Title
The Use of Eye-Tracking as an Assessment Measure for Social Attention in Autism Spectrum Disorder

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The Use of Eye-Tracking as an Assessment Measure for Social Attention in Autism Spectrum Disorder

A dissertation submitted in partial satisfaction of the

requirements for the degree Doctor of Philosophy

in Counseling, Clinical, and School Psychology

by

Anahita Navab

Committee in charge:

Professor Robert Koegel, Chair

Professor Erin Dowdy

Professor Ty Vernon

September 2017

The dissertation of Anahita D. Navab is approved

Erin Dowdy

Ty Vernon

Robert Koegel, Committee Chair

April 2016

ACKNOWLEDGEMENTS

I would like to first express my gratitude to the children, families, and adults with ASD that I have been fortunate enough to work with over the last seven years. You have taught me endless invaluable lessons, and I deeply admire your openness and willingness to collaborate and connect with me.

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I am very much appreciative for my incredible advisor and supervisor team, Drs. Robert and Lynn Koegel. You have both provided me with so many opportunities to learn and grow in academia, as well as clinically and personally. I am very thankful for your guidance, collaboration, and encouragement through all of these years.

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I am so grateful for all of my fellow graduate students and colleagues for their support and collaboration, especially Amber Miller, Jessica Bradshaw, Kristen Ashbaugh, Anna Krasno, Amy Barrett, Jordan Ko, Erin Engstrom, Alexis Olson, and Aileen Chang. All of you inspire me immensely and am very appreciative to have shared challenges, successes, and many laughs with you.

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Last, but certainly not least, thank you to my partner, Daniel P. Holden, who has been my companion, comic relief, life coach, and endless supporter throughout the most challenging times during graduate school. You have filled my experiences with so much love and brightness, and I cannot thank you enough for being there for me.

CURRICULUM VITAE
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EDUCATION

Ph.D. Candidate in Counseling, Clinical, and School Psychology, University of California, Santa Barbara, (expected) June 2017

- Emphasis in Clinical Psychology
- Dissertation Title: *The Use of Eye-Tracking as an Assessment Measure for Social Attention in Autism Spectrum Disorder*
- Prospectus Defended: June 2015
- Prospectus Chair: Robert L. Koegel, Ph.D.

M.A. Counseling Psychology, University of California, Santa Barbara, June 2014

- Thesis Title: *The Use of Reframing During Conversation in Adults with ASD*
- Thesis Advisor: Robert L. Koegel, Ph.D.

B.A. Psychology, University of California, Los Angeles, June 2006

- Cum Laude
- Psychology Departmental Honors Thesis: 2009-2010

CLINICAL EXPERIENCE

Therapist, Parent Educator & Researcher in Pivotal Response Treatment 2012-present
Agency: Koegel Autism Center
Setting: Department Clinic, University of California, Santa Barbara
Supervisors: Robert L. Koegel, Ph.D. Ty Vernon, Ph.D., & Lynn Kern Koegel, Ph.D.
Population: Children and adults age 2-30 & Families
Presenting Issues: Autism Spectrum Disorder, Asperger's Disorder, Pervasive Developmental Disorders, Behavior Problems, Speech and Language Disorders

- Provide parent education in empirically validated interventions, including Pivotal Response Treatment, functional assessment, self-management, priming, functional communication training, and social facilitation strategies
- Conduct individual behavior therapy with toddlers, children, adolescents, and adults with Autism Spectrum Disorder through funding agencies such as Autism Speaks and the Department of Rehabilitation (DOR)
- Supervise client programs and coordinate with undergraduate therapists, parents, teachers, and directors

- Perform clinical intakes, administer assessments, and write integrated psychological reports
- Collect behavioral data to develop clinical research projects, monitor client progress, and write quarterly progress reports
- Average 10-15 hours/week

Senior Assessment Clinician 2014 - present
Agency: Koegel Autism Center Assessment Clinic
Setting: Department Clinic, University of California, Santa Barbara
Supervisor: Ty Vernon, Ph.D.
Population: Children age 1-4 & Families
Presenting Issues: Autism Spectrum Disorder

- Conduct multi-day assessments with toddlers on the spectrum as a component of a treatment research grant funded by Autism Speaks
- Integrate information from a number of direct assessments and parent reports to establish appropriate diagnoses
- Assessments administered include Mullen Scales of Early Learning, Preschool Language Scales, Peabody Picture Vocabulary Test, Expressive Vocabulary Test, Preschool Language Scales, Vineland Adaptive Behavior Scales, MacArthur-Bates Communicative Development Inventory, Early Intervention Parenting Self-Efficacy Scale, eye-tracking assessments, and structured laboratory observations of parent-child interactions
- Provide therapeutic feedback to families addressing assessment results, diagnostic implications, and recommendations for treatment
- Compose integrated assessment reports including diagnosis, comprehensive assessment results, and treatment recommendations
- Average 4-8 hours/week

Assessment Center Clinician April 2013 - Aug. 2015
Agency: Psychology Assessment Center
Setting: Department Clinic, University of California, Santa Barbara
Supervisors: Jordan Witt, Ph.D., & Erik Lande, Ph.D.
Population: Children and adolescents 8 – 18 & Adults

- Conducted assessments with child, adolescent, and adult clients with a variety of referral questions such as personality, attention, and learning disorders
- Assessments included a clinical interview, cognitive, achievement, personality, and neuropsychological measures, and collaborative feedback sessions
- Assessments administered included the Wechsler Intelligence Scale for Children, Wechsler Adult Intelligence Scale, Wechsler Individual Achievement Test, Differential Ability Scales, Woodcock-Johnson Tests of Achievement, California Verbal Learning Test for Children, Rey-Osterrieth Complex Figure Test, Stroop Neuropsychological Screening Test, Comprehensive Trail Making Test, Test of Visual-Motor Integration, Conners' Continuous Performance Test, Personality Assessment Inventory, Behavior Assessment System for Children, Thematic Apperception Test, and Roberts Apperception Test.
- Average 2-5 hours/week

Psychological Assistant Sept. 2014 - Dec. 2015
Agency: Child Abuse Listening and Mediation (CALM)
Setting: Community Mental Health Agency, Santa Barbara, CA
Supervisors: Ryan M. Smith, Psy.D. (individual) & Jessica Adams, Ph.D. (group)
Population: Children ages 2 mo – 7 years, Families & Adults
Presenting Issues: Child sexual, physical, and emotional abuse, neglect, domestic violence, Post Traumatic Stress Disorder, severe mood and behavior disorders, substance abuse, Post-Partum Depression, prevention of child abuse with children 0 – 5 and their families

- Conducted individual and family psychotherapy with a socioeconomically diverse cross-section of children and families for whom traumas such as recent or past child abuse, sexual abuse, or family violence were a major treatment concern
- Used evidence-based treatment methods, including Trauma-Focused Cognitive-Behavior Therapy, Parent-Child Interaction Therapy (PCIT), Acceptance and Commitment Therapy (ACT), mindfulness, parenting didactics, play therapy strategies and behavioral management strategies
- Co-led a children's domestic violence group (ages 5-7) and a Dialectical Behavior Therapy (DBT) skills group for parents
- Conducted semi-structured intake interviews, administered assessments, and utilized information from a number of sources to inform case conceptualization and treatment planning
- Conducted assessments including clinical interviews, school observations and consultations with various professionals
- Coordinated with professionals such as school teachers, Child Welfare Services staff, and special education school staff in order to best serve client needs
- Average 15-20 hours/week

Assessment Specialist June 2013-Aug. 2014
Agency: Child Abuse Listening and Mediation (CALM)
Setting: Community Mental Health Agency, Santa Barbara, CA
Supervisor: Jessica Adams, Ph.D.

- Scored assessments, including the Trauma Symptom Checklist for Children, Trauma Symptom Inventory, Achenbach's Child Behavior Checklist, Parenting Stress Index, Adult Adolescent Parenting Inventory, Center for Epidemiology Depression Scale, and Child Sexual Behavior Inventory
- Wrote intake, follow-up, and termination assessment reports based on assessment results
- Made treatment recommendations based on assessment results; analyze data for reports, and collaborated with assessment team members to create an efficient assessment process for the agency
- Average 8 hours/week

Clinical Therapist, Advanced Practicum June 2013 - March 2014
Agency: Hosford Counseling & Psychological Services Clinic
Setting: Department Clinic, University of California, Santa Barbara
Supervisors: Steve Smith, Ph.D., & Heidi Zetzer, Ph.D.

Population: Couples, Families, & Adults
Presenting Issues: Depression, Bipolar Disorder, Anxiety, Childhood Trauma, Adjustment Disorders, and difficulties in social relationships, family, and marital issues

- Conducted outpatient psychotherapy using Short Term Psychodynamic Psychotherapy, Acceptance Commitment Therapy (ACT), and methods of case conceptualization
- Conducted therapy sessions in the individual and couples modality
- Conducted clinic intakes and presented intake cases to clinic supervisors for case assignment
- Maintained case files, wrote case notes, and attended monthly clinic meetings and weekly individual and/or group supervision
- Average 10 hours/week

Clinical Therapist, Basic Practicum Jan. 2013 - April 2014
Agency: Hosford Counseling & Psychological Services Clinic
Setting: Department Clinic, University of California, Santa Barbara
Supervisor: Heidi Zetzer, Ph.D.
Population: Undergraduate Students

- Conducted brief therapy (three sessions) for clients of varying cultural backgrounds
- Administered assessments to track progress and wrote brief reports
- Used basic therapy skills from Rogerian, Psychodynamic, and Cognitive-Behavioral models
- Average 5 hours/week

Clinician, Applied Behavior Analysis Autism Treatment 2010 - 2011
Agency: Early Child Partial Hospitalization Program (ECPHP)
Setting: Semel Institute, University of California, Los Angeles
Supervisors: Tanya Paparella, Ph.D., & Stephanie Freeman, Ph.D.
Population: Children ages 2-13
Presenting Issues: Autism Spectrum Disorder and Pervasive Developmental Delays

- Implemented early intervention for children with autism
- Engaged in applied behavioral analysis individualized to patients' specific needs
- Average 5-10 hours/week

