Video Modeling Motor Skill Performances: An Eye-Tracking Analysis of Children with Autism Spectrum Disorder

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A Dissertation

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ABSTRACT

Motor competence provides young children the opportunity to move, explore, and interact with their environment. Furthermore, it provides young children the opportunity to build on more complex motor skills and movement patterns (Haywood & Getchell, 2014; Payne & Isaacs, 2002). However, studies have shown deficits and delays in the motor development of children with autism. Therefore, it is necessary to identify evidence-based practices and instructional strategies to support the motor development of children with autism.

One evidence-based practice shown to be effective in teaching children with autism is video modeling (Wong et al., 2014). Deeply rooted in the works of Albert Bandura's Social Cognitive Theory (1986, 1977), numerous studies have shown video modeling to be an effective practice in teaching behavioral functioning, social communication skills, and functional skills (Bellini & Akullian, 2007). However, very few studies have examined the effects of video modeling in teaching motor skills to children with autism.

The purpose of this study was to examine the visual attention patterns of children with autism as they observed video-modeled demonstrations of motor skill performances. Using eye-tracking technology, quantitative data were collected on three eye-tracking metrics: (a) time to first fixation, (b) total visit duration, and (c) visit count. This study also examined the effects of attentional highlighting motor skill performances. Eye-tracking research has shown children with autism to have atypical patterns of visual attention (Klin, Jones, Schultz, Volkmar, & Cohen, 2002).

Thirty-five males, ages 8-12 years participated in the study. Fourteen participants were diagnosed with autism and 21 participants were identified as typically developing children. All participants met the following inclusion criteria: (a) male, (b) ages 8-12 years, (c) understood verbal instruction, (d) had the visual acuity to watch a computer monitor at a distance of 20 inches, (e) successfully completed a 5-point eye-tracking calibration procedure, (f) maintained proper body positioning during the eye-tracking procedure, and (g) visually attended to a 2-minute video of motor skill performances. Data were collected during one 30-minute visit to a university-based eye-tracking lab.

The findings of this investigation indicated no statistically significant differences in the visual attention patterns of children with autism (ASD) compared to typically developing children (TD). However, major findings from the study include the following: One, with regard to time to first fixation, results indicated that children with autism took longer to attend the visual stimuli. This finding appeared in both the non-highlighted and highlighted conditions and across all four motor skill performances. Two, results indicated that children with autism visually attended to the AOIs for a shorter duration than typically developing children. This finding occurred in both the non-highlighted and highlighted conditions and across the four motor skill performances. Three, with regard to attentional highlighting, children with autism in the highlighted condition had faster times to first fixation than children with autism in the non-highlighted condition. Four, attentional highlighting increased total visit duration to the Action AOIs for children with autism. Five, an overall finding showed that both children with autism and typically developing children to have similar patterns of visual attention

to the AOIs (e.g., both the ASD and TD groups attended to the Action AOI for the longest period of time, followed by the Head AOI, and then the Cone AOI). These findings are to be interpreted with caution, as future research is needed.

Understanding the visual attention patterns of children with autism could lead to more innovative ideas in the design, creation, and presentation of video-modeled motor skill performances. The aim of this study was to provide a foundation for future research to support the motor development of children with autism, so they can live a healthy and physically active lifestyle.

Keywords: autism spectrum disorder, motor skill development, video modeling, and eye-tracking technology

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APPROVAL OF THE DISSERTATION

This dissertation, **Video Modeling Motor Skill Performances: An Eye-Tracking Analysis of Children with Autism Spectrum Disorder** has been approved by the Graduate Faculty of the Curry School of Education in partial fulfillment of the requirements for the Doctor of Philosophy Degree.

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Luke Kelly, chair

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July 30, 2018 Date

DEDICATION

To my Mom

Ann Marie Judge

January 2, 1932 – July 24, 2002

“Remember to always follow your heart.”

I miss you Mom, everyday!

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CHAPTER I: INTRODUCTION

Autism spectrum disorder is a neurodevelopmental disorder characterized by impairments in social communication, interaction, and restricted patterns of behavior. The disorder often coincides with intellectual disabilities, language impairments, and behavioral challenges (Diagnostic and Statistical Manual of Mental Disorders fifth ed.; DSM-5; American Psychiatric Association [APA], 2013). Approximately one in 59 children in the United States has been diagnosed with autism. The lifelong disorder is nearly four times more common in males than females and has been reported in all ethnic, racial, and socioeconomic groups (Baio et al., 2018). While much attention has been given to the core features of autism (i.e., social communication, interaction, and restricted and repetitive patterns of behavior), there has been a growing interest in the motor characteristics of this population.

In a review of the literature, Van Damme, Simons, Sabbe, and van West (2015) estimated a prevalence rate of motor impairment in children with autism to range between 33 to 100%. In a similar investigation, Fournier, Hass, Naik, Lodha, and Cauraugh (2010) reported substantial deficits in the motor coordination and postural stability (e.g., effect size ≥ 0.80) in this population. Though motor impairment is not identified as a core feature of autism, some argued that motor impairment should be considered a potential core feature of the disorder. It was further suggested that motor interventions focus on gait, balance, arm movement, and motor planning (Fournier et al., 2010). Motor competence provides young children the opportunity to move, explore, and

Interact with their environment. Furthermore, it provides young children the opportunity to build on more complex motor skills and movement patterns (Haywood & Getchell, 2014; Payne & Isaacs, 2002). As researchers continue to examine the motor characteristics of children with autism, there has been increased attention to infants at-risk of autism. Infants at-risk of autism are siblings of children diagnosed with the disorder (Flanagan, Landa, Bhat, & Bauman, 2012). Recent investigations have evidenced an array of motor deficits and delays in at-risk infants that were later diagnosed with autism.

Reports have shown motor impairment in grasping, object manipulation (Libertus, Sheperd, Ross, & Landa, 2014), head lag (Flanagan et al., 2012), posture (Nickel, Thatcher, Keller, Wozniak, & Iverson, 2013), and gait patterns (Esposito, Venuti, Apicella, & Muratori, 2011). Moreover, in a study of 87 infants at-risk for autism Landa and Garrett-Mayer (2006) reported nearly half of the infants showed "developmental worsening between 14 and 24 months" (p. 135). Similarly, Lloyd, MacDonald, & Lord (2013) concluded that motor delays in young children with autism often become more pronounced with age.

Several investigations have reported motor deficits in children and adolescents with the disorder. Researchers have evidenced deficits in posture stability (Mache & Todd, 2016), static balance (Whyatt & Craig, 2012), joint mobility (Shetreat-Klein, Shinnar, & Rapin, 2014), and overall gross motor performance (Liu, Hamilton, Davis, & ElGarhy, 2014; Pan, Tsai, & Chu, 2009; Staples & Reid, 2010). Some investigations have even explored possible links between motor impairment and the core features of autism.

Bhat, Galloway, and Landa (2012) compared low and high-risk infants at 3 and 6 months. Results showed a greater number of infants at-risk for autism had motor deficits at 3 and 6 months. At 18 months, a majority of the infants at-risk for autism had both motor and communication delays. Bedford, Pickles, and Lord (2015) examined a possible link between motor development and communication in 209 children with autism. Data showed gross motor abilities as a significant predictor of both receptive and expressive language development in children between the ages of 2 to 9 years (Bedford et al., 2015).

In a study of 35 children with autism, ages of 6-15 years, MacDonald, Lord, and Ulrich (2013) explored the relationship between motor skills and social communicative skills. From this investigation, researchers found children with motor skill deficits to have greater social communicative skill deficits. The study also concluded object-control skills significantly predict calibrated ASD severity (MacDonald et al., 2013). Similarly, MacDonald, Lord, and Ulrich (2014) examined the relationship between motor skills and social communication of young children with and without autism. Results from this investigation showed fine and gross motor skills significantly predicted calibrated autism severity in young children. As in their previous investigation (i.e., MacDonald et al., 2013), the researchers concluded that children with motor skill deficits tend to have greater social communicative skill deficits (MacDonald et al., 2014).

