition with PECS</strong></td>
</tr>
</tbody>
</table>

**Farewell – 7 points**

<table>
<thead>
<tr>
<th>Introduction using PECS</th>
<th>Description</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ready position &amp; Ready response</strong></td>
<td>Trainer ensures that the child is ready for the condition. This might involve getting the child to come to his/her spot and then asking the child, “Are you ready to say goodbye?”</td>
<td>1 point</td>
</tr>
<tr>
<td><strong>Condition Instructions</strong></td>
<td>Trainer says, “Today we are going to sing the __________________ goodbye song”.</td>
<td>1 point</td>
</tr>
</tbody>
</table>
| **Trials**              | - Bye to the child – Trainer sings the whole song and says bye to the child.  
                        | - Bye to model/trainer – Trainer waits for child to fill in words during the song and asks child to say bye to the model. | 2 points (1 point per trial) |
| **Help for clean up**   | Trainer asks the child to roll the mat and help in clean up.                | 1 point |
| **Transition with PECS**| Trainer prompts child to move the picture down on the board following completion of the condition. | 1 point |

**General Session Characteristics – 11 points**

<table>
<thead>
<tr>
<th>Session conditions completed</th>
<th>Description</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Introduction</strong></td>
<td></td>
<td>8 points (1 point per condition)</td>
</tr>
<tr>
<td><strong>Contact game</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Breathing game</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Looking game</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Pose game</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Partner game</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Relaxation &amp; thanking</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Goodbye song</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Environmenta l arrangement</th>
<th>Description</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Trainer</strong></td>
<td>Trainer is facing the child. Limited materials in the vicinity. Props kept away and within trainer’s control. Model sits/stands at an angle to the child</td>
<td>1 point</td>
</tr>
<tr>
<td><strong>Eye contact</strong></td>
<td>Trainer makes sure to obtain eye contact with the child while asking any question or while providing any commands. If the child does not provide eye contact, the trainer prompts by saying, “Can you look at me _______? Can you show me good looking?”</td>
<td>1 point</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Incremental prompts</th>
<th>Description</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Visual model</strong></td>
<td>Within each condition, the trainer provides incremental prompts as necessary to get the child to copy her.</td>
<td>1 point</td>
</tr>
<tr>
<td><strong>Verbal prompts</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Hand on hand assistance</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix B

BRUNINIKS OSERETSKY TEST OF MOTOR PROFICIENCY (BOT-2)

1. Examples of Gross Motor Items
2. Examples of Fine Motor Items
Appendix D

YOGA POSE TEST

STANDING POSES

SITTING POSES

LYING POSES
Appendix E

EXIT QUESTIONNAIRE

1. I found the intervention very useful.

<table>
<thead>
<tr>
<th>Do not Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

2. I found the intervention highly innovative.

<table>
<thead>
<tr>
<th>Do not Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

3. I am satisfied with the intervention.

<table>
<thead>
<tr>
<th>Do not Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

4. I would recommend the intervention to other parents.

<table>
<thead>
<tr>
<th>Do not Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

5. I would continue the intervention with my child after the study.

<table>
<thead>
<tr>
<th>Do not Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>
Appendix F

JOINT ATTENTION TEST

Check when complete

Points Earned

_____ 1. Hold out hand for shaking, or wave “hi” (no verbal prompt)
   “Hey Joey!” (With gesture of shaking hands or waving “hi”)
   “Joey, could you give me a handshake/could you wave hi?” (With gesture)
   □ Correct action
   □ Look at face
   □ Eye contact
   □ Smil
   □ Verbal response __________________________
   □ Response Level (L1/ L2/ L3) ________________

_____ 2. Hand Pen (no verbal prompt)
   “Hey Joey, take this!” (With gesture)
   “Joey, do you want to take this pen?” (With gesture)
   □ Correct action
   □ Look at face/appropriate direction
   □ Eye contact
   □ Verbal response __________________________
   □ Response Level (L1/ L2/ L3) ________________

_____ 3. Look at the poster on the side and say “That reminds me of…..” or “How beautiful is that……?” (No gesture)
   “Look at that!” (With gaze, no gesture)
   “Joey, look at that picture!” (With gaze, no gesture)
   □ Correct action (worth 3 points)
   □ Look at face/appropriate direction
   □ Eye contact
   □ Verbal response __________________________
   □ Response Level (L1/ L2/ L3) ________________

_____ Additional prompt – Look at another similar picture and say “And how about that one? What’s that….?” (With point)
   □ Correct action (worth 3 points)
   □ Look at face/appropriate direction
   □ Eye contact
   □ Verbal response __________________________