Therapist, Pivotal Response Treatment 2010 - 2011
Agency: Koegel Autism Center
Setting: Home, community
Supervisors: Anne Paullin, M.A., & Lynn Koegel, Ph.D.
Population: Children ages 3-13
Presenting Issues: Autism Spectrum Disorder and Pervasive Developmental Delays

- Obtained reliability in coding and conducting Pivotal Response Treatment
- Conducted individual behavior therapy with children
- Average 10-15 hours/week

Clinician, Day Treatment Intensive Program 2009 - 2010
Agency/Setting: Day Treatment Intensive Program, Children's Institute, Inc., Torrance

Supervisor: Bruce Baker, Ph.D.
Population: Children ages 3-5
Presenting Issues: Behavioral/emotional difficulties due to child neglect/abuse

- Assisted in the Day Treatment Intensive Program, preparing and leading activities
- Modeled effective child development and behavior management
- Intervened and assisted in de-escalation of crisis situations
- Average 5-10 hours/week

Clinician, Music Therapy/Child Life Services 2007 - 2010
Agency/Setting: UCLA Mattell Children's Hospital
Supervisor: Amy Bullock, Director
Population: Children ages 3-13
Presenting Issues: Pediatric physical injuries/disease/disorders

- Assisted the hospital's licensed music therapist in developing the Music Rx Program
- Used musical and general helping techniques to improve emotional, mental, and physical wellbeing of hospitalized children with a range of medical conditions
- Average 5 hours/week

SUPERVISION EXPERIENCE

Autism Clinic Program Supervisor July 2012 - present
Agency: Koegel Autism Center
Setting: Department Clinic, University of California, Santa Barbara
Supervisors: Robert L. Koegel, Ph.D., Ty Vernon, Ph.D., & Lynn Kern Koegel, Ph.D.

- Provide weekly supervision to doctoral student and undergraduate therapists
- Coordinate with Autism Center directors and regional centers to ensure quality of care
- Write quarterly reports on client goals and progress
- Provide ongoing training in the motivational procedures and behavioral principles of Pivotal Response Treatment
- Trained and provided ongoing consultation in the use of self-management, peer-helping, and daily living checklists for clinicians working with adult clients through the Department of Rehabilitation (DOR)
- Coordinate care for families and individuals, including interfacing with outside agencies such as the Disabled Students Program, the Tri-County Regional Center, and health insurance companies
- Provide consultation on annual academic and social goals for the purpose of Individualized Education Program meetings
- Use client data to develop and implement clinical research projects
- Average 5-10 hours/week

RESEARCH EXPERIENCE

Koegel Autism Center, University of California, Santa Barbara
Doctoral Dissertation Research June 2015 - present

Title: The Use of Eye-Tracking as an Assessment Measure for Social Attention in Autism Spectrum Disorder

- Co-authored and received an intervention research grant from Autism Speaks
- Examines eye-tracking preferential looking behaviors for preschoolers with ASD when compared to typically developing controls, as well as relationships with autism symptomology and visual attention to caregivers during naturalistic interactions
- Dissertation prospectus defended and accepted
- Data collection and analysis completed, writing and final revisions in process
- Committee: Robert L. Koegel, Ph.D. (Chair), Ty Vernon, Ph.D., & Erin Dowdy, Ph.D

Master's Thesis Research June 2013 - June 2014

Title: The Use of a Reframing Intervention during Social Conversation in Adults with ASD

- Co-authors: Robert L. Koegel, Ph.D., & Lynn K. Koegel, Ph.D.

Clinic Coordinator Sept. 2011-July 2012

Supervisors: Robert Koegel, Ph.D., & Lynn Koegel, Ph.D.

- Coordinated data compilation, research communication, client contacts, and correspondence for the center. Acted as a communication liaison between researchers and clients. Updated and re-designed the center's research website.

Center for Autism Research and Treatment, University of California, Los Angeles

Honors Thesis Student 2009 - 2010

Title: Eye-Tracking as a Measure of Response to Joint Attention in Infants at Risk for Autism

- Collaborators: Marian Sigman, Ph.D., Ted Hutman, Ph.D., Scott Johnson, Ph.D., & Kristen Gillespie-Lynch, Ph.D.

Research Assistant 2009 - 2011

Supervisors: Marian Sigman, Ph.D., & Ted Hutman, Ph.D.

- Analyzed eye-tracking data using Microsoft Excel. Coded video recordings of infant assessments. Analyzed results in SPSS. Attended weekly lab meetings, engaged in data entry and management.

Fernald Child Study Center, University of California, Los Angeles

Research Assistant 2008 - 2009

Supervisor: Bruce Baker, Ph.D.

- Participated in a coding team for the Collaborative Family Study (CFS). Attended weekly meetings to develop a coding system based qualitative data. Coded video recordings and engaged in data entry in the CFS database.

GRANT FUNDING

Autism Speaks

Treatment Grant - $120,000 2014 - 2016
Investigator, Grant Co-Author
The use of eye-tracking as an outcome measure for an innovative early social intervention for ASD
Principle Investigators: Robert Koegel, Ph.D., & Ty Vernon, Ph.D.

Family Services Chapter Grant - $5,000 2014 - 2015
Investigator, Grant Co-Author
Improving social conversation abilities in adults with autism
Principle Investigators: Robert Koegel, Ph.D., & Lynn Koegel, Ph.D.

PEER-REVIEWED PUBLICATIONS

Navab, A., Koegel, R.L., Dowdy, E., & Vernon, T. (2015). Ethical considerations in the application of the scientist-practitioner model for psychologists conducting intervention research. *Journal of Contemporary Psychotherapy, 45*(3). doi: 10.1007/s10879-015- 9314-3

Koegel, L.K., **Navab, A.**, Ashbaugh, K., & Koegel, R.L. (in press). Using reframing to reduce negative statements in social conversation for adults with autism spectrum disorder. *Journal of Positive Behavior Interventions.* doi: 10.1177/1098300715596136

Koegel, L.K., Ashbaugh, K., **Navab, A.**, & Koegel, R.L. (in press). Increasing empathic communication skills for adults with autism spectrum disorder. *Journal of Autism and Developmental Disorders.*

Ashbaugh, K., Kim, S., **Navab, A.**, & Koegel, R.L. (in press). Autism spectrum disorder: Social factors. *The SAGE Encyclopedia of Abnormal and Clinical Psychology.*

Navab, A., Gillespie-Lynch, K., Park, G., Sigman, M., Johnson, S.P., Hutman, T. (2012). Eye-tracking as a measure of responsiveness to joint attention in infants at risk for autism. *Infancy,* 1-16.

Sproatt, D., **Navab, A**., Koegel, R.L., and Koegel, L.K. (2011). Definition of operant conditioning. *Encyclopedia of Autism Spectrum Disorders,* Volkmar, F.R.

CONFERENCE PRESENTATIONS

Navab, A., & Vernon, T. (2015, September). The use of eye-tracking as an outcome measure for an innovative early social intervention for ASD. Symposium presented at the 8th Annual International Pivotal Response Treatment Conference, University of California, Santa Barbara, CA.

Bradshaw, J., **Navab, A.**, Horowitz, E., German, T., Vernon, T., & Koegel, R.L. (2015, May). *Social attention as a baseline measure of social motivation in toddlers with autism spectrum disorder.* Poster presented at the International Meeting for Autism Research (IMFAR), Salt Lake City, UT.

Horowitz, E., Bradshaw, J., **Navab, A.**, German, T., Vernon, T., & Koegel, R.L. (2015, May). *Spontaneous goal attribution in children with ASD: A comparative eye-tracking study.* Poster presented at the International Meeting for Autism Research (IMFAR), Salt Lake City, UT.

Navab, A. (2014, September). The Use of Reframing to Decrease Negative Statements during Conversation in Adults with ASD. Presented at the 7th Annual International Pivotal Response Treatment Conference, University of California, Santa Barbara, CA.

Navab, A., Ashbaugh, K., Miller, A., Bradshaw, J., Koegel, L., & Koegel, R. (2014, May). *The use of positive reframing in social conversation for adults with ASD.* Poster presented at the International Meeting for Autism Research (IMFAR), Atlanta, GA.

Bradshaw, J., Reshes, H., **Navab, A.**, Miller, A., Vernon, T., & Koegel, L. (2014, May). *The effects of a parent-mediated early toddler intervention on improving functional communication.* Poster presented at the International Meeting for Autism Research (IMFAR), Atlanta, GA.

Miller, A. R., Clarke, T., Cornish, M., Dresser, K., Fredricks, M., Russo, K., Wu, V., Bradshaw, J., **Navab, A.** & Vernon, T. W. (2014, May). *Preliminary data on individualized social skill outcome measures associated with the START group social skills intervention for adolescents with ASD.* Poster presented at the International Meeting for Autism Research (IMFAR), Atlanta, GA.

Navab, A.. (2014, April). The use of reframing during conversation in adults with ASD. In *Scientifically based social interventions in inclusive settings for individuals with ASD.* Symposium conducted at the Cal-TASH Convention, Burlingame, California.

Bradshaw, J., **Navab, A.**, Lucyga, S., Koegel, L., Koegel, R.L. (2013, May). *Coordinated positive engagement during social interactions in infancy: An early identification and intervention study.* Poster presented at the International Meeting for Autism Research (IMFAR), San Sebastian, Spain.

Navab, A., & Miller, A. (2012, September). Self-management and Pivotal Response Treatment. Presented at the 5th Annual International Pivotal Response Treatment Conference, University of California, Santa Barbara.

Navab, A., Gillespie-Lynch, K., Park, G., Sigman, M., Johnson, S.P., Hutman, T. (2011, May). *Eye-tracking as a measure of joint attention in infants at risk for autism.* Poster presented at the UC Conference for Research in Special Education, Disabilities, & Developmental Risk, Los Angeles, CA.

Navab, A., Gillespie-Lynch, K., Park, G., Sigman, M., Johnson, S.P., Hutman, T. (2011, May). *Eye-tracking as a measure of responsiveness to joint attention in infants at risk for autism.* Poster presented at the International Meeting for Autism Research (IMFAR), San Diego, CA.

Gillespie-Lynch, K., Hutman, T., Gaither, S.E., Park, G., **Navab, A**., Sigman, M., & Johnson, S.P. (2011, April). *Social attention or gaze following: Which is reduced during eye-tracking of infant sibs?* Poster presented at the Society for Research in Child Development, Montreal, Canada.