While intellectual impairment is not a core feature of autism, Green et al. (2009) examined a possible link between motor impairment and IQ in children between the ages of 10-14 years. Results from this investigation indicated greater motor impairment in children with an IQ < 70 when compared to children with an IQ > 70. The authors concurred that a systematic and routine assessment of motor impairments in children with autism should be considered (Green et al., 2009). Likewise, Hilton, Zhang, Whilte, Klohr, and Constantino (2012) examined the relationship between IQ and autism severity. Results indicated that 83% of the children with autism scored at least one standard deviation below the mean scores, while 6% of the children without autism scored at least one standard deviation below the mean. The study concluded that successful interventions for motor proficiency might support complex social-cognitive impairments in children with autism (Hilton et al., 2012).

As a growing body of literature has shown motor impairments to have far-reaching implications on the overall development of children with autism (Downey & Rapport, 2012; Fournier et al., 2010; Leonard & Hill, 2014), additional research is warranted. A greater understanding of the motor characteristics of this population could lead to early diagnosis, enhanced motor interventions, and greater prognostic outcomes (Downey & Rapport, 2012; Liu & Breslin, 2013; Liu et al., 2014; Matson, Mahan, Hess, Fodstad, & Neal, 2010; Paquet, Olliac, Golse, & Vaivre-Douret, 2016). While it is necessary to support all children with motor competency, it is especially important to support individuals with pre-existing motor impairment (e.g., children with autism and infants at-risk of the disorder).

According to the Society of Health and Physical Educators (SHAPE America), ". . . motor competency is essential for participation in physical activity and for health-enhancing fitness" (America, S. H. A. P. E., Couturier, Chepko, & Holt, 2014, p. 6). For this reason, it is imperative for researchers, practitioners, and parents/caregivers to utilize evidence-based practices and interventions to support children with autism in living a healthy and physically active lifestyle.

According to the Individuals with Disabilities Education Act (2004), children and adolescents, ages of 3-21 years, have the right to free and appropriate public education (FAPE) in the least restrictive environment (LRE). The law mandates special education, including physical education, to provide specially-designed instruction to meet the unique needs of children and youth with disabilities (Individuals with Disabilities Education Act [IDEA], 2004). IDEA defines physical education as the "development of (a) physical education and motor fitness, (b) fundamental motor skills and patterns, and (c) skills in aquatics, dance, and individual and group games and sport (including intramural and lifetime sports)" (IDEA, 2004, Section 300.39 Special Education). While federal legislation has long supported the instruction of physical education to children with disabilities, physical educators have acknowledged the challenges of teaching physical education to children with autism.

In a study of 43 certified physical educators, Obrusnikova and Dillon (2011) found cooperation, competition, and individualized instruction to be amongst the most challenging situations in teaching physical activity to children with autism. As researchers continue to investigate these challenges, it is imperative for physical educators to utilize evidence-based practices to support this population.

One such evidence-based practice is modeling (Wong et al., 2014). Deeply rooted in the works of Albert Bandura's Social Cognitive Theory (1986, 1977), modeling has long been "acknowledged to be one of the most powerful means of transmitting values, attitudes, and patterns of thought and behavior" (Bandura, 1986, pp. 47-48). Modeling has been used by parents, teachers, coaches, and physical educators as an instructional strategy to convey relevant information to learners (Ashford, Bennett, & Davids, 2006). While modeling has shown to be effective in teaching an array of targeted skills and behaviors, Bandura (1986) asserted that for observational learning to occur the four subprocesses must coincide. The four governing subprocesses of observational learning are: (a) attentional processes, (b) retention processes, (c) production processes, and (c) motivational processes.

Bandura (1986) described the four subprocesses accordingly. The attentional processes determine the information to be observed and extracted from a modeled event. In the retention processes, the observed information is transformed and symbolically coded so the modeled behavior can be learned. In the production processes, the symbolically coded information of a modeled event is transformed into the action. Moreover, the motivation processes determine the likelihood that a modeled behavior would be repeated. Incentives (i.e., direct, vicarious, and self-produced) are contributing factors to the motivational processes (Bandura, 1986). With regard to observational learning and physical activity, a few studies have acknowledged Bandura and the four subprocesses of observational learning with typically developing children and adolescents.

Studies have evidenced the effects of observational learning in basketball (O'Loughlin, Chroinin, & O'Grady, 2013), gymnastics (Bouazizi, Azaiez, & Boudhiba, 2014), track and field (Panteli, Tsolakis, Efthimiou, & Smirniotou, 2013), diving (Rymal, Martini, & Ste-Marie, 2010), throwing (Doussoulin & Rehbein, 2011), and performances on balance beams (Ste-Marie, Rymal, Vertes, & Martini, 2011a), and trampolines (Ste-Marie, Vertes, Rymal, & Martini, 2011b). Though studies have shown observational learning to have a profound impact on typically developing children (Bandura, 1986), the impact of observational learning may differ for children with autism (Charlop-Christy, Le, & Freeman, 2000; Corbett, 2003; Corbett & Abdullah, 2005).

As noted previously, autism is characterized by deficits in social communication and social interaction (APA, 2013). Therefore, in-vivo modeling, also known as live modeling, may not be conducive for some children with autism. Face-to-face interaction between the model and observer may be aversive and may impede observational learning (Charlop-Christy et al., 2000; Corbett, 2003; Corbett & Abdullah, 2005). For that reason, video modeling has been utilized to facilitate observational learning (Corbett, 2003; Corbett & Abdullah, 2005).

Video modeling is a technique in which a video representation of a targeted behavior is presented to the learner (Bellini & Akullian, 2007). Bandura (1986) referred to this technique as symbolic modeling. The learner watches a video demonstration of a targeted skill or behavior and then replicates the skill or behavior. The model may be a peer, sibling, adult, or self (Bellini & Akullian, 2007). To date, both the National Professional Development Center (Wong et al., 2014) and the National Autism Center (National Autism Center [NAC], 2015) acknowledge video modeling as an effective evidence-based practice in teaching children with autism.

Four types of video modeling procedures have shown to be effective in the facilitation of observational learning. They include: (a) basic video modeling, (b) video self-modeling, (c) point-of-view modeling, and (d) video prompting (Franzone & Collet-Klingenberg, 2008).

Basic video modeling is a technique in which a peer, sibling, or adult model demonstrates a targeted skill or behavior. A video representation of the targeted skill or behavior is presented to the learner. Once the video is observed, the learner is provided an opportunity to model the event (Cardon, 2016).

Video self-modeling (VSM) is a technique in which learners observe themselves successfully performing a targeted skill or behavior. Though additional time is needed to create and edit the video, the strategy has shown great promise in teaching children with autism (Cardon, 2016).

Point-of-view video modeling (POVM) is a technique in which a video recording is taken from the first person perspective. The model’s hands are observed manipulating the materials to complete a task. POVM is most commonly used in teaching systematic procedures (i.e., washing hands) (Cardon, 2016).

Lastly, video prompting is a technique in which each step of a targeted skill or behavior is recorded. Pauses are built into the video to allow time for the learner to complete one-step before viewing subsequent steps (McCoy & Hermansen, 2007).