_____ 4. Novel object: Look at the object and say “That looks interesting!” (no gesture)
   “Joey, do you know what that is?” (with gaze, no gesture)
“Have you seen the Tomá before?” (with point)
- Correct action (worth 3 points)
- Look at face/appropriate direction
- Eye contact
- Verbal response ______________________________
- Response Level (L1/ L2/ L3) _____________________

5. Personal object prompt: “My brother/sister has those…”
   “Where did you get that, Joey?” (With gaze, no gesture)
   “Where did you get that watch/shoe/wristband?” (With gaze, no gesture)
   - Correct action (worth 3 points)
   - Look at face/appropriate direction
   - Eye contact
   - Verbal response ______________________________
   - Response Level (L1/ L2/ L3) _____________________

6. Hi-five prompt: Show hand (no verbal prompt)
   “You did a really good job!?” (With gesture)
   “Hey Joey, could you give me a hi-five?” (With gesture)
   - Correct action
   - Look at face/hand
   - Eye contact
   - Verbal response ______________________________
   - Response Level (L1/ L2/ L3) _____________________

7. Lo-five prompt: Show hand (with no verbal response)
   “Great job!” (With gesture)
   “Hey, Joey, could you give me a lo-five?” (With gesture)
   - Correct action
   - Look at face/hand
   - Eye contact
   - Verbal response ______________________________
   - Response Level (L1/ L2/ L3) _____________________

8. Hold out hand for waving bye (no verbal prompt)
   “Hey Joey!” (With gesture of waving “bye”)
   “Joey, could you wave bye?” (With gesture of waving “bye”)
   - Correct action
   - Look at face/appropriate direction
   - Eye contact
   - Smile
   - Verbal response ______________________________
   - Response Level (L1/ L2/ L3) _____________________

TOTAL POINTS
Appendix G

IRB APPROVED CONSENT FORM

University of Delaware
Parental Permission Form – Full Consent

Title of Project: Play Intervention Study

Principal Investigator(s): Anjana Bhat, PT, PhD

Other Investigators: None

You are being asked to participate in a research study. This form tells you about the study including its purpose, what you will be asked to do if you decide to participate, and any risks and benefits of being in the study. Please read the information below and ask the research team questions about anything we have not made clear before you decide whether to participate. Your participation is voluntary and you can refuse to participate or withdraw at any time without penalty or loss of benefits to which you are otherwise entitled. If you decide to participate, you will be asked to sign this form and a copy will be given to you to keep for your reference.

WHAT IS THE PURPOSE OF THIS STUDY?

This purpose of this project is to compare the effects of four different play-based interventions on the motor and social communication skills of children with autism between 3 and 14 years of age. These interventions will be a useful treatment tool for clinicians and parents who work with children with social and motor impairments such as autism, developmental coordination disorders, etc.

Children with autism spectrum disorders and other related disorders (Attention Deficit Hyperactivity Disorders, Developmental coordination Disorders (DCD), Rett’s Disorder, or Fragile X Syndrome) between 3 to 14 years of age may participate in this study. We plan on recruiting up to 100 children with Autism Spectrum Disorders.

A research assistant will call you to take you through this form and tell you more about the study. If you are interested in participating in the study, we will also interview you to obtain demographic information and to ensure your child’s eligibility. In addition, you will be asked to fill out questionnaires on your child’s development. Specifically, families of children with autism spectrum disorders will need to provide us with a medical record or a letter from your child’s physician, pediatrician, psychiatrist, or psychologist confirming the child’s diagnosis and level of functioning. We will also have you complete a screener called the Social Communication Questionnaire to briefly assess your child’s social functioning. In addition, you will have to schedule a visit to our lab or the UD Psychology clinic for us to confirm your child’s IQ level and severity of autism. Additional testing could be done in our lab, at your home, or at your school depending on your convenience and permission from your child’s school administrator. We will be videotaping all the sessions we conduct with your child.

Page 1 of 6

Parent’s/Guardian’s initials:_____

170
WHAT WILL YOU BE ASKED TO DO?

If you and your child agree to be in the study, your child will participate in 36 hours of testing and training. These include four testing sessions (two tests before and two tests after the training weeks) and 32, 30-45 minute training sessions delivered over an eight-week period. Each test lasts about one hour and is conducted at our lab or child's home/school. Expert trainers deliver two sessions at home/school and parents deliver two more sessions at home each week. Parents/teachers are to join the child during the expert sessions; however, if they are unable to do so we do ask them to be in the vicinity of the testing/ training area. You will also be receiving about 30 minutes of training each week on how to complete the homework with your child. Overall, you and your child will participate over ten weeks (or 38 testing or training sessions).