Navab, A., Gillespie-Lynch, K., Park, G., Sigman, M., Johnson, S.P., Hutman, T. (2010, May). *Eye-tracking in infants at risk for autism.* Poster presented at the Stanford Psychology Undergraduate Conference, Palo Alto, CA.

Navab, A., Gillespie-Lynch, K., Park, G., Sigman, M., Johnson, S.P., Hutman, T. (2010, May). *Eye-tracking as a measure of responsiveness to joint attention.* Poster presented at the UCLA Psychology Undergraduate Research Conference, Los Angeles, CA.

Gillespie-Lynch, K., Hutman, T., Gaither, S., **Navab, A.,** Beck-Pancer, D., Sigman, M., & Johnson, S.P. (2010, May). *Responding to and learning joint attention: A comparison of infant siblings of children with autism and typically developing infants.* Poster presented at the International Meeting for Autism Research (IMFAR), Philadelphia, PA.

HONORS & AWARDS

University of California, Santa Barbara

Graduate Student Travel Grant	2013-2016
Hosford Hero Award	2013
UC Block Grant Award	2012-2015

University of California, Los Angeles

Phi Beta Kappa National Honor Society	2009-2010
Psi Chi Honors Membership	2008-2010
Honors Program	2009-2010

TEACHING EXPERIENCE

Graduate Teaching Assistant for Doctoral Courses, University of California, Santa Barbara
April – June 2015
Behavioral Assessment and Intervention in Children and Adolescents
Instructor: Robert L. Koegel, Ph.D.

Graduate Teaching Assistant for Undergraduate Courses, University of California, Santa Barbara

January – March 2016
Introduction to Educational and Vocational Guidance
Instructor: Lauren Meier, Ph.D.

January – March 2014
Introduction to Autism
Instructor: Robert L. Koegel, Ph.D.

Invited Guest Lectures

October 2015
"Autism Spectrum Disorders-Early Diagnosis, Referrals, and Treatment"
Typical/Atypical Development, California State University Channel Islands
Instructor: Mari Estrada-Gonzalez, Ph.D.

April 2015
"*Autism Spectrum Disorders-Diagnosis and Treatment*"
Child Abuse Listening and Mediation (CALM), Santa Barbara, CA

"Introduction to Mindfulness"
Girls Rock SB, Santa Barbara, CA
Everyone Does Outreach Program

"Mindfulness in Everyday Life"
Jodi House Brain Injury Support Center, Santa Barbara, CA
Everyone Does Outreach Program

February 2015
"*The Use of Eye-Tracking in the Identification, Assessment, and Prognosis of ASD*"
Introduction to Autism, Santa Barbara City College
Instructor: Whitney Detar, Ph.D.

October 2013
"*The Use of Positive Reframing in Social Conversation for Adults with ASD*"
Practicum in Applied Psychology, University of California, Santa Barbara
Instructor: Matthew Quirk, Ph.D.

Trainings

October 2013
Professional Workshop: Vocational Training for Adults with ASD
Department of Rehabilitation, Orange, CA

Workshops

September 2013
"*Improving Social Conversation for Adults with ASD*"

6th Annual International Pivotal Response Treatment Conference
Koegel Autism Center, University of California, Santa Barbara

OTHER PROFESSIONAL EXPERIENCES

Department of Counseling, Clinical, and School Psychology, University of California, Santa Barbara

Clinic Committee Member	Sept. 2015 - present
Everyone Does Outreach Member	Sept. 2014 - June 2015
Student Admissions Committee Member	Sept. 2013 - June 2014
Student Social Committee Member	Sept. 2013 - June 2014

Child Abuse, Listening, and Mediation (CALM)

Certified Yoga Instructor for Staff and Clinical Groups	August 2015 - present

TRAINING AND CERTIFICATIONS

Certification, Autism Diagnostic Observation Schedule-2 Assessment — March 2016
Intensive Two-Day Training Course
Western Psychological Services, Los Angeles, CA

Level 2 Certification, Gottman Method Couples Therapy — Feb. 2016
Intensive Two-Day Training Course
University of California, Santa Barbara, CA

Certification, Trauma-Focused Cognitive Behavioral Therapy — Sept. 2014
Intensive Two-Day Training Course
Child Abuse Listening Mediation (CALM), Santa Barbara, CA

Certification, Trauma-Focused Cognitive Behavioral Therapy — March 2014
Online Training Course
TF-CBT*Web*, Medical University of South Carolina

Certification, Pivotal Response Treatment for Autism — Sept. 2012
Koegel Autism Center, University of California, Santa Barbara, CA

MEMBERSHIP IN PROFESSIONAL ORGANIZATIONS

Graduate Student Affiliate, American Psychological Association

Student Affiliate, APA Division 33: Intellectual and Developmental Disabilities

Student Member, International Society for Autism Research

ABSTRACT

The Use of Eye-Tracking as an Assessment Measure for
Social Attention in Autism Spectrum Disorder

by

Anahita D. Navab

Research has demonstrated that early assessment of autism spectrum disorder (ASD) in toddlers enables earlier intervention, which enhances developmental gains for this population (Rogers et al., 2012; Vernon, Koegel, Dauterman, & Stolen, 2012). Eye-tracking technology has proven to be a particularly promising avenue for assessment of atypical social looking behaviors in young children with ASD, due to its non-intrusive yet rigorous method of data collection (Oakes, 2012). A growing body of eye-tracking literature demonstrates that when compared to typically developing controls, toddlers on the spectrum exhibit decreased attention towards socially and emotionally salient stimuli and increased fixation on non-social stimuli (Pierce et al., 2011; Shic, Bradshaw, Klin, Scassellati, & Chawarska, 2011). This ability of eye-tracking methodology to detect deviation away from a typical gaze pattern when presenting social and non-social stimuli, and even in doing so predict an autism diagnosis, justifies its increasing use as a method of autism assessment. However, there is currently little known regarding how looking preferences in specific eye-tracking paradigms relate to severity of autism social affect symptoms, or how they may

relate to preferential gaze during naturalistic interactions with caregivers. The current study seeks to firstly assess replication of ASD preferential non-social looking behaviors with the use of an eye-tracking paradigm. This project also seeks to enhance the understanding of social attention in toddlers on the spectrum by investigating relationships between non-social eye-tracking looking behaviors and severity of autism symptoms, as well as with social gaze during naturalistic dyadic interactions.

TABLE OF CONTENTS

Introduction

Research in the area of social attention for young children with Autism Spectrum Disorder (ASD) is essential, given that our understanding of early social impairments in individuals on the spectrum forms the foundation for comprehending later difficulties in social interactions, such as struggles with communication and motivation during social encounters (Droucker, Curtin, & Vouloumanos, 2013; Hughes & Ensor, 2010). In this way, it is often thought that autism symptoms can form a cascading or "snowball" effect, such that individuals on the spectrum face increasing disadvantage as they progress through life (Jones & Klin, 2009).

However, relevant strengths in early attentional behaviors such as joint attention may conversely predict positive outcomes related to social communication and intellectual functioning in those with ASD, as recent research has indicated (Poon, Watson, Baranek, & Poe, 2012). Thus, it is imperative that we continue to uncover the relative areas of strength and vulnerability in the domain of social attention, in that initial consistent attentiveness to social experiences tends to shift the developmental trajectory of young children on the spectrum towards normative cognitive and social growth (Wan et al., 2013).

Efforts towards identifying such diagnostic and prognostic profiles of children with autism have previously primarily focused on standardized assessments evaluating social, cognitive, behavioral, and adaptive functioning domains, elucidating within-group findings as well as differences between autism, developmentally delayed, and typically developing populations (Bryson, Landry, & Wainwright, 1997; Chawarska, Klin, & Volkmar, 2008; Condouris, Meyer, & Tager-Flusberg, 2005; Joseph, McGrath, & Tager-Flusberg, 2005;

Mundy, Sigman, Ungerer, & Sherman, 1986; Smith, 1997; Stone, Ousley, Hepburn, Hogan, & Brown,

1999). Research in recent years has focused efforts on implementing more rigorous technology such as neurophysiological brain imaging and eye-tracking measures to identify the means by which young children on the spectrum process environmental stimuli (Blasi et al., 2015; Bradshaw, Shic, & Chawarska, 2011; Chawarska & Shic, 2009; Corbett, Mendoza, Abdullah, Wegelin, & Levine, 2006; Dapretto et al., 2005; Greene et al., 2011; Sasson, Turner-Brown, Holtzclaw, Lam, & Bodfish, 2008; Speer, Cook, McMahon, & Clark, 2007; Redcay & Courchesne, 2008; Zielinski et al., 2012). Such methodologies have even been used to predict social competence and autism symptomology based on neural and gaze responses, again alluding to the importance of examining early attentional patterns (Chawarska, Macari, & Shic, 2013; Cheung et al., 2011; Elsabbagh et al., 2012; Klin, Jones, Schultz, Volkmar, & Cohen, 2002).

Eye-Tracking in the Assessment of ASD

The use of eye-tracking technology in particular has been increasingly implemented as one of the least invasive, yet one of the most unbiased and fine-grained measures of looking behaviors such as face processing, attention during social scenes, and joint attention (Hanley et al., 2014; Oakes, 2012; Aslin, 2007; Feng, 2011). While initial research on gaze behavior employed less precise and more bias-prone methods such as behavioral coding from videos, eye-tracking has since provided increased accuracy in studying these looking behaviors as both spontaneous and task-directed gaze. With this tool, we are now able to more effectively record the types of information that individuals do and do not make visually available to themselves when viewing social stimuli. A vast and ever-growing body

of research has employed this methodology in studying social looking behaviors in typically developing (TD) infants and toddlers (Richmond & Nelson, 2009; Senju & Csibra, 2008; Johnson, McQueen, & Huettig, 2011; Hunnius, Bekkering, & Cillessen, 2009).

This more recent ability becomes especially meaningful when considering young children with autism spectrum disorders (ASD), seeing as both the conditions of ASD and early age limit the language capabilities of participants being assessed. In place of reliance on language measures that may not provide sufficient information based on these limitations, eye-tracking methodology captures spontaneous and nonverbal attention allocation in experiments depicting social information (faces, people, social interaction). Eye-tracking technology therefore has the potential to provide rich insight into the fundamental attentional and processing systems that guide behavior in young children with autism. Such a paradigm allows for a deeper, more nuanced understanding of the social processing mechanisms that accompany observable behavior. In this way, eye-tracking studies may provide insight into the everyday social interaction difficulties faced by individuals with ASD in a fashion that was not previously possible (Boraston & Blakemore, 2007).