While much of the literature on video modeling has focused on social-communication, functional skills, and behavioral functioning (Bellini & Akullian, 2007), very few investigations have examined the effects of video modeling on motor skill performances. For example, video modeling has been used to teach children with autism line dancing (Gies, 2012), yoga (Gruber, 2008), push-ups (Trocki-Ables, 2014), aquatic play skills (Yanardag, Akmanoglu, & Yilmaz, 2013), and social games (Kourassanis, Jones, & Fienup, 2014). The findings of these investigations extend the literature on video modeling to include the teaching of physical activity to children and adolescents with autism.

Though video modeling has shown great promise, there is limited information on where children visually attend to the modeled demonstrations. According to Bandura (1986), attention is the first subprocess of observational learning and must take place for learning to occur. Therefore, understanding the visual attention patterns of children with autism could lead to more innovative ideas in the design, creation, and presentation of video-modeled motor skill performances.

To explore the visual attention patterns of children with autism, researchers have utilized eye-tracking technology. Eye-tracking is a non-invasive method of detecting eye movement. The technology provides quantitative information on where someone visually attends. An eye-tracker is the actual device that detects and records eye movement. Currently, there are two types of eye-tracking devices (i.e., remote and mobile). Remote eye-trackers are attached to a computer monitor and are often used in a laboratory setting. Mobile eye-trackers are worn as eyewear and can be used in the environment. Both devices rely on the pupil-corneal reflection to monitor eye movement. The pupil-corneal reflection enables the eye-tracker to capture and record eye movements such as fixations and saccades. Fixations are eye movements that steady the retina over an area of interest on the visual stimuli (Duchowski, 2007). Saccades are rapid movements of the eye that transition from one fixation to another (Bojko, 2013). Depending on the eye-tracking analytical software, the data collected can be converted into an array of metrics (i.e., time to first fixation, total visit duration, and visit count) (Bojko, 2013; Duchowski, 2007; Holmqvist et al., 2011). Over the years, eye-tracking technology has gained popularity amongst researchers studying an array of neuropsychiatric conditions and special populations (Shic, 2013).

With regard to autism, several studies have used eye-tracking technology to compare children with autism to typically developing children. One of the earliest investigations examined the visual fixation patterns of children with autism while viewing naturalistic social situations (Klin et al., 2002). More recently, researchers have examined gaze performance during communication actions (Falck-Ytter, Fernell, Hedvall, von Hofsten, & Gillberg, 2012), gaze performance on semi-naturalistic social interactions (Falck-Ytter, von Hofsten, & Gillberg, & Fernell, 2013), gaze performance during adult-children play interaction (Shic, Bradshaw, Klin, Scassellati, & Chawarska, 2011),visual exploration patterns of social and non-social pictures (Sasson & Touchstone, 2014; Sasson, Turner-Brown, Holtzclaw, Lam, & Bodfish, 2008), and visual preferences (Pierce et al., 2015).

Nevertheless, only a few investigations have used eye-tracking technology to examine the motor characteristics of children with autism. Vivanti, Nadig, Ozonoff, and Rogers (2008) compared the visual attention patterns of meaningful actions and non-meaningful gestures with objects. In a series of studies, Vivanti et al. (2011) compared children and adolescents with autism to typically developing peers on unconventional goal-directed actions, model gaze direction towards objects, use of emotional cues, and direct and averted gaze patterns of the model. Extending the literature on eye-tracking technology, Vivanti & Dissanayake (2014) examined the effects of direct and averted gaze patterns of the model performance with preschoolers.

Eye-tracking technology has great potential to assist researchers in understanding the complexity of autism. To date, no studies have examined the visual attention patterns of children with autism as they observe motor skill performances related to physical activity.

Purpose of the Study

The purpose of this study was to examine the visual attention patterns of children with autism as they observed video-modeled demonstrations of motor skill performances. Using eye-tracking technology, quantitative data were collected on three eye-tracking metrics: (a) time to first fixation, (b) total visit duration, and (c) visit count. In addition, the study examined the effects of attentional highlighting on motor skill performances (e.g., placing a yellow highlight arrow next to the action area of the motor skill performance). Eye-tracking studies have shown children with autism to have atypical patterns of visual attention compared to typically developing children (Klin et al., 2002). For example, children with autism have shown decreased interest in faces, increased interest to background objects (Shic et al., 2011), greater preference for geometric shapes (Pierce et al., 2015), decreased interest in biological motion (Klin, Lin, Gorrindo, Ramsay, & Jones, 2009), limited exploration of images, and longer periods of fixation (Sasson et al., 2008). Understanding the visual attention patterns of children with autism could lead to more innovative ideas in the design, creation, and presentation of video-modeled motor skill performances.

Research Questions

This study addressed the following research questions:

RQ 1: During the presentation of a motor skill performance, how does the mean time to first fixation (TFF) (seconds) of children with autism compare to typically developing children?

H_0: There are no differences in the mean TFF (seconds) of children with autism when compared to typically developing children.

H_1: There are differences in the mean TFF (seconds) of children with autism when compared to typically developing children.

RQ 2: During the presentation of a motor skill performance, how does the mean TFF (seconds) of the non-highlighted condition compare to the highlighted condition?

H_0: There are no differences in the mean TFF (seconds) between the non-highlighted and highlighted conditions.

H_1: There are differences in the mean TFF (seconds) between the non-highlighted and highlighted conditions.

RQ 3: During the presentation of a motor skill performance, how does the mean total visit duration (TVD) (seconds) of children with autism compare to typically developing children?

H_0: There are no differences in the mean TVD (seconds) of children with autism when compared to typically developing children.

H_1: There are differences in the mean TVD (seconds) of children with autism when compared to typically developing children.

RQ 4: During the presentation of a motor skill performance, how does the mean TVD (seconds) of the non-highlighted condition compare to the highlighted condition?

H_0: There are no differences in the mean TVD (seconds) between the non-highlighted and highlighted conditions.

H_1: There are differences in the mean TVD (seconds) between the non-highlighted and highlighted conditions.

RQ 5: During the presentation of a motor skill performance, how does the mean visit count (VC) of children with autism compare to typically developing children?

H_0: There are no differences in the mean VC of children with autism when compared to typically developing children.

H_1: There are differences in the mean VC of children with autism when compared to typically developing children.

RQ 6: How does the mean VC of the non-highlighted condition compare to the highlighted condition?

H_0: There are no differences in the mean VC between the non-highlighted and highlighted conditions.

H_1: There are differences in the mean VC between the non-highlighted and highlighted conditions.

Measures

This study examined two independent variables (i.e., group and condition) and three dependent variables (i.e., time to first fixation, total visit duration, and visit count).

Independent Variables:

1. Group: Autism (ASD) and typically developing (TD) children.
2. Condition: Non-highlighted video (NH) and highlighted video (H).

Dependent Variables:

1. Time to First Fixation - the measure of time (seconds) to fixate on the first area of interest (i.e., action, cone, or head) for each of the motor skill performances.
2. Total Visit Duration - the measure of time (seconds) spent in the area of interest (i.e., action, cone, or head) for each of the motor skill performances.
3. Visit Count - the number of visits within an area of interest (i.e., action, cone, or head) for each of the motor skill performances.

Definition of Terms

Anticipatory posture. An infant reaching out with arms to be picked up by a parent or caregiver (Kanner, 1943).

Area of Interest (AOI). A defined region of a display from which quantitative data are collected (Holmqvist et al., 2011).

Continuous motor skills. Motor skills that do not a have a defined starting and ending point (Fairbrother, 2010).

Cross-hair. An eye-tracking technique used to ensure that all visual patterns began at the same point for each array (Tobii Studio, 2016).

Discrete motor skills. Motor skills that have a defined starting and ending point; often performed rapidly (Fairbrother, 2010).

Dynamic stimulus. A visual stimulus that involves motion or movements such as movies, videos, or real-world scenarios (Blascheck et al., 2014).

Eye gaze. The location of the human eye at a given point in time (Bergstrom & Schall, 2014).