Testing sessions: During these sessions we will obtain pre- and post-training measures of your child’s motor and social skills using standardized tests as well as motion analysis. During the first testing session, your child will be asked to perform many gross motor and balance activities and his/her performance will be rated. Each activity will be explained and demonstrated to the child and then he/she will have to copy the tester’s actions. We will also conduct a play-based session to examine your child’s social skills.

During the second testing session, your child will be involved in various whole body actions, drumming, and walking games such as moving slow and fast to the beat of slow or fast music. We will place electromagnetic sensors on the child’s hands and feet to examine their arm and leg motions. A portable electromagnetic system will help track your child’s movements. In addition, your child may don a headband to examine his/her attention patterns. The headband carries a tiny video camera that records eye gaze data of your child into a light camcorder inside the child’s vest. We use non-allergic, micropore tape to stick the markers onto your child’s hands. Lastly, you will be asked to fill out additional questionnaires regarding your child’s motor skills and everyday activities.

Lastly, your child will be asked to walk across an open area/hallway over a 2-minute period. Before and after the test we will collect measures such as breathing rate, heart rate, and blood pressure using non-invasive, finger or wrist, non-invasive, portable devices. At the end of the session, we will show you how to use the device that measures your child’s activity rate and we will ask your child to wear it over any two 6-hour to 12-hour periods, when the child is active. You will also fill out a log of physical activity/inactivity for the day when your child wore the activity monitor. Similar measures will be obtained during early, mid, and late training sessions.

Training sessions: During each training session, activities will differ based on the grouping of the child. Your child will be randomly assigned to one of the play-based groups (A, B or C) or the “tabletop play” group (Group D) or the control group (Group E).
Children in Group A will go through several different conditions. Within each condition, your child will be asked to move together with the adult trainer or take turns with the adult trainer. The session will start with your child singing introductory songs with the trainer. Next, your child will move to the beat of music. In addition, your child will sing action songs as he/she imitates the trainer and engage in music making using various instruments. Next, your child will play walking games and will end with a calming activity to soothing music. Lastly, the session will end with a farewell song. Each session lasts for about 30 to 45 minutes.

Children in Group B will engage in various yoga-based activities such as breathing exercises, eye-head movements, whole body stretching, chanting/storytelling, and relaxation. Activities will increase in complexity across weeks based on postures acquired as well as breathing patterns. Stretching will be done in various body postures. Movements will be done synchronously as a group or turns will be taken between the group members. Each training session lasts about 30 to 45 minutes. We will play songs and music appropriate for the theme of the day (songs, stories, and games).

Children in Group C will engage in various dance-based activities such as introductory sequences, warm up sequences, eastern dances, western dances, cool down, and closing sequences. Movements will be done synchronously as a group or turns will be taken between the group members. Each training session lasts about 30 to 45 minutes. We will be playing songs and music appropriate to the various dance forms learned.

Children in Group D will engage in several different table-top activities using a variety of toys including i) reading books ii) building activities with legos, puzzles etc, and iii) art-crafts involving coloring, cutting, and pasting. Each session lasts for about 30 to 45 minutes. Within each activity, your child will work with an adult trainer who guides the child and plays with the child during the different activities.

Children in Group E will not receive any intervention. However, they will receive assessments of social and motor functioning during one pretest and posttest.

WHAT ARE THE POSSIBLE RISKS AND DISCOMFORTS?

The risks associated with this study are minimal to absent. Occasionally, some participants may experience fatigue during testing. If you or your child becomes fatigued during testing or training, we will take a break or stop. In addition, during testing we attach sensors onto your child’s hands using non-allergenic tape; however, it is possible that your child may develop some skin irritation. If your child is afraid of the training activities, we will discontinue the session.

In a school or preschool setting, your child may feel inconvenienced because he or she is being pulled out of class activities. We will be very flexible to do the testing during a time that is preferred by the child and the teacher. If you choose to visit our lab, there may be inconveniences involved in scheduling multiple visits to our lab. We will do our best to accommodate you and your child's schedules. You are free to ask questions at any time during
the study. Children with autism may have difficulty participating in social interactions with others. We will make best efforts to work with the teacher or the parent to ensure that the child feels secure. We will not begin or continue testing if the child is upset or asks to stop testing.

WHAT ARE THE POTENTIAL BENEFITS?

There may not be immediate and direct health benefits for you or your child. Your taking part in this study may help others in the future. The information gained from your participation will improve our understanding of how play-based interventions benefit children with autism. The knowledge gained from this study may develop a treatment to enhance the social, communication, and motor skills of children with autism.

HOW WILL CONFIDENTIALITY BE MAINTAINED?