A growing body of literature focused on these attentional processes has shown that children with autism tend to prioritize their visual engagement on non-social aspects over socially relevant details in visual stimuli representing their surrounding environment (Klin, Lin, Gorrindo, Ramsey, Jones, 2009; Shic, Bradshaw, Klin, Scassellati, & Chawarska, 2011; Shultz, Klin, & Jones, 2011; Sasson, Turner-Brown, Holtzclaw, Lam, & Bodfish, 2008). Recent research has demonstrated that in this way, children with autism have eye gaze patterns and loci of focus that deviate greatly from those of typically developing children,

and thus are able to be distinguished diagnostically (Chawarska & Shic, 2009; Chawarska, Macari, & Shic, 2012; Pierce, Conant, Hazin, Stoner, & Desmond, 2011; Pierce et al., 2015; Klin, Lin, Gorrindo, Ramsey, Jones, 2009; Sasson, Turner-Brown, Holtzclaw, Lam, & Bodfish, 2008; Shultz, Klin, & Jones, 2011).

Social Stimuli Processing in Early ASD Research.

Specifically, one line of eye-tracking research has focused on measuring preference for social versus non-social stimuli in one's environment. This has been addressed through preferential looking paradigms presenting side-by-side films of social and non-social stimuli, as well as those assessing preferential looking within one dynamic social scene. An example of the former paradigm type was utilized in a study by Pierce, Conant, Hazin, Stoner, and Desmond (2011). This research employed a paradigm in which toddlers two to four years in age were presented with side-by-side films of moving geometric patterns and children in high action. Diagnostic groups included toddlers on the autism spectrum, those with developmental delay (DD), and typically developing (TD) controls.

Data for this paradigm were analyzed using eye-tracking technology to determine a total fixation duration and the number of saccades within each movie type. These analyses were compared between diagnostic groups, and results revealed that toddlers with ASD as young as 14 months spent significantly more time than the other two diagnostic groups fixating on dynamic geometric images than other diagnostic groups. In addition, percentage of time fixating on geometric patterns positively predicted classification of ASD. If a toddler spent more than 69% of his or her time fixating on geometric patterns, then the positive predictive value for accurately classifying that toddler as having an ASD was 100%.

These findings imply that toddlers with ASD may be viewing non-social stimuli as more relevant or valuable than social stimuli. Furthermore, such results shed light on the potential for a preference for geometric patterns to be used as an easily detectable early signature of infants and toddlers at risk for ASD. A follow-up study was conducted, revealing that toddlers with ASD who strongly preferred geometric images had worse cognitive, language, and social skills compared to those who visually prioritized social images (Pierce et al., 2015). These results suggest that this enhanced visual preference for geometric repetition may serve as an early developmental biomarker of an ASD subtype with more severe symptoms.

Research has also recently been employed with the use of eye-tracking technology to assess preferential looking to biological motion in ASD, as this ability may be a fundamental precursor to adaptive social interactions with other individuals (Klin & Jones, 2008; Klin, Lin, Gorrindo, Ramsey, & Jones, 2009). Klin and Jones (2008) conducted initial research on this topic in a 15-month-old diagnosed with ASD, while Klin, Lin, and Gorrindo (2009) expanded this inquiry to three diagnostic groups of children with ASD, DD, and a TD control sample. This research utilized a preferential looking task using side-by-side animations of upright and inverted point-light figures to measure visual fixation patterns and specifically orienting to biological motion in the upright figure. This figure acted out childhood games such as playing peek-a-boo or singing a nursery rhyme, as an accompanying audio soundtrack played to match the actions of the upright figure. The upright and inverted figures were identical except that the inverted figure was rotated 180 degrees and played in reverse order.

Results of both studies indicated that participants failed to orient to the biological motion animation; that is, they displayed random looking patterns across both the upright and inverted point-light displays. In contrast, both control groups demonstrated significant preferential looking to the upright figures depicting biological motion. Instead of attuning to biological motion, the ASD participants were highly sensitive to the presence of non-social, physical contingency that occurred within the stimuli by chance, such as audiovisual synchrony that occurred when the collision of point-lights was paired with a clapping sound that the stimuli played. These findings raised the hypothesis that the preferential engagement with socially relevant stimuli of biological motion may be derailed in children with autism from a very young age, with cascading consequences for the lifelong social impairments characteristic of ASD.

Several other studies have focused on ASD preferential looking within one scene, as opposed to comparing two side-by-side (Shic, Bradshaw, Klin, Scassellati, & Chawarska, 2011; Chawarska, Macari, & Shic, 2013; Hosozawa, Tanaka, Shimizu, Nakano, & Kitazawa, 2012). Shic et al. (2011) employed eye-tracking to examine ASD looking behaviors in the context of an adult-child play interaction. In comparison to control groups, one- to two-year-old toddlers with ASD focused preferentially on background objects such as toys, and less attention to the activities of other people in the film clip shown. While toddlers with ASD spent the same overall amount of time as control groups looking at people in the video, they looked substantially less at people's heads and more at their bodies. The results showed that these looking behaviors served as predictors of cognitive deficits and greater autism severity, suggesting that this early disruption in monitoring of social activities may limit future paths to observational learning.

Similarly, Hosozawa et al. (2012) employed a paradigm of short video clips (six seconds each) excerpted from a film or TV program for children, in order to compare two- to four-year old TD and ASD toddlers on looking behaviors with embedded people and faces. These clips contained one to several people engaged in social interaction, such as conversation or speaking to the audience. Analyses revealed that toddlers with ASD looked away from actors prematurely during speech episodes and looked less at faces than the TD group. Again, in these findings we see a tendency for these individuals to limit themselves from viewing socially relevant stimuli.

Especially relevant to prediction of ASD prognosis was an eye-tracking study conducted

by Chawarska et al. (2013). This study found that compared to control groups, six-month-old infants later diagnosed with ASD looked less at a dynamic social scene, demonstrating atypical spontaneous social monitoring. Instead, increased attention was directed toward the background of the scene. Further, when these infants did look at the scene, compared to the TD control group they spent less time monitoring the actress in general and her face in particular. This implies a tendency not to spontaneously look to people and their activities. This limited attentional bias toward people again falls in line with a potential lack of motivation to attend to social information, that may very well have a detrimental impact on the specialization of social brain networks and the emergence of social interaction patterns. This study demonstrated that behavioral signs of later diagnosed ASD can be detected as early as six months of age, equivalent to the earliest age that brain-based markers have been identified (Elsabbagh et al., 2012; Wolff et al., 2012).

The above studies demonstrate that toddlers on the spectrum tend to display increased fixation on non-social stimuli either when presented side-by-side or interweaved with social stimuli in eye-tracking paradigms. However, there is an issue of ecological validity encountered in the interpretation of eye-tracking research findings that has yet to be thoroughly discussed or investigated in this field. While those conducting this line of research are aware that the eye-tracking assessments are simulated paradigms linked to broader claims regarding child development such as social perception processing and even ASD diagnosis, the large leap to these claims is rarely questioned. Studies such as those conducted by Navab et al. (2012) have begun to elucidate the connections between social looking behaviors captured in eye-tracking paradigms and those seen in naturalistic behavioral assessments, as well as severity of autism symptomology. However, this line of research will benefit from more investigation as to the nature of relations between eye-tracking findings and those that emerge in the actual social world that individuals with ASD must navigate.

The Current Study

This proposed project directly aims to develop and evaluate an experimental eye-tracking paradigm in the assessment of social attentional processing difficulties in young children with ASD when compared to normative gaze data obtained from typically developing children. That is, this study will assess the extent to which a participant child's eye gaze patterns are fundamentally altered from the social visual preferences of typically developing (TD) children. The paradigm employed will be one referred to as the Social versus Geometric Preferential Paradigm (SGP Paradigm) modified from that used by Pierce

et al. (2011). This paradigm will assess a looking preference for moving non-social geometric images versus dynamic social videos in ASD participants.

Another aim of this research is to determine the relation between looking behaviors according to the eye-tracking task and severity of autism social affect symptomology according to standardized assessment measures. Lastly, this project aims to assess ecological validity of eye-tracking assessment by determining the relations between looking behaviors as determined by eye-tracking data analysis and those recorded in naturalistic social interactions with participant caregivers. The use of multiple evaluation methods will allow for a comprehensive depiction of social looking behaviors in those on the spectrum reflected across a number of assessment modalities.

Research Questions

This study aims to extend research related to early preferential looking by addressing the

following questions for children with ASD between the ages of 18-54 months:

Research Question 1: Will young children diagnosed with ASD display a preference for non-social stimuli when compared to control children as measured by differential looking scores (DLS) and percentage of first gazes to social stimuli in an eye-tracking assessment referred to as the SGP Paradigm?

Research Question 2: Will young children diagnosed with ASD display a preference for non-social stimuli when compared to the control sample as measured by gaze to participants' caregivers in naturalistic parent-child interactions during a structured laboratory observation (SLO)?

Research Question 3: For all participants, will correlations be found between social looking behaviors as measured by the eye-tracking DLS and first gaze data and those recorded as gaze to participants' caregivers in naturalistic parent-child interactions during a structured laboratory observation (SLO)?

Research Question 4: For participants diagnosed with ASD, will correlations be found between ASD looking behaviors as measured by the eye-tracking DLS and first gaze data and standardized assessment of social affect autism symptomology according to the Autism Diagnostic Observation Schedule (ADOS-2)?

Research Question 5: For participants diagnosed with ASD, will correlations be found between naturalistic looking behaviors to caregiver as measured by the SLO and standardized assessment of social affect autism symptomology according to the Autism Diagnostic Observation Schedule (ADOS-2)?