Eye-tracker. A device used to measure the position of the eye and to determine where a person is visually attending (Bergstrom & Schall, 2014).

Eye-tracking. A technique used to obtain quantitative measures of where an individual is visually attending (Shic, 2013).

Fixations. Eye movements that steady the retina over an area of interest on the visual stimuli (Duchowski, 2007).

Fovea. A small area of the retina where cells are responsible for high visual acuity (Duchowski, 2007).

Foveal vision. The visual field in which visual acuity is the greatest; approximately 2° of the visual field. It is approximately the width of a thumbnail about an arm's length away (Holmqvist et al., 2011).

Head box. The area relative to the eye-tracker that the participant can move without compromising the quality of the recorded data (Holmqvist et al., 2011).

Infants at-risk for autism. Siblings of children diagnosed with autism spectrum disorder (Flanagan et al., 2012).

In-vivo modeling. A type of modeling in which the learner watches a live presentation of a targeted skill or behavior (Charlop-Christy et al., 2000).

Modeling. A process whereby an observer assimilates the information needed to approximate the actions of a performer; also known as observational learning (Ashford et al., 2006; Bandura, 1986).

Near-infrared light. The light source used to create a corneal reflection from which the eye-tracking device measures eye movement (Bojko, 2013).

Pupil-corneal reflection. A non-invasive method of detecting and tracking the eye as it moves; used to estimate the point of gaze (Holmqvist et al., 2011).

Purkinje Reflections. Four reflections that occur, as incoming light is redirected from the eye (e.g., cornea and eye lens); often referred to as P_1, P_2, P_3, and P_4 (Crane, 1994; Duchowski, 2007).

Saccade dysmetria. Atypical movements of the eye that result in either under shooting or over shooting a fixed position (Netto & Colafêmina, 2010).

Saccades. Rapid movements of the eye that transition from one fixation to another (Bojko, 2013).

Smooth pursuit. Eye movements that closely track moving objects by steadily matching its velocity (Duchowski, 2007).

Social Communication Questionnaire (SCQ). A brief assessment instrument designed to evaluate the communication skills and social functioning of children who may have autism spectrum disorder (Rutter, Bailey, & Lord, 2003).

Static stimulus. A visual stimulus that remains stationary, such as images, pictures, photos, or advertisements (Blascheck et al., 2014).

Stimulus. The visual information presented to the participant during an eye-tracking experiment (Blascheck et al., 2014).

Stimulus over-selectivity. Difficulty in responding to multiple cues in the environment (Lovaas, Schreibman, Koegel, & Rehm, 1971).

Time to First Fixation. An eye-tracking metrics that measures the length of time from the onset of a visual stimulus to the participant's first fixation to an AOI (Tobii Studio, 2016).

Total Visit Duration. An eye-tracking metrics that measures the length of time the eye attends to a specific area of the visual stimuli (Bergstrom & Schall, 2014); the most widely used measure in eye-tracking research (Holmqvist et al., 2011).

Video modeling. A modeling procedure designed to facilitate observational learning (Corbett, 2003; Corbett & Abdullah, 2005) via a video representation of a desired behavior (Bellini & Akullian, 2007).

Vineland Adaptive Behavior Scales-3rd Edition (VABS-3). A common assessment instrument used to measure personal and social skills for everyday living (Sparrow, Cicchetti, & Saulnier, 2016).

Visit Count. An eye-tracking metrics that measures the number visits and re-visits to an AOI; visits end when the eyes move outside the AOI (Tobii Studio, 2016).

Visual attention. The narrow, high-resolution field of foveal vision often measured in eye-tracking research. Common eye-tracking measures include time to first fixation, fixation duration, and fixation count (Tobii Studio, 2016).

Delimitations

Delimitations are the characteristics of a study that limit the scope of the inquiry as determined by the conscious decisions made throughout the development of the proposal. Therefore, this study was delimited in the following areas:

1. To reduce participant variability, all participants were male and between the ages of 8 to 12 years.
2. Participants diagnosed with ASD had a professional diagnosis of the disorder.
3. All participants were required to meet the inclusion criteria as stated on the Research Participant Demographic Information Form (see Appendix F).
4. Only continuous motor skills (i.e., dribbling a basketball) were presented in the video. Therefore, the findings cannot be generalized to discrete motor skill performances (i.e., throwing a ball).
5. Data collection took place at a university-based eye-tracking laboratory. Therefore, the findings cannot be generalized to other learning environments.

Limitations

Limitations are the characteristics of a study that could influence the interpretation or generalizability of the findings. This study acknowledged the following limitations:

1. The study only included participants from the southern region of the United States.
2. Due to the heterogeneity of the disorder, the results of this investigation cannot be generalized to all individuals with autism.

3. The principal investigator was new to the southern Mississippi region. To attain the required number of participants, recruitment took placed throughout the investigation.
4. The principal investigator was new to the brand of eye-tracking technology provided by the university.

Statement of Significance

Video modeling is an evidence-based practice shown to be effective in teaching an array of skills to individuals with autism (Bellini & Akullian, 2007). However, very few studies have examined the effects of video modeling on teaching motor skill performances to children with autism. Theoretically rooted in the works of Albert Bandura's Social Cognitive Theory (1986, 1977), this investigation examined the attentional subprocesses of observational learning. Studies have shown children with autism to exhibit atypical patterns of visual attention compared to typically developing peers (Klin et al., 2002; Vivanti et al., 2011; Vivanti et al., 2008). Using eye-tracking technology, this study provides quantitative data on the visual attention to motor skill performances of children with autism. Understanding the visual attention patterns of children with autism could lead to more innovative ideas that promote a healthy and physically active lifestyle.

CHAPTER II: LITERATURE REVIEW

The purpose of this study was to examine the visual attention patterns of children with autism as they observed video demonstrations of motor skill performances. This chapter will provide a review of the relevant literature on the following topics: (a) autism spectrum disorder, (b) modeling motor skill performances, (c) video modeling and autism spectrum disorder, and (d) eye-tracking technology. Each topic will be examined, and relevant literature will be summarized. At the conclusion of this chapter, the topics will be summarized, and possibilities for future research will be discussed.

SECTION I: Autism Spectrum Disorder

This section of the literature review will provide an overview of autism spectrum disorder. It will (a) identify the core diagnostic criteria, (b) define the severity levels, and (c) review the literature on the motor characteristics of children with autism. This section will conclude with a summary of autism spectrum disorder.

Overview of Autism Spectrum Disorder

Autism Spectrum Disorder is a neurodevelopmental disorder characterized by impairments in social communication and interaction, and restricted patterns of behavior (APA, 2013). Individuals diagnosed with the disorder can range from a mild impairment to a severe disability (National Institute of Mental Health [NIMH], 2016). Often autism coincides with intellectual disabilities, language impairments, and behavioral challenges (APA, 2013). According to the Centers for Disease Control and Prevention (CDC)

(2018), approximately 1 in 59 children in the United States has been diagnosed with autism by age 8. The lifelong disorder is four times more common in males (1 in 37) than females (1 in 151); and it has been reported in all ethnic, racial, and socioeconomic groups (Baio et al., 2018).

According to the Autism and Developmental Disabilities Monitoring Network (ADDM) report for 2014, prevalence estimates of autism in children aged 8 years has increased from 6.7 in 2000 to 16.8% in 2014 (Baio et al., 2018). Some have proclaimed the increased prevalence is a result of external factors such as increased awareness, access to screening diagnostic services, early identification, and changes in the diagnostic criteria (Blumberg et al., 2013; Schieve et al., 2011). While there is no known cure for autism, numerous studies have shown early intervention to be an effective treatment (Baio et al., 2018; CDC, 2018).