Your child’s confidentiality is protected through the following procedures: All data that contain personal information are kept locked in a secure location at the STAR campus, University of Delaware, Newark, DE. Identification numbers will be assigned to all participants and these numbers will be used on all tests, questionnaires, and videotapes. We will use password-protected computers. We will limit access to the data to only those individuals who work on the project. Your research records may be viewed by the University of Delaware Institutional Review Board, but the confidentiality of your records will be protected to the extent permitted by law.

We also must let you know that if during your participation in this study our research team was to observe or suspect, in good faith, child abuse or neglect, we are required by Delaware state law obligates us to file a report to the appropriate officials.

WILL THERE BE ANY COSTS TO YOU FOR PARTICIPATING IN THIS RESEARCH?

The study procedures will be provided at no cost to you. If you visit our lab you will incur the costs of transportation to and from the lab. Parking is free.

WILL YOU RECEIVE ANY COMPENSATION FOR PARTICIPATION?

You and your child will receive $50 as participation incentive on completion of all testing sessions and a significant number of the training sessions.

WHAT IF YOU ARE INJURED DURING YOUR PARTICIPATION IN THE STUDY?

If you are injured during research procedures, you will be offered first aid at no cost to you. If you need additional medical treatment, the cost of this treatment will be your responsibility or that of your third-party payer (for example, your health insurance). By signing this document you are not waiving any rights that you may have if injury was the result of negligence of the university or its investigators.
DO YOU HAVE TO TAKE PART IN THIS STUDY?

Taking part in this research study is entirely voluntary. You do not have to participate in this research. If you choose to take part, you have the right to stop at any time. If you decide not to participate or if you decide to stop taking part in the research at a later date, there will be no penalty or loss of benefits to which you are otherwise entitled. Your refusal will not influence current or future relationships with the University of Delaware.

WHO SHOULD YOU CALL IF YOU HAVE QUESTIONS OR CONCERNS?

If you have any questions about this study, please contact the Principal Investigator, Anjana Bhat at 443-523-8680 or 302-831-7608 or email at abhat@udel.edu.

If you have any questions or concerns about your rights as a research participant, you may contact the University of Delaware Institutional Review Board at 302-831-2137.

ADDITIONAL PERMISSIONS

Please note that apart from permission 1, responding ‘No’ to other additional permissions does not make you ineligible for the study. However, if you say “No” to permission 1 we cannot continue your participation in the study as that would hinder our ability to accomplish the goals of this research.

1. I understand that this research requires collection of identifiable information, health information, and data such as questionnaires and videotapes. I also understand that my child will not be identified by his/her name on all forms of data. Hence, I give permission to retain all our data for 10 years for current and future studies.
   Parent or legal guardian initials here: ___

2. I understand that my child’s data including health forms, questionnaires, and video data can be used for future studies. Hence, I give permission to retain all our data indefinitely for current and future studies.
   Parent or legal guardian initials here: ___

3. I understand that no identifying information beyond that contained in my child’s picture/videotape will be provided in a scientific or educational session/document. Hence, I give permission to print/show my child’s picture/videotape to scientific and educational audiences for research and instructional purposes only.
   Parent or legal guardian initials here: ___

4. I understand that my child’s picture/videotape may be used for public relations purposes including advertisement/promotion of the study via internet, newspapers, radio, and television. However, I would like to be contacted to reconfirm my interest before my child’s picture/videotape is used for public relations purposes.
   Parent’s/Guardian’s initials: ___
picture/videotape is used. With this condition, I give permission to use my child's picture/videotape for public relations purposes only.
Parent or legal guardian initials here: ___

5. I understand that the researchers may contact me with questions regarding my child's development, new studies, or new developments in their research. I give them permission to retain our contact information for future communication.
Parent or legal guardian initials here: ___

_________________________________________________________________________________

You have been informed about the study's purpose, procedures, possible risks and benefits. You have been given the opportunity to ask questions about the research and those questions have been answered. You will be given a copy of this consent form to keep. Your signature below indicates that you and your child voluntarily consent to participate in the study (A) as well as you provide us permission to work with your child (B).

(A) Consent to participate

__________________________________________  ____________________________________  __________
Signature: Parent or Legal Guardian          Print Name                   Date:

(B) Parental permission

__________________________________________  ____________________________________  __________
Signature: Parent or Legal Guardian          Print Name                   Date:

_______________________________
Print Child’s Name                    Relationship to child: ______________

__________________________________________  ____________________________________  __________
Signature: Person Obtaining Consent     Print Name:                        Date:

Page 6 of 6                           Parent's/Guardian's initials: ___