Method

Participants

Participants included 46 young children aged 18-54 months, and each child's primary caregiver. 23 young children who met criteria for diagnosis of autism and 23 typically developing children matched on chronological age were enrolled in the project. For the participants with autism, inclusionary criteria included the following: (a) an age between 18-54 months, (b) a diagnosis of autism obtained by meeting DSM-V diagnostic criteria (APA, 2013), (c) either falling in the *mild-to-moderate* or *moderate-to-severe* concern range on the Autism Diagnostic Observation Schedule – Toddler Module (ADOS-2-T; Lord, Luyster, Gotham, & Guthrie, 2012) or qualifying for an *autism* classification on Modules 1 or 2 of the Autism Diagnostic Observation Schedule, Second Edition (ADOS-2; Lord et al., 2012).

Children with co-occurring seizure disorders, significant hearing/vision loss, genetic conditions, or other comorbid medical conditions were excluded from participation. Prior to the onset of the study, 61% of ASD participants were receiving behavioral intervention, 61% were receiving speech therapy, and 48% were in the process of receiving occupational therapy.

Both ASD and TD participants were recruited through local family and child social and support groups, in addition to local advertisements. Parents of typically developing children participated in a telephone screening in which they were asked whether their child had any signs of delays, symptoms of trauma, or concerns of autism as indicated by physicians during well-baby checkups. If parents confirmed that none of these concerns were present, they were included for participation in the study. Families of typically developing participants were financially compensated with gift cards amounting to $25. Families of ASD participants were not financially compensated but received developmental assessment as well as intervention services as part of a larger ongoing study at no cost for participation. Full demographic information is included in Table 1.

Table 1

Participant Demographic Information

Characteristic	Number of Participants (Percent of Sample)	
	ASD (N=23)	TD (N=23)
Age		

18-30 Months	7 (30%)	15 (65%)
30-42 Months	11 (48%)	5 (22%)
42-54 Months	5 (22%)	3 (13%)
Sex		
Male	21 (91%)	11 (48%)
Female	2 (9%)	12 (52%)
Ethnicity		
Euro American	13 (57%)	19 (82%)
Asian	3 (13%)	0 (0%)
Latino	6 (26%)	2 (9%)
Mixed	1 (4%)	2 (9%)

Setting

Research procedures took place in the clinic assessment rooms of the University Autism Center. Rooms were equipped with adult- and child-sized tables and chairs and each contained a digital camera for filming experimental procedures. The clinical assessments and parent-child interaction assessments took place in separate rooms. Clinical assessments

took place in a room with an adult-sized and child-sized table and a portable digital camera to capture the examiner, child, and parent. The parent-child interaction assessments took place in a separate room with minimal distractions and no toys besides those required in the assessment were available to the child or parent.

Eye-tracking assessments took place in an assessment room equipped with a SensoMotoric Instruments (SMI) eye-tracking system, including a large display monitor on which images, animated, and video events were shown. The room was equipped with a car-seat secured on a chair to ensure stable viewing of the stimuli. Research procedures such as data management, analysis, and coding took place in three designated computer rooms with data storage server capacities.

Assessment Procedures

As part of a larger ongoing intervention study, ASD participants were screened and determined to meet inclusion criteria. After this initial screening process, three broad measures were administered over the course of a two-day intake process (a) several eye-tracking paradigms, (b) behaviorally-coded videos of structured parent-child interactions, (c) the remaining standardized assessment battery of developmental, language, adaptive, and diagnostic tools. Characteristics about the child's background were also collected for later analysis. This information included chronological age, family socio-economic status, parent education and marital status, racial/ethnic background, adjunct support services, prior intervention services, and medical history. This assessment procedure typically took approximately five hours to complete.

The typically developing sample participated in a one-day assessment using several eye-tracking paradigms, as well as behaviorally-coded videos of structured parent-child

interactions. This assessment procedure typically lasted one hour. These normative eye-tracking and naturalistic behavioral measures from typically developing children served as comparative data.

Dependent Measures for Research Question 1: Will young children diagnosed with ASD display a preference for non-social stimuli when compared to typically developing controls as measured by differential looking scores (DLS) and percentage of first gazes to social stimuli in an eye-tracking assessment referred to as the SGP Paradigm?

Eye-Tracking Assessment. The primarily goal of this analysis was to determine the extent to which the social visual preferences of ASD participants were fundamentally altered from those of typically developing (TD) children as measured by eye-tracking. An SMI eye-tracker was used to collect data on the x-y coordinates of fixation points viewed on the stimulus presentation monitor. For the paradigm described below, dependent measures included looking time to specified regions of interest (ROIs) in the scene. Looking time to each ROI was calculated and analyzed over various time samples throughout the duration of presentation (described in greater detail under Statistical Analyses). Additional fine-grained analyses, such as the calculation of the differential looking score (DLS) and the percentage of first gazes to social stimuli were conducted to investigate the distribution of attention to various social and non-social aspects of scenes and the change of the attention distribution over time. Each child

participated in the eye-tracking paradigm in order to measure social-perceptual changes.

Social versus Geometric Preference Paradigm (SGP Paradigm). As a robust measure of assessing social versus non-social motivation at the very basic level of visual attention, this visual preference paradigm involves two stimuli competing for the child's attention. This

paradigm is modeled after the social preference task created by Pierce et al. (2011). These six five-second video stimuli were presented side-by-side and were approximately matched on visual salience properties. The images differed only in regard to semantics: one being social in nature, the other non-social. The social stimuli included children in high action doing activities such as jumping and yoga, while the non-social stimuli consisted of dynamic geometric patterns. Previous studies have identified this type of paradigm as differentiating young children with ASD and those without (e.g. Pierce et al., 2011; Pierce et al., 2015). ROIs included the total social and non-social stimulus to understand global preference. Social preference ratios as determined by differential looking scores and percentage of first gazes to social stimuli were calculated for each participant and compared across diagnostic groups.

Dependent Measures for Research Question 2: Will young children diagnosed with ASD display a preference for non-social stimuli when compared to typically developing controls as measured by gaze to participants' caregivers in naturalistic parent-child interactions during a structured laboratory observation (SLO)?

Structured Laboratory Observation (SLO). This research question aimed to determine the extent to which the social looking behaviors of ASD participants differed from those of typically developing (TD) children during naturalistic interactions with participant caregivers. Three videos of parent-child interactions were recorded during the assessment process. All videos were five minutes in length and took place in a clinic room within the Koegel Autism Center. The room was equipped with a standard set of toys appropriate for toddlers. In the first video, the child was allowed to explore the toys and the parent was instructed to observe their child approximately three feet away from them

without initiating any interaction. The parent was instructed to respond appropriately to any interaction initiated by the child, but to quickly redirect the child to play on their own. In the second video, parents were told to play with their child in an attempt to elicit as much social-communication as possible from them. Parents asking for more specific guidance were told to use whatever activity or toy they feel will best engage their child. In the final video, the parent and child were placed in a room without play materials. The parents were again instructed to play and elicit social-communication, this time without the use of external stimulus materials. For the purposes of this dissertation, only the data from the second SLO video were analyzed, given that this video best represented the presence of social (caregiver) and non-social stimuli (toys) in the natural environment competing for the participants' attention, most similar to the vying of attention between social and non-social stimuli in the SGP eye-tracking paradigm. In analyzing gaze behaviors from the SLO, participants' social looking behaviors when interacting with the caregiver in a naturalistic context were able to be determined and consequently compared to looking preferences as measured by more fine-grained eye-tracking analyses.

Behavioral Coding of Child Looking Behaviors.

Behavioral coding of child looking behaviors, specifically gaze to caregiver during the SLO, was completed by the lead investigator of this study and trained undergraduate research assistants in psychology who had foundational knowledge of child development. Child gaze to caregiver was defined as the percentage of five-second intervals a child displayed a look to the face or body of the caregiver during the dyadic parent-child interaction. This variable was coded in five-second intervals using interval recording (see Table 2). For each five-second interval in the conversation, a plus (+) was recorded if the

child gazed to the caregiver's face or body during the interval, and a minus (-) was recorded if the participant did not make any gazes to the caregiver during the interval. Research assistants were blind to the hypothesis of the study and trained to 80% reliability on this coding scheme. Reliability was subsequently calculated for 25% of the videos, selected at random using a computer-generated program. A reliability of 80% and Kappa above .7 was considered satisfactory (Kazdin, 2011).

Table 2

Child Gaze to Caregiver Interval Coding Template

Min. 1 Interval	0:00-1:00		
:00-:04		:30-34	
:05-:09		:35-39	
:10-:14		:40-:44	
:15-:19		:45-49	
:20-:24		:50-54	
:25-:29		:55-:59	
Min. 2 Interval	1:00-2:00		
:00-:04		:30-34	
:05-:09		:35-39	
:10-:14		:40-:44	
:15-:19		:45-49	
:20-:24		:50-54	
:25-:29		:55-:59	
Min. 3 Interval	2:00-3:00		
:00-:04		:30-34	
:05-:09		:35-39	
:10-:14		:40-:44	
:15-:19		:45-49	
:20-:24		:50-54	
:25-:29		:55-:59	
Min. 4 Interval	3:00-4:00		
:00-:04		:30-34	
:05-:09		:35-39	
:10-:14		:40-:44	
:15-:19		:45-49	
:20-:24		:50-54	
:25-:29		:55-:59	
Min. 5 Interval	4:00-5:00		
:00-:04		:30-34	
:05-:09		:35-39	
:10-:14		:40-:44	
:15-:19		:45-49	
:20-:24		:50-54	
:25-:29		:55-:59	

Dependent Measures for Research Question 3: For all participants, will correlations be found between social looking behaviors as measured by the eye-tracking DLS and first gaze data and those recorded as gaze to participants' caregivers in naturalistic parent-child interactions during a structured laboratory observation (SLO)?

The aim of this research question was to assess the ecological validity of this eye-tracking paradigm by determining the relations between eye-tracking looking behaviors and those recorded in naturalistic social interactions with participant caregivers. The eye-tracking DLS and first gaze data, as well as the naturalistic looking data from the SLO, as described above, were analyzed for this question.

Dependent Measures for Research Question 4: For participants diagnosed with ASD, will correlations be found between ASD looking behaviors as measured by the eye-tracking DLS and first gaze data and standardized assessment of social affect autism symptomology according to the Autism Diagnostic Observation Schedule (ADOS-2)?