Core Diagnostic Criteria

According to the Diagnostic and Statistical Manual of Mental Disorders-5, for an individual to be diagnosed with autism spectrum disorder, specific diagnostic criteria must be evident. For example, an individual must exhibit mild to severe impairments in social interaction and communication, as well as the presence of restricted and repetitive patterns of behavior. Furthermore, the core diagnostic criteria must be evident during early development and not better explained by an intellectual disability or developmental delay. Though the core features of autism may be detected during early development, the characteristics may not become evident until the child has experienced increased social demands. Adding to the complexity of the disorder are several associated features. Such features include intellectual disabilities, language impairments, motor deficits, anxiety, depression, and self-injurious behavior (APA, 2013). Nevertheless, the variability of symptoms makes diagnosing the disorder a complex process (Huerta & Lord, 2012; Jeste & Geschwind, 2014).

Autism Severity Levels

Another major challenge of autism is determining the level of severity of the disorder. For this reason, the DSM-5 has defined three levels of severity for each of the core features of autism (e.g., impairments in social interaction and communication, and a presence of restricted and repetitive patterns of behavior). The levels of severity are defined as Level 1 - requiring support, Level 2 - requiring substantial support, and Level 3 - requiring very substantial support (APA, 2013). Though the DSM-5 provides qualitative differences between the levels, some argue for more quantitative measures to differentiate the severity of the disorder (Weitlauf, Gotham, Vehorn, & Warren, 2014).

In a study of 726 participants with autism, Weitlauf et al. (2014) reported participants with mild, moderate, and severe autism symptoms had varying levels of adaptive and cognitive impairment. From this investigation, Weitlauf et al. (2014) assert "that it is not clear how individuals with mixed levels of impairment across cognitive, adaptive, and autism-specific symptom domains should be classified in terms of the DSM-5" and that "potential discrepancies between severity categorizations that may have inadvertent service implications" (Weitlauf et al., 2014, p. 471). Until more elucidated methods of classifying autism are attained, it has been suggested for researchers to provide both qualitative and quantitative identification of autism-specific symptoms, cognitive and adapted functioning, language skills, the pattern of onset, and comorbid symptoms of their sample population. Providing adequate sample characterization will help increase the homogeneity of samples and enhance the interpretability and replicability of the research (Grzadzinski, Huerta, & Lord, 2013). Furthermore, Grzadzinski et al. (2013) recommended diagnostic measures that provide both qualitative and quantitative data. Diagnostic measures and rating scales include the following: Autism Diagnostic Observation Schedule-2 (Lord et al., 2012), Autism Diagnostic Interview-Revised (Rutter, Le Couteur, Lord, & Faggioli, 2005), Childhood Autism Rating Scale-2 (Schopler, Van Bourgondien, Wellman, & Love, 2010), Gilliam Autism Rating Scale-Second Edition (Gilliam, 2005); Social Communication Questionnaire (Rutter et al., 2003), and the Vineland-3 Adaptive Behavior Scales - Third Edition (Sparrow et al., 2016).

Review of Literature on the Motor Characteristics of Autism

Several studies have documented an array of motor impairments in children with autism, as well as infants at-risk of the disorder (Downey & Rapport, 2012; Fournier et al., 2010; Paquet et al., 2016; Van Damme et al., 2015). Recent investigations have even explored possible links between motor deficits and a child’s overall development (Bedford et al., 2015; Green et al., 2009; MacDonald et al., 2013; MacDonald et al., 2014). Though motor impairment is not considered a core feature of autism (i.e., social communication, interaction, and stereotypic behaviors), motor deficiencies have long been reported.

As far back as 1943, Leo Kanner vividly depicted several characteristics of autism. In his landmark report titled, Autistic Disturbances of Affective Contact, Kanner observed eleven children, whose condition differed “so markedly and uniquely from anything reported” (Kanner, 1943, p. 217). About the same time, Hans Asperger observed four children in his landmark report titled, ‘Autistic Psychopathy’ in Childhood. He observed children with autism as having “. . . a fundamental disturbance which manifests itself in their physical appearance, expressive functions and, indeed, their whole behavior” (Asperger & Frith, 1991, p. 37). Through direct observation and parental reports, both authors observed social withdraw, stereotyped movements, resistance to change, and unusual interests (Asperger & Frith, 1991; Kanner, 1943). Ironically, both Kanner and Asperger’s observations parallel the with today’s core features of autism.

What's more, Kanner and Asperger both observed deficits and delays in the motor performance of this population (Asperger & Frith, 1991; Kanner, 1943). Kanner reported deficits in anticipatory posture, difficulties in adjusting their body to the posture of the person who holds them, clumsiness in gait and gross motor performances, and sluggish reflexes. He described one child as graceful in water (swimming) but appeared awkward in mobility (Kanner, 1943). Likewise, Asperger reported children as being “clumsy from a motor point of view” (Asperger & Frith, 1991, p. 61) and having rather delayed motor milestones. He also noticed children as having limited control of their body, difficulties in maintaining rhythm, and could only move body parts with extreme effort. Asperger reported that “nothing was spontaneous or natural, everything was intellectual” (Asperger

& Frith, 1991, p. 57). He further described that catching and throwing was “extremely comical in appearance” (Asperger & Frith, 1991, p. 66). Nevertheless, a growing body of literature continues to evidence an array of motor deficits and delays in this population.

Understanding the importance of early intervention, several investigations have directed their attention to infants at-risk for autism. Bhat et al. (2012) compared the motor development of infants at-risk for autism (*n* = 24) to infants at low-risk for autism (*n* = 24). Using the Alberta Infant Motor Scale (AIMS) (Piper & Darrah, 1994), Bhat et al. (2012) compared infants at-risk for autism to infants at low-risk for autism. Results showed a greater number of infants at-risk for autism had motor deficits at 3 and 6 months. Furthermore, approximately 67–73% of the infants at-risk for autism that exhibited early motor delays, later experienced communication delays. From this investigation, it was suggested that motor and social communication evaluations be administered to infants at-risk of the disorder. A limitation of this investigation was that no report was provided on motor development beyond 6 months of age (Bhat et al., 2012).

In a similar investigation of infants at-risk for autism, Nickel et al. (2013) examined the early posture development of 22 infants at high-risk for autism and 18 infants at low-risk for autism. Home videos of the infants at 6, 9, 12, and 14 months of age during everyday play and activities were coded and classified. Results from the investigation showed infants at high-risk for autism were slower to develop in sitting and standing postures. Four of the infants at high-risk for autism, later diagnosed with the disorder, had substantial delays in posture development. The authors concurred that postural delays could affect an infant's ability to explore and learn from the environment. A limitation of this study was a small sample size (Nickel et al., 2013).

In a longitudinal study, Flanagan et al. (2012) examined 20 high-risk infants and 21 low-risk infants for autism from 6 months to 36 months of age. Using a video analysis of the pull-to-sit task from Mullen Scales of Early Learning (Mullen, 1995), results showed head lag was significantly associated with autism at 36 months ($p = .020$) and was more frequently observed in high-risk than in low-risk infants at 6 months ($p = .018$). From this investigation, the authors suggest adding the pull-to-sit task to existing developmental screening procedures for infants at-risk of the disorder. The authors concluded that early detection of motor delays could lead to early intervention and greater prognosis. Limitations of this investigation were a relevantly small sample size and a lack of a control group (Flanagan et al., 2012).

In a comparison study of 129 infants, Libertus et al. (2014) used the Mullen Scales of Early Learning (Mullen, 1995) during toy play to examine the motor skills of infants at 6 months. The infants were grouped accordingly: (1) LR Non (low-risk autism, no developmental delays; (2) HR Non (high-risk autism, no developmental delays); (3) HR DD (high-risk autism, with developmental delays; and (4) HR ASD (high-risk or diagnosed with ASD). Results indicated that infants at high-risk for autism exhibited less mature object manipulation in a highly structured context (assessment) and reduced grasping activity in an unstructured context (free-play) than infants at a low-risk for autism. The authors recommend qualitative and quantitative research on early object-exploration of infants at-risk for autism. A limitation of this study was the selection of object exploration-focus items from the MSEL (Mullen, 1995) used in the study (Libertus et al., 2014).

One of the most recognized milestones in early motor development is independent walking, often achieved at 12 months (Adolph & Joh, 2009; Adolph & Robinson, 2013). Unlike sitting and crawling, independent walking allows a young child to use their hands to gesture, manipulate objects, and interact with their environment (Bedford et al., 2015). Clearfield (2011) reported infants with the ability to walk independently “spent significantly more time interacting with the toys and with their mothers and made more vocalizations and more directed gestures compared to infants in the walker” (Clearfield, 2011, p. 15). However, independent walking may be somewhat of a challenge for infants and toddlers with or at-risk of autism.

Esposito et al. (2011) used home video analysis to investigate the first unsupported gait of toddlers with autism. The study compared three groups: (1) autism (n = 20, age 14.2 months ± 1.4 months); (2) typically developing toddlers (n = 20, age 12.9 months ± 1.1 months); and (3) toddlers with non-autistic developmental delays (n = 15, age 13.1 months ±0.8 months). Results showed toddlers with autism have more atypical, foot and arm movement than typically developing toddlers and toddlers with non-autistic developmental delays. The authors proclaim that motor development could be a possible bio-marker for infants at-risk for autism. A limitation of this study was the lack of standardization in the setting that the participants were observed (e.g., home videos) (Esposito et al., 2011).

Similarly, Shetreat-Klein et al. (2014) examined gait and prevalence of toe walking, passive joint mobility, and “age at walking.” In a comparison study of 38 children with autism (mean age 4 years 6 months) and 38 children without autism (mean age 4 years 8 months), Shetreat-Klein et al. (2014) found young children with autism had significantly greater joint mobility ($p < .002$), more gait abnormalities ($p < .0001$), and on average walked 1.6 months later than young children without autism. From these findings, the researchers concurred that attention should be directed towards the motor deficits of children with autism. In this investigation, the researchers acknowledged the modest sample size as a limitation.

Landa and Garrett-Mayer (2006) and Lloyd et al. (2013) further evidenced the need for early motor screening of infants at-risk for autism. In a study of 87 infants at-risk for autism, Landa and Garrett-Mayer (2006) examined high-risk infants for autism ($n = 60$) to low risk infants for autism ($n = 27$) at 6, 14, and 24 months. Using the Mullen Scales of Early Learning (Mullen, 1995) results showed no statistically significant group differences at 6 months. However, nearly half of the infants showed “developmental worsening” (p. 634) between 14 and 24 months (Landa & Garrett-Mayer (2006).

Likewise, Lloyd et al. (2013) used the Mullen Scales of Early Learning (Mullen, 1995) and had similar findings. In a cross-sectional analysis of 162 young children with autism ages 12-36 months, the data showed significant motor delays in young children with autism. Lloyd et al. (2013) also examined 58 children with autism from the above sample. A repeated-measure ANCOVA evidenced significant motor delays in both fine and gross motor development. What's more, the findings concurred that motor delays of children with autism become more pronounced with age.

As a result, investigations continue to report an array of motor deficits and delays in children and adolescents with autism. In a comparison study of 22 children with and without autism ages 5-12 years, Mache & Todd (2016) examined the postural sway of children with autism to children without autism. Using the Test of Gross Motor Development-3 (TGMD-3) (Ulrich, in press) to assess motor skills and a force plate to measure postural sway, the data showed significantly greater postural sway in children with autism. Results from this investigation indicated that children with autism lack the postural control to perform complex motor skills. In this investigation, the researchers acknowledged the relatively small sample size as a limitation and the participants were not representative of individuals with autism as a population (e.g., participants required certain abilities to participate in the investigation) (Mache & Todd, 2016).

Staples & Reid (2010) used the TGMD-2 to compare children with autism ages 9-12 years to three typically developing groups based on: (1) chronological age, (2) movement skill performance, and (3) mental age. With regard to chronological age, the TD group (n = 25) scored significantly better than the ASD group (n = 25) on locomotor and object control skills. When matched on movement skill performance, results indicated that the ASD group (n = 22) performed similarly to the TD group (n = 22) approximately half their age. In the comparison based on mental age equivalence, results showed that the TD group (n = 9) scored significantly greater than the ASD group (n = 19) on locomotor and object control skills. The findings concluded that the ASD group was more impaired than would be expected given their cognitive level (Staples & Reid, 2010).

Whyatt & Craig (2012) compared 59 children ages 7-10 years. The study matched children with autism to two groups of age-matched typically developing children: (1) a receptive vocabulary matched group and (2) a nonverbal IQ-matched group). The study found significant motor impairment in children with autism, particularly with catching a ball and static balance. Here the author concluded "motor skill deficits associated with autism may not be pervasive, but more evident in activities that demand complex, interceptive actions, or core balance ability" (Whyatt & Craig, 2012, p. 1799).

Extending the literature to include children with ADHD, Ament et al. (2015) examined two hundred children ages 8-13 years. The investigation compared three groups: (1) children with autism, (2) children with ADHD, and (3) typically developing children. Based on the overall performance on the Movement Assessment Battery-2 for Children (MABC-2) (Henderson, Sugden, & Barnett, 2007), both the autism and ADHD groups had greater motor impairment than the typically developing group; and the autism group had greater motor impairment than the ADHD group. The study also reported that the children with autism were most challenged with catching and static balance tasks when compared to the ADHD group. A limitation of this investigation was the restricted age range and the difficulty in generalizing the findings to a larger population (Ament et al., 2015).

Pan et al. (2009) also included children with ADHD. The investigation compared the motor skills of three groups of children ages 6-10 years. The groups included autism (*n* = 28), attention deficit hyperactivity disorder (ADHD) (*n* = 29), and children without disabilities (*n* = 34). After controlling for age, the autism and ADHD groups scored significantly lower on overall gross motor development than the group of children without disabilities (*p*'s < .05). The study also evidenced that children with autism had a lower performance level than children with ADHD (*p*'s < .01) on both the locomotor and object control skills. This study was limited to males, gross motor skills, and no control measure for IQ, social impairment, cognitive level, or receptive language ability within the disabilities (Pan et al., 2009).

To examine fine and gross motor skills, Liu & Breslin (2013) compared children with autism to age-matched typically developing children. Sixty children participated in the study. Using the MABC-2 (Henderson et al., 2007), 30 children with autism ages 3-16 years were compared to 30 age-matched typically developing children. Data showed that 100% of the typically developing children were classified in the green zone of the MABC-2, while, 80% of the children with autism were classified in the red and amber zones. The total score was interpreted in terms of a "traffic light" system. Scores in the red zone (at or below 5th percentile) indicated definite motor impairment. Scores in the amber zone (6th to 15th percentile) were in the "at risk" category, and scores in the green zone (above 16th percentile) indicated motor performance in a typical range. The study also reported that children with autism had significantly lower scores on the MABC-2 than typically developing children on ball skills and balance. A limitation of this investigation was an overrepresentation of females in the control group (Liu & Breslin, 2013).

Extending the literature, Liu et al. (2014) examined the gross motor skill performance of 21 children with autism (mean age 7.57 years) and 21 age-matched typically developing children (mean age 7.38 years). Using the Test of Gross Motor Development-2 (TGMD-2), gross motor quotient scores showed 81% of the children with autism were below 79 and classified as poor, and about 76% children scored below 70 and received a very poor rating. These findings contribute to a growing body of literature that evidence motor deficits in children with autism. Furthermore, the researchers concluded that therapeutic interventions could positively impact the motor competence of children with autism (Liu et al., 2014).