Autism Diagnostic Observation Schedule – Section Edition. (ADOS-2; Lord, Luyster,

Gotham, & Guthrie, 2012; Lord et al., 2012). This research question aimed to determine the relation between looking behaviors according to the eye-tracking task and severity of autism social affect symptomology according to standardized assessment measures. The ADOS-2 is a semi-structured, standardized observational assessment of autistic diagnosis and symptomology in individuals aged 12 months to adulthood that incorporates updated diagnostic algorithms. One of three modules (Modules Toddler through 2) was administered as appropriate by a doctoral level developmental psychologist certified to be reliable in administration. The Toddler Module tests infants and toddlers aged 12 to 30 months, while

Modules 1 and 2 test individuals 31 months and older. Administration of the ADOS-2 allows the examiner to record numerous behaviors associated with ASD, resulting in three aggregate scores: a total Social Affect (SA) score, a total Restricted and Repetitive Behavior (RRB) score, and a Total score (the severity of autism symptoms).

Specifically, the SA subscale score was investigated in this study as a means of understanding participants' social abilities in naturalistic interactions, in isolation as well as in relation to looking preferences as determined by eye-tracking measures and the SLO. The SA subscale is comprised of two smaller subsections, Communication and Reciprocal Social Interaction. The Communication subsection includes the individual item of frequency of spontaneous vocalization directed to others, as well as an item related to gestures. The Reciprocal Social Interaction includes the following individual items: unusual eye contact, facial expressions directed to others, integration of gaze and other behaviors during social overtures, shared enjoyment in interaction, showing, spontaneous initiation of joint attention, response to joint attention, and quality of social overtures.

The internal consistency for the SA domain is high for both the ADOS-2 Modules 1-3 (0.87-0.92) and for the Toddler Module (0.88-0.90; McCrimmon & Rostad, 2014). Test-retest reliability is strong for both Modules 1-3 (0.68-0.92) and the Toddler Module (0.64-0.88). Interrater reliability across all modules of the ADOS-2 is strong (0.79-0.98). Predictive validity is strong (sensitivity ranging from 60%-95% and specificity ranging from 75%-100% for Modules 1 and 2, and both are at 86% or above for the Toddler Module). In order to ensure a common metric for assessing autism social affect symptomology, all ADOS-2 scores were converted to the Module 1 algorithm by removing scores that were

only specific to Module 2 and the Toddler Module, and completing scores that were specific to Module 1.

Dependent Measures for Research Question 5: For participants diagnosed with ASD, will
correlations be found between naturalistic looking behaviors to caregiver as measured by
the SLO and standardized assessment of social affect autism symptomology according to the Autism Diagnostic Observation Schedule (ADOS-2)?

The last research question sought to ascertain the nature of relations between social impairment as measured by the ADOS-2 and social gaze to caregiver during naturalistic interactions for ASD participants, in order to determine the associations between these measures while examining their respective relations to eye-tracking social gaze measurement. The naturalistic gaze data from the SLO and social affect data from the ADOS-2 were analyzed for this research question.

Statistical Analyses

For eye-tracking analyses, data points with low validity (owing to head movement, eye-blinks) and of insufficient length were excluded (spatial threshold: 30 pixels; temporal threshold 100msec). The total length of time the participants spent looking at the regions of interest for each event was calculated using a differential looking score (DLS). The DLS was calculated as follows: the time spent looking at the non-social areas of the videos was subtracted from the amount spent looking at the location containing social targets, and divided by the total time looking at both ROIs. This gave a range of +1 to -1, with positive

scores indicating a preference in looking toward the social video, and negative scores indicating a preference in looking at the non-social sections of the video. In addition, the eye-tracking software was used to determine the first point of fixation, or the "first gaze" to either the social or non-social stimuli across all six trials presented, and from this the percentage of first gaze to social stimuli was calculated in order to determine the participants' initial preferential looking behaviors.

For Research Question 1, an independent samples t-test was employed to assess for differences between social looking behaviors according to the DLS and first gaze data in the ASD and TD samples in the SGP Paradigm. Additionally, the use of effect sizes allowed not only the assessment of differences in eye-tracking looking behaviors between the two groups, but also provided a measure for the magnitude of the between-group difference. An independent samples t-test and effect size were also calculated for Research Question 2 to determine the differences in looking behaviors between the two groups in the naturalistic interaction of the SLO. Pearson correlations between social gaze to caregiver in the structured laboratory observation (SLO) during naturalistic parent-child interaction and first gaze and looking preference scores in the SGP eye-tracking paradigm were determined. Lastly, correlations between ASD non-social looking behaviors as measured by eye-tracking DLS in the SGP paradigm, as well as those by the SLO, and autism social symptomology (according to the ADOS-2 Social Affect subscale) were assessed using Pearson correlations.

Results

Descriptive Statistics

The final sample after excluding children with co-occurring medical conditions and not meeting autism severity criteria consisted of 46 participants, 23 being diagnosed with

ASD and 23 typically developing controls. Descriptive statistics including range, mean, and standard deviation for each measure are reported in Table 3. The distribution of each variable is also described. Generally, it is acceptable for kurtosis to fall between -2 and +2. Table 3 displays the range, mean, standard deviation, and values for skewness and kurtosis for all measures. The differential looking scores (DLS) and percentage of first gazes to social stimuli in the SGP Paradigm met assumptions of normality and no deletion of outliers or transformations for these variables were required.

The variable measuring participants' gaze to their caregivers during the SLO had a skewness of 1.75 and a kurtosis of 3.32, therefore not meeting the assumption of normality. An outlier, defined as any value that exceeded 3 standard deviations above or below the mean, was identified that appeared to be affecting skewness and kurtosis of this variable. However, upon examination it was determined that the outlier was not due to error, but rather valid variation in the construct of interest. A log transformation was applied to assess changes in normality; however, the transformed variable had a skewness of 1.48 and a kurtosis of 2.12, thus still not meeting the assumption of normality. The original variable with the outlying data point was therefore used and skewness was noted as a limitation of the data interpretation. Assumptions of independent samples and homogeneity of variance according to Levene's test were met for all variables examined.

Table 3

Descriptive Statistics for the Combined Total Sample

Measure	Range		Mean (SD)	Skewness	Kurtosis
	Minimum	Maximum			
DLS	-0.68	0.73	0.19 (0.30)	-0.66	0.81
First Gaze	0.33	1.00	0.57 (0.16)	0.53	-0.03
SLO Gaze	0.00	0.53	0.11 (0.12)	1.75	3.32
ADOS-2 SA	7	19	13.30 (3.51)	-0.29	-1.01

Primary Analyses

Comparisons of gaze behaviors. The first research question focused on whether young children with ASD would display a preference for non-social stimuli when compared to typically developing controls as measured by the DLS and percentage of first gazes to social stimuli in the SGP Paradigm. This question was posed to determine the extent of eye-tracking visual preferential differences between ASD and TD participants. An independent samples t-test was conducted to measure the differences in looking behaviors across the ASD and TD groups. Findings revealed a statistically significant difference with a large effect size between the ASD and TD samples when comparing looking behaviors on the paradigm ($t = -3.23$, $p < 0.01$, Cohen's $d = 0.97$; see Table 4). That is, ASD toddlers displayed a statistically significant preference for non-social stimuli compared to TD controls when presented with side-by-side social and geometric dynamic stimuli. This finding was not extended to calculation of first gaze, as participants did not significantly differ on the amount that their first gaze was drawn to the social stimulus upon viewing the paradigm ($t = 1.60$, $p > 0.05$, Cohen's $d = 0.45$). The ASD sample did have a slightly higher percentage of first fixations on the social stimuli ($M=0.61$) than the TD sample ($M=0.54$) despite spending more time fixating on the non-social stimuli.

The second research question pertained to whether young children diagnosed with ASD would display a preference for non-social stimuli when compared to typically developing controls as measured by gaze to participants' caregivers in naturalistic parent-child interactions during the SLO. This question was explored in order to understand visual preference differences in an ecologically valid context. An independent samples t-test revealed no statistically significant differences between ASD and TD toddlers in the proportion of time spent gazing at

their caregivers during the SLO ($t = 0.41$, $p > 0.05$, Cohen's $d = 0.17$).

Table 4

Independent Samples T-Tests Between DLS, First Gaze Social, and SLO Gaze for ASD and TD Samples

Measure	*t*	*df*	*p*-value	95% CI
DLS	-3.23	44	0.00	-0.42 - 0.10
First Gaze Social	1.60	44	0.12	-0.02 - 0.17
SLO Gaze	0.41	44	0.68	-0.06 - 0.08

The third research question tested whether correlations would be found between social looking behaviors as measured by the eye-tracking DLS and first gaze data and those recorded as gaze to participants' caregivers in naturalistic parent-child interactions for all participants during the SLO. This purpose of this question was to ascertain the extent of ecological validity in eye-tracking assessment, by comparing to gaze behaviors during eye-tracking tasks to those during naturalistic interactions. Pearson correlations were conducted to measure the relations between eye-tracking and SLO gaze behaviors (see Table 5). Data revealed that for participants diagnosed with ASD, no statistically significant correlations were found between these individuals' amount of gaze directed at their caregivers during the SLO and their DLS scores ($r = 0.12$, $p > 0.05$) or the first gaze data ($r = 0.09$, $p > 0.05$). Similarly, significant relations did not exist for TD toddlers' gaze to their caregivers during the SLO and their DLS scores ($r = 0.01$, $p > 0.05$) or their first gaze data ($r = -0.15$, $p > 0.05$).

Table 5

Correlations Between Gaze to Caregiver during the SLO and Eye-Tracking DLS and First Gaze Social Measures

Eye-Tracking Measure	Gaze to Caregiver during SLO			
	ASD		TD	
	Correlation Coefficient (*r*)	*p*-value	Correlation Coefficient (*r*)	*p*-value
DLS	0.12	0.58	0.01	0.96
First Gaze Social	0.09	0.68	-0.15	0.49

Relations between gaze behaviors and autism symptomology.

A fourth research question was posed regarding participants diagnosed with ASD, as to whether correlations would be found between ASD looking behaviors as measured by the eye-tracking DLS and first gaze data and standardized assessment of social affect autism symptomology according to the ADOS-2. This analysis was conducted to determine whether non-social looking preferences captured by eye-tracking would relate to the extent of social impairment according to the ADOS-2, as a means of exploring eye-tracking as a potential diagnostic tool. Table 6 illustrates Pearson correlations showing that for ASD toddlers, social affect symptomology according to the ADOS-2 did not correlate with eye-tracking DLS ($r = -0.31$, $p > 0.05$) or first gaze ($r = 0.12$, $p > 0.05$). That is, visual preference in the eye-tracking paradigm did not predict severity of autism social affect impairment.