As studies continue to evidence motor impairment in children with autism, several researchers have explored possible links between motor impairment and the associated features of autism. For example, in a study of 35 children with autism, ages 6-15 years, MacDonald et al. (2013) examined the relationship between motor skills and social communicative skills. The authors hypothesized that children with greater motor skills would have greater social communicative skills. From this investigation, researchers found children with motor skill deficits to have greater social communicative skill deficits. In addition, the study found object-control skills to significantly predict calibrated autism severity ($p < .05$). This study was limited to children with an IQ >64 (MacDonald et al., 2013).

MacDonald et al. (2014) examined the relationship between motor skills and the core behaviors of young children with autism, as indicated by the calibrated autism severity scores (Gotham, Pickles, & Lord, 2009). Participants included 233 children between the ages of 14-33 months with autism, PDD-NOS, and non-ASD (developmental delay) participated in the investigation. Results showed that fine and gross motor skills significantly predicted calibrated autism severity. The study concluded that young children with weaker motor skills have greater social communicative skill deficits. This study was limited to the use of the Mullen Scales of Early Learning (MSEL) (Mullen, 1995). The researchers acknowledged that a more sensitive motor skill assessment instrument could have been used (MacDonald et al., 2014).

In a longitudinal study of 209 participants from ages 2-9 years, Bedford et al. (2015) measured expressive and receptive language at 2, 3, 5, and 9 years. Measures of gross motor, visual reception, and autism symptoms were collected at the 2-year visit. Researchers evidenced a relationship between early gross motor abilities and the subsequent rate of receptive and expressive language development in children with autism. The researchers identified the use of various parent reports and observational measures as a strength of the study (Bedford et al., 2015).

Green et al. (2009) examined 101 children with autism ages 10-14 years. The sample included 89 males and 12 females. Using the MABC-2 (Henderson et al., 2007) and the Developmental Coordination Disorder Questionnaire (DCDQ) (Wilson, Kaplan, Crawford, & Roberts, 2007) data showed that 79% of the children with autism had motor impairments on the MABC-2 while an additional 10% had borderline impairments. This investigation concluded that children with childhood autism had greater motor impairment when compared to children with broader autism. The study also revealed that children with an IQ < 70 were more impaired when compared to those with an IQ > 70. A limitation of this study was that only two-thirds of the participants completed the motor assessment battery (Green et al., 2009).

Lastly, in an investigation of 67 sibling pairs from families affected by autism, Hilton et al. (2012) examined the relationship between IQ and autism severity. Using the Bruininks Oseretsky Test of Motor Proficiency 2nd Edition (Bruininks & Bruininks, 2005), results showed 83% of the children ages 4 to 21 years with autism scored at least one standard deviation below the mean score; while 6% of the children without autism scored at least one standard deviation below the mean. The authors concluded that successful interventions for motor proficiency could support complex social-cognitive impairments in children with autism (Hilton et al., 2012).

Though numerous studies have made significant contributions to the literature on the motor characteristics of autism, additional research is needed. A better understanding of the motor abilities of this population could lead to early diagnosis, enhanced motor interventions, and greater prognostic outcomes (Downey & Rapport, 2012; Fournier et al., 2010; Liu & Breslin, 2013; Liu et al., 2014; Matson et al., 2010; Paquet et al., 2016; Van Damme et al., 2015).

Summary of Literature on Autism Spectrum Disorder

As early as 1943, Leo Kanner and Hans Asperger both observed the core features of autism (i.e., impairments in social communication, interactions, and restricted patterns of behaviors). What's more, they both observed an array of motor deficits and delays in this population (Asperger & Frith, 1991; Kanner, 1943). Though motor impairment is not considered a core feature of autism, numerous studies have evidenced motor impairment in children and adolescents with autism as well as infants at-risk of the disorder.

As noted previously, motor competence provides children the ability to explore and interact with their environment and the opportunity to build on more complex motor skills and movement patterns (Haywood & Getchell, 2014; Payne & Isaacs, 2002). As documented in this review of literature, children with autism often face unique challenges in their motor development. For that reason, it is imperative for all those associated with this population to acknowledge the importance of early screening, detection, and diagnosis (if warranted). Furthermore, it is necessary to support this population with evidence-based practices and instructional strategies that promote a healthy and physically active lifestyle. For a summary of the literature on motor characteristics of children with autism, see Table 1.

Table 1. *Literature on the Motor Characteristic of Children with Autism*

Study	Sample	Participants	Age	Design	Assessment	Findings
Ament et al. (2015)	200	ASD, ADHD, TD	8-13 yrs.	ANOVA	MABC-2	ASD and ADHD evidenced motor impairment; ASD had greater motor impairment than ADHD
Bedford et al. (2015)	209	ASD, PDD-NOS, DD	2-9 yrs.	latent growth curve model	VABS, MSEL, ADI-R	Relationship between early GM abilities and the subsequent rate of receptive & expressive language with ASD.
Bhat et al. (2012)	48	ASD, TD	3-6 mon.	ANOVA	AIMS, MSEL	Siblings of children with ASD presented significant motor delays within the first half year of life.
Esposito et al. (2011)	55	ASD, TD, DD	12-15 mon.	ANOVA	WOS, PPSW, GMDS, CARS	Significant differences in gait patterns among toddlers with ASD.
Flanagan et al. (2012)	40	high-risk, low-risk for ASD	6–36 mon.	Fisher's exact tests, chi-square analysis	MSEL, ADOS	Head lag significantly associated with ASD at 36 mon. and more frequent in HR than in LR infants.

Note. ADI-R-Autism Diagnostic Instrument-Revised (Rutter et al., 2005); ADOS-Autism Diagnostic Observation Schedule (Lord, Rutter, DiLavore, & Risi, 2002; Lord et al., 2012); AIMS-Alberta Infant Motor Scale (Piper & Darrah, 1994); CARS-Childhood Autism Rating Scale (Schopler, Reichler, & Renner, 2002; Schopler et al., 2010); GMDS-Griffiths Mental Development Scales (Griffiths, 1996); Leiter-R (Roid & Miller, 1997); MABC-2-Movement Assessment Battery for Children-2 (Henderson et al., 2007); MSEL-Mullen Scales of Early Learning (Mullen, 1995); PPSW-Positional Pattern for Symmetry during Walking; VABS-Vineland Adaptive Behavior Scales (Sparrow, Balla, & Cicchetti, 2005); WOS-Walking Observation Scale.

Table 1 (continued)

Literature on the Motor Characteristics of Children with Autism

Study	Sample	Participants	Age	Design	Assessment	Findings
Green et al. (2009)	101	ASD, broader ASD	10-14 yrs.	repeated-measures MANOVA	MABC-2, DCDQ	Motor impairments are very common in children with ASD and those with broader ASD; including those with high IQ and low IQ.
Landa & Garrett-Mayer (2006)	87	low-risk and high-risk for ASD	6-24 mon.	Longitudinal linear regression, ANOVA	MSEL, ADOS	Results indicated no statistically significant difference at 6 mons; but the high-risk group showed greater deficits at 14 mons.
Libertus et al. (2014)	129; 46	high-risk for ASD	6 mon.	*t*-scores, ANOVA	MSEL, ADOS	HR infants exhibited less mature object manipulation structured (MSEL) context and reduced grasping activity in unstructured (free-play).
Liu & Breslin (2013)	60	ASD, TD	3-16 yrs.	ANOVA	MABC-2	80% of children with ASD were in the red/amber zones MABC-2, suggesting motor difficulty or at risk for motor delay.