Lastly, a final question was posed as to whether if for participants diagnosed with ASD, correlations would be found between naturalistic looking behaviors to their caregivers as measured by the SLO and standardized assessment of social affect autism symptomology according to the Autism Diagnostic Observation Schedule (ADOS-2). This comparison was

explored in order to determine whether social impairment as captured during interactions with an experimenter during the ADOS-2 would relate to lack of social gaze to caregiver during naturalistic interactions. This would therefore provide information regarding how these measurements do or do not relate to each other, as they are also being explored in relation to eye-tracking measurement of social looking behaviors. Implementation of the Pearson correlation revealed that no statistically significant correlation was found between gaze to caregiver as measured by the SLO and social affect autism symptomology according to the ADOS-2 (r = -
0.10, $p > 0.05$; see Table 6).

Table 6

Correlations between Autism Social Affect Symptomology and Gaze Behaviors for Participants with ASD

Measure	ADOS-2 Social Affect Symptomology	
	Correlation Coefficient (r)	p-value
DLS	-0.31	0.16
First Gaze Social	0.12	0.60
SLO Gaze	-0.10	0.65

Secondary Analyses

Age and gender effects. Additional statistical analyses were run in order to determine whether demographic variables had a differential effect on any significant primary analyses, i.e. DLS, first gaze, SLO gaze to caregiver, and social affect symptomology in the ASD sample. Age was significantly correlated with the DLS ($r = 0.41$, $p < 0.05$) and the ADOS-2 social affect symptomology ($r = -0.57$, $p < 0.01$) for the ASD group, such that higher age was associated with more social looking and lower social affect symptoms. Age was not significantly correlated with the first gaze eye-tracking measure ($r = -0.35$, $p > 0.05$) or gaze to caregiver during the SLO ($r = 0.16$, $p > 0.05$). For the TD sample, age was significantly negatively correlated with the DLS measure ($r = -0.67$, $p < 0.01$), but not with the first gaze ($r = -0.10$, $p > 0.05$) or the gaze to caregiver during the SLO ($r = 0.20$, $p > 0.05$).

An ANCOVA was performed in order to ascertain the magnitude of effect that age had when taking into account the significant difference found between the ASD and TD

group on the DLS score. Results indicated that when using age as a covariate, the condition of group assignment still had a highly significant effect on the DLS score (F = 7.85, $p > 0.01$) and age did not have a significant effect on this score (F = 0.25, $p > 0.05$).

Spearman correlations revealed that gender of the ASD sample (males, N = 21; females, N = 2) was not significantly associated with the DLS (p = 0.19, $p > 0.05$), first gaze (p = -0.02, $p > 0.05$), gaze to caregiver (p = 0.29, $p > 0.05$), or social affect symptomology (p = 0.14, $p > 0.05$) for the ASD sample. Similarly, gender of the TD sample (males, N = 11; females, N = 12) was not significantly associated with the DLS (p = -0.03, $p > 0.05$), first gaze (p = -0.15, $p > 0.05$), or gaze to caregiver (p = 0.32, $p > 0.05$) for the TD sample.

Interrelations within clinical measures. Pearson bivariate correlations between all clinical measures were also conducted to determine how the clinical measures of toddler gaze behavior and symptomology are related to each other. This analysis revealed no significant relations between the DLS and the First Gaze Social ($r = -0.27$, $p > 0.05$), gaze to caregiver during the SLO ($r = 0.04$, $p > 0.05$), or social affect symptomology ($r = -0.31$, $p > 0.05$). Similarly, no significant relations were found between the First Gaze Social and the gaze to caregiver ($r = -0.01$, $p > 0.05$) or social affect symptomology variables ($r = 0.12$, $p > 0.05$). Lastly, significant relations were not found between the gaze to caregiver and autism symptomology ($r = -0.10$, $p > 0.05$) for participants with ASD.

Discussion

The primary goal of this study was to understand social looking behavior as captured by eye-tracking measurement for toddlers with ASD, as well as its relation with autism symptomology and gaze behavior during naturalistic interactions with caregivers. Results generally revealed that non-social looking behaviors during the eye-tracking paradigm under

investigation reliably distinguished toddlers on the spectrum from typically developing controls who gazed more at social stimuli. However, the preference for social or non-social stimuli during the task did not significantly correlate with autism symptomology for the ASD sample, or gaze towards caregivers during naturalistic interactions for either sample. For the ASD sample, a relation was not found between autism social affect symptomology and gaze toward caregiver. The eye-tracking task therefore has utility in determining the probability of an autism diagnosis for a given individual, but may not relate to severity of social impairment or the nature of social gaze behaviors during naturalistic interactions. The severity of social impairment during interactions with an experimenter conducting the ADOS-2 also may not relate to social gaze behavior during naturalistic interactions with a caregiver. These findings hold implications for the assessment and intervention of ASD and warrant further exploration of the significance of social attention in toddlers on the spectrum. The implications of the results will now be discussed in relation to each of the following research questions.

Research Question 1: Will young children diagnosed with ASD display a preference for non-social stimuli when compared to control children as measured by differential looking scores (DLS) and percentage of first gazes to social stimuli in an eye-tracking assessment referred to as the SGP Paradigm?

Results depicted a clear distinction between ASD and TD children regarding visual preferences. Measurement by the DLS scores in the SGP paradigm showed that toddlers on the spectrum exhibited a strong preference for non-social stimuli while TD toddlers showed a strong social preference. This finding confirms those of previous research studies illustrating that preference for non-social stimuli is a clinical characteristic of toddlers with

ASD, and has been found to serve as an early risk marker for ASD in infants as young as 6 months (Chawarska, Macari, & Shic, 2013; Pierce et al., 2015; Shic, Bradshaw, Klin, Scassellati, & Chawarska, 2011). The finding of the current study builds upon the literature with the implementation of a new paradigm and the differential looking score (DLS), not previously utilized in this specific line of inquiry.

The results indicate that the SGP paradigm has the ability to distinguish children on the spectrum from those who are typically developing, as early as 18 months of age. This finding may relate to previous literature focused on social avoidance and gaze aversion in ASD. The non-social preference that ASD participants displayed corresponds with prior evidence of avoidance of social stimuli both in eye-tracking literature (Chawarska, Macari, & Shic, 2013; Hosozawa, Tanaka, Shimizu, Nakano, & Kitazawa, 2012; Pierce et al., 2015; Shic, Bradshaw, Klin, Scassellati, & Chawarska, 2011). In addition, some research has found that gaze aversion away from social stimuli during face-to-face interactions may be a strategy that those on the spectrum use to reduce the cognitive load imposed on them during such tasks (Doherty-Sneddon, Riby, & Whittle, 2012). It may be considered that the phenomenon seen in the current study could be mirroring such an effect. It is possible that participants with ASD were likely to first fixate on the social stimuli to gather information, but then quickly became cognitively oversaturated and subsequently redirected gaze to non-social stimuli in an effort to manage and preserve cognitive resources during the task. Further research in this area of gaze aversion from social stimuli during eye-tracking and its effect on performance during cognitive tasks is warranted in order to gain a deeper understanding of attentional processes in ASD.

Research Question 2: Will young children diagnosed with ASD display a preference for

non-social stimuli when compared to the control sample as measured by gaze to participants' caregivers in naturalistic parent-child interactions during a structured laboratory observation (SLO)?

Results indicated that ASD and TD children did not differ significantly in terms of gaze to caregiver during the SLO, as both groups gazed minimally at their caregivers during the interaction. This finding differs from previous research on gaze behaviors during parent-child interactions utilizing small ASD and TD samples, as significant differences were found across the two groups in the behaviors of joint attention, sustained attention, eye contact, and eye gaze (Karanth & Archana S, 2013). It could be argued that both groups in the current study showed a strong non-social preference when interacting with caregivers in an ecological context, if measured by gaze alone. However, it must also be taken into account that although the groups were matched by being within the age range of 18-54 months, within that age window the TD sample had a slightly lower age range than the ASD sample. This difference may have affected the SLO data even if not affecting the aforementioned eye-tracking differences between samples. Upon examining the aforementioned outlier in the TD sample, it was determined that this older participant (42 months) gazed quite a bit more at her caregiver than most of the other younger TD toddlers. It may therefore be hypothesized that with a greater sample of older TD participants, a higher percentage of gazes to caregiver would have been found, thus depicting differences in preferences between the groups in an ecologically valid setting.

Research Question 3: For all participants, will correlations be found between social looking behaviors as measured by the eye-tracking DLS and first gaze data and those

recorded as gaze to participants' caregivers in naturalistic parent-child interactions during a structured laboratory observation (SLO)?

To the author's knowledge, no research has explored the significance of non-social looking in eye-tracking as it relates to gaze during naturalistic interactions with caregivers. The current study aimed to fill this gap in the literature by examining relations between looking behaviors during the SGP paradigm and those towards caregivers during the SLO. Results showed that for both samples, no significant correlations were found between eye-tracking measures of social preference and those determined by behavioral coding of gaze during the SLO. This finding in conjunction with the above results indicate that while the eye-tracking paradigm appears to distinguish the ASD from the TD sample, the gaze patterns during the SLO do not distinguish the two samples and accordingly do not relate to the eye-tracking measurement of gaze. Therefore, it may make sense to bring into question the ecological validity of the eye-tracking measurement. However, if the supposedly "ecologically valid" SLO interaction does not reliably distinguish the two samples and does not relate in terms of gaze behavior to the eye-tracking measurement, it may also make sense to question the validity of measuring gaze to caregiver during the SLO as a visual social preference measurement.

For example, future research may benefit from examining other types of atypical gaze behavior that have distinguished ASD samples during parent-child interactions in previous research, such as those focused on joint attentional focus impairments (Adamson, Baker, & Deckner, 2004; Mundy, Sigman, & Kasari, 1994). Other potentially fruitful lines of inquiry could include studying gaze behavior in other variations of the SLO, such as those without toys in the room or those with a stranger instead of the caregiver, to obtain

measurement of gaze during different social environmental conditions. Finally, future research may consider measuring gaze during more complex naturalistic social and non-social scenes seen in daily life that would more closely mirror the complexity of the stimuli used in the eye-tracking paradigm.

Research Question 4: For participants diagnosed with ASD, will correlations be found between ASD looking behaviors as measured by the eye-tracking DLS and first gaze data and standardized assessment of social affect autism symptomology according to the Autism Diagnostic Observation Schedule (ADOS-2)?

Neither of the eye-tracking measurements of visual preference related to social affect impairment in the ASD sample. Again, this finding proves to be interesting given that the DLS eye-tracking measurement distinguished the ASD from the TD sample. These results stand in contrast to those of Pierce et al. (2015) and Pierce et al. (2011), where such studies found that the non-social visual preference displayed by ASD children predicted autism diagnosis and even symptom severity. When examining the results of the current study, it could be considered that the SGP Paradigm gaze measurement and that of the ADOS-2 Social Affect subscale may be capturing different components of the ASD diagnosis in this particular sample, thus explaining their lack of correlation to each other. For example, the SGP Paradigm captures preference for a scene of geometric moving images over the social stimuli of children in high action. Meanwhile, even the most gaze-related items on the Social Affect subscale measure behaviors such as unusual eye contact, facial expressions directed towards others, integration of gaze and other behaviors, showing items to others, and initiation of joint attention. Whereas it could be hypothesized that a lack of visual preference to social stimuli would relate to a lack of these social gaze-related behaviors, it

could be conjectured that they are in fact different components of the autism spectrum. The utility of each of these measurement tools may be greatest if they are examined in conjunction with each other when forming an ASD diagnosis for a given individual, since they may be addressing different aspects of the complex picture of autism.

Research Question 5: For participants diagnosed with ASD, will correlations be found between naturalistic looking behaviors to caregiver as measured by the SLO and standardized assessment of social affect autism symptomology according to the Autism Diagnostic Observation Schedule (ADOS-2)?

Regarding the final research question, a similar result was found such that the gaze behavior during the SLO was not significantly related to social affect impairment according to the ADOS-2 for the ASD sample. Again, this could be alluding to a difference in measurement, since the SLO gaze behavior to caregiver may vary greatly from the social impairment captured by the ADOS-2. The other factor to consider would be the nature of the two assessments, as the SLO involves the participant interacting with the caregiver, while the ADOS-2 requires interaction with an experimenter that the child likely has not met before. Gaze behaviors during these interactions may vary depending on comfort levels with a caregiver versus a stranger, and may therefore explain the lack of relation between these two variables.

The gaze aversion literature may be useful to consider here, as the ADOS-2 is arguably a more cognitively demanding task with structured prompts provided by an unfamiliar experimenter, versus an unstructured play-based interaction potentially with less demands, taking place with a familiar caregiver. The literature evidences a tendency of the ASD population to increasingly avert gaze from social stimuli as tasks grow more complex

and demanding (Doherty-Sneddon, Riby, & Whittle, 2012). A related line of research found that in an ASD sample, gaze aversion did not differ across cognitive tasks with a familiar experimenter and an unfamiliar experimenter (Doherty-Sneddon, Whittle, & Riby, 2013). However, to the author's knowledge this examination has not been compared between unfamiliar experimenters and familiar caregivers. It would therefore be of interest to explore differences in cognitive demand levels in the ADOS-2 and SLO, by nature of the assessment content itself and by nature of requiring interaction with a stranger versus caregiver.

It is evident that there is a dearth of literature comparing these two exact assessments. However, some research has shown inverse relations between autism symptom severity according to the ADOS-2 and quality of parent-child interaction as measured by behavioral and self-report tools such as the Dyadic Coding Scale and the Parent-Child Relationship Inventory (Beurkens, 2011; Beurkens, Hobson, & Hobson, 2013). Further research may help to elucidate the nature of relations between these various assessment modalities, as each different style of measurement, whether it may be various forms of parent-child interaction observations or parent report measurement, may capture different aspects of social attention and engagement in this population.

Secondary Analyses

Age and gender effects. In exploring how demographic variables may be related to significant findings in the primary analyses, age was found to be correlated with the DLS scores for both the ASD and TD group. Interestingly, while the ASD group's visual preference became more social on this measure as age increased, the TD group's preference became less geared towards constant social looking with increased age. This result may have been affected by the overall difference in age between the two samples, as the ASD

group was generally older than the TD group, and the two samples may have therefore been representing different phenomenons occurring at different age points. Regardless, additional analyses revealed that when factoring for age, the reason for the statistically significant difference between the two groups still proved to be the condition of the groups rather than the variable of age. Age also significantly correlated with lower social affect symptoms of the ASD group according to the ADOS-2, which may have been an important consideration had the correlations related to social affect symptomology been statistically significant. Age and gender were not found to be correlated with any of the other variables under investigation, suggesting that the primary findings are applicable to all toddlers between 18-54 months regardless of age or gender.

Intercorrelations within clinical measures. A third exploratory analysis investigated intercorrelations among all clinical measures. The associations between these measures in toddlers have not yet been thoroughly explored and this analysis serves as a foundation for future research. The lack of correlation between any of the measures suggests that they may be capturing different aspects of the autism diagnosis, as well as different aspects of typical development. Future research may benefit from exploring relations across more similar measures such as comparing scores obtained during social interactions with a stranger during the ADOS-2 to those with a stranger during the SLO, as opposed to the scores that were measured during interactions with participant caregivers.

Limitations

The current study has several limitations that warrant further investigation and replication of the conclusions and speculations explored in the discussion. Firstly, this study would benefit from increasing statistical power by being replicated with a larger sample of

toddlers. In addition, the racial/ethnic diversity of the current sample and particularly the TD sample was somewhat limited as it primarily consisted of children of European American descent. Investigating cultural differences in a sample of more demographically diverse children may prove to be informative. The gender of the typically developing sample was nearly evenly distributed, while the gender of the ASD sample was heavily skewed towards males. While this matches the diagnostic presentation of the larger population of children on the spectrum, the overall differences in gender between the groups may have also been a limitation. For the ASD sample, future research may benefit from including analyses of the amount of treatment received prior to the beginning of the study, in order to determine whether relations exist between amount of treatment received and performance on social attention measures.

With regard to age, the mean age of the ASD sample was seven months older than that of

the typically developing sample. This difference in age may have affected the results, as the younger TD sample may have exhibited less socially developed behavior as a result of being of a younger age group. The aforementioned outlier may be an example illustrating how having a higher age group of TD children may have shown an increase in social gaze behaviors as measured in the SLO. However, the significant difference found in DLS eye-tracking scores between the two groups did not appear to be affected by age, showing that this phenomenon of distinguishing the ASD from TD groups can be exhibited even with a younger, potentially less socially developed TD group.

Limitations also exist in the measures that were utilized for the current study. Although

there were two eye-tracking measures, a behaviorally coded measure, and a measure of ASD symptomology, the study may have benefited from the use of several additional measures. Within the behavioral coding of the SLO, the study may provide a richer picture of the toddlers' social profile by including coding of other social behaviors such as verbal communication, gestures, joint engagement, and initiations with participant caregivers. Additionally, other subscales of the ADOS-2 may be considered for analysis, such as the Restricted and Repetitive Behaviors subscale and the Total ADOS-2 score, in order to understand relations with various components of autism diagnosis as well as overall symptomology. Lastly, a battery of measures such as those focused on cognitive, language, and adaptive skills, would be beneficial to verify that there were no delays or signs of autism symptomology present in the typically developing sample.

Implications for Assessment

The primary aim of the current study was to better understand social attention in toddlers

with ASD in order to inform early identification of ASD and intervention efforts. Decreased visual focus on social stimuli has long been a clinical concern for researchers, clinicians, and parents. This study identified a non-social visual preference as an indicator of autism diagnosis when compared to social visual preference in the typically developing sample, but did not relate to more ecologically valid assessments with caregivers or standardized assessments of autism social affect impairment.

However, the SLO and ADOS-2 measures did not correlate with each other either, meaning that it is possible that each assessment type may provide their own utility. As mentioned earlier, non-social preferences as measured by eye-tracking paradigms have

proven to be fruitful with regard to predicting autism diagnosis as well as severity (Chawarska, Macari, & Shic, 2013; Jones, Carr, & Klin, 2008; Pierce et al., 2015; Shic, Bradshaw, Klin, Scassellati, & Chawarska, 2011). With regard to standardized assessment, the ADOS-2 has been confirmed as a reliable and valid measure of ASD diagnosis and severity (McCrimmon & Rostad, 2014). The gaze behavior coded on the SLO, however, did not distinguish the ASD from the TD sample, and it is likely that coding for the other social gaze behaviors on the SLO mentioned above, or examining other variations of the SLO assessment, could yield results that would assist assessment of autism diagnosis. Additional research in this area of multiple methods of assessment with larger sample sizes could help to improve understanding of visual preference as a potential symptom of ASD and whether this behavioral marker in the toddler years warrants early intervention.

Implications for Intervention

Methods of assessment in early childhood years such as those examined in this study should ultimately result in development of early treatment and prevention efforts. As mentioned earlier, a preference for non-social stimuli similar to that found in the current study relates to social impairment in children on the spectrum (Pierce et al., 2015). It is therefore critical that early intervention is focused on increasing the ability of children on the spectrum to associate social stimuli with rewarding qualities. It may be proposed that when children are motivated enough to visually attune to relevant social information, they may then make this knowledge available to themselves and can learn from it in a meaningful way that promotes successful navigation in complex social interactions throughout the lifetime.

Research in this area has illustrated the social gains resulting from utilizing socially embedded reinforcers in PRT-based intervention, including increased child affect, directed positive affect, and verbal initiations, as well as increased in synchronous transactional parent-child engagement and generalized increase in parent-child behaviors (Vernon, 2014; Vernon, Koegel, Dauterman, & Stolen, 2012). Preliminary eye-tracking evidence (Vernon, Navab, & Bradshaw, 2015) may hold promise with regard to measuring such gains as seen through social visual preference post-treatment. A promising next step would be to continue to elucidate the changes seen after intervention through eye-tracking measurement as well as ecologically relevant social laboratory observations, in order to ascertain the extent to which such innovative assessment methods may inform early intervention and thus benefit this treatment population.

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