Note. ADI-R-Autism Diagnostic Instrument-Revised (Rutter et al., 2005); ADOS-Autism Diagnostic Observation Schedule (Lord et al., 2002; Lord et al., 2012); DCDQ-Developmental Coordination Disorder Questionnaire (Wilson et al., 2007); MABC-2-Movement Assessment Battery for Children-2 (Henderson et al., 2007); MSEL-Mullen Scales of Early Learning (Mullen, 1995); VABS-Vineland Adaptive Behavior Scales (Sparrow et al., 2005).

Table 1 (continued)

Literature on the Motor Characteristics of Children with Autism

Study	Sample	Participants	Age	Design	Assessment	Findings
Liu et al. (2014)	42	ASD; TD	7 yrs.	MANOVA	TGMD-2	ASD showed significant delays in GM skills compared to age-matched peers.
Lloyd et al. (2013)	162	sibling of ASD	12–36 mon.	*t*- scores, ANOVA, ANCOVA	MSEL, VABS, ADI-R	Significant motor delays that become more pronounced with age in very young children with ASD.
MacDonald et al. (2013)	35	ASD	6-15 yrs.	univariate GLM	TGMD-2, ADOS, SB-5; SSIS Rating Scale	Object-control skill significantly predicted calibrated ASD severity; weaker motors greater social communication deficits.
MacDonald et al. (2014)	233	ASD, PDD-NOS, non-ASD	14-49 mon.	multiple regression analysis	MSEL, ADOS, VABS	A relationship exists between motor skills and the core features of ASD, deficits in the social and communicative domain.
Mache & Todd (2016)	22	ASD, without ASD	5-12 yrs.	repeated measures ANOVA	TGMD-3, RBS-R	Deficits in postural stability that appeared to influence the performance of GM skills.

Note. ADOS-Autism Diagnostic Observation Schedule (Lord et al., 2002; Lord et al., 2012); MSEL-Mullen Scales of Early Learning (Mullen, 1995); SSIS -Social Skills Improvement System Rating Scales (Gresham & Elliott, 2008); TGMD-2-Test of Gross Motor Development-2 (Ulrich, 2000); VABS-Vineland Adaptive Behavior Scales (Sparrow et al., 2005).

Table 1 (continued)

Literature on the Motor Characteristics of Children with Autism

Study	Sample	Participants	Age	Design	Assessment	Findings
Nickel et al. (2013)	40	high-risk, low-risk for ASD	6 mon.	ANOVA	ADOS	HR infants were slower to develop sitting & standing postures;
Pan et al. (2009)	91	ASD, ADHD, TD	6-10 yrs.	ANCOVA, chi-square analysis	TGMD-2	ASD & ADHD scored significantly lower than controls on GM development; decreased performance with ASD than ADHD
Shetreat-Klein et al. (2014)	76	ASD, TD	4yr 6 mon.	*t*-test, chi-square analysis	na	ASD had significantly greater joint mobility, more gait abnormalities; and walked on averag 1.6 months later than TD
Staples & Reid (2010)	91	ASD, TD (CA), TD (DEV), TD (MA)	9-12 yrs.	ANOVA	TGMD-2, Leiter-R, ADOS, SRS	Performance of fundamental movement skills among most children with autism is considerably delayed by late childhood
Whyatt & Craig (2012)	59	ASD, TD (A), TD (RV)	7-10 yrs.	ANOVA, MANOVA	MABC-2, BPVS-II, WNV	significant deficits with ASD with catching & static balance; deficits may be more apparent in activities demanding complex, interceptive actions or core balance ability

Note. ADOS-Autism Diagnostic Observation Schedule (Lord et al., 2002; Lord et al., 2012); MSEL-Mullen Scales of Early Learning (Mullen, 1995); RBS-R-Repetitive Behavior Scale-Revised (Lam & Aman, 2007); TGMD-2-Test of Gross Motor Development-2 (Ulrich, 2000); TGMD-3-Test of Gross Motor Development-3 (Ulrich, in press).

SECTION II: Modeling Motor Skill Performances

This section of the literature review will focus on modeling as an instructional strategy to teach motor skill performances to children and adolescents. It will (a) define modeling as an instructional strategy, (b) introduce Bandura's Social Cognitive Theory, and (c) review the literature on modeling motor skills performances. This section will conclude with a summary of modeling motor skills performances.

Overview of Modeling Motor Skill Performances

Modeling has been widely accepted as an instructional strategy in teaching motor skills and movement patterns. Parents, teachers, coaches, and physical educators have long used modeling, or demonstration, as a means to convey relevant information to learners. Modeling, often referred to as observational learning (Ashford et al., 2006), has long been "acknowledged to be one of the most powerful means of transmitting values, attitudes, and patterns of thought and behavior" (Bandura, 1986, pp. 47-48). Across an array of academic disciplines, modeling has been referred to as vicarious learning, social facilitation, matched-dependent behavior, demonstration, mimicry, copying (Williams, Davids, & Williams, 1999), imitation (Gould & Roberts, 1982), and action observation (Fadiga, Fogassi, Pavesi, & Rizzolatti, 1995). The array of terms and definitions have made it quite challenging for researchers from various backgrounds to communicate across disciplines (Zentall & Galef, 2013). Some have indicated that the lack of precision and consistency of the term has hindered the study of complex human behavior (Douglas Greer, Dudek-Singer, & Gautreaux, 2006). Modeling has been referred to as "the process of reproducing actions that have been executed by another individual" (McCullagh, Weiss,

& Ross, 1989, p. 475). It has also been acknowledged as “a process whereby an individual assimilates the information necessary to approximate the actions of others” (Ashford et al., 2006, p. 185). In a more elaborate explanation of the term, modeling has been defined as:

> . . . a general process whereby an observer reproduces the overt actions exhibited by a model (either a real life model or a model symbolized through film or video tape), regardless of whether the responses are novel and thus newly acquired, or are modified versions of existing response repertoires within the observer (Gould & Roberts, 1982, p. 215).

Herein, the terms modeling, demonstration, and observational learning will be used synonymously to refer to the process whereby an observer replicates the overt actions of an in-vivo (live) or video model.

Albert Bandura’s Social Cognitive Theory

Albert Bandura’s theoretical perspective on modeling and observational learning have long captured the interest of many social psychologists. However, this was not always the case amongst motor learning theorists. Bandura’s previous work was primarily designed for the acquisition of social skills and behavior. His work was often questioned by researchers in the field of motor learning. Upholding a strong allegiance to Adam’s Closed Loop Theory (Adams, 1971) and Schmidt’s Schema Theory (Schmidt, 1975), researchers in the field of motor learning believed there were viable differences between in acquiring social skills and acquiring motor skills (Newell & Walter, 1981; as cited in McCullagh et al., 1989). For that reason, researchers in the field of motor development argued that Bandura’s original formulations lacked developmental considerations (Yando, Seitz, & Zigler, 1978). Nevertheless, Bandura's progressive reformulations of the Mediational-Continuity Theory (Bandura, 1969), the Social Learning Theory (Bandura, 1977), and the Social Cognitive Theory (Bandura, 1986) prevailed.

According to Bandura (1986), ". . . modeling has always been acknowledged to be one of the most powerful means of transmitting values, attitudes, and patterns of thought and behavior" (Bandura, 1986, pp. 47-48). He proclaimed that "most human behavior is learned through the observation of a model" (Bandura, 1986, p. 47) and that "modeling influences have a much broader psychological effects than the simple response mimicry implied by the term imitation" (Bandura, 1986, pp. 48-49). By observing the actions of others, individuals can acquire the cognitive skills and rules to organize new patterns of thought and behavior. However, for observational learning to occur, four subprocesses must coincide (Bandura, 1986).

Four Subprocesses of Observational Learning

The governing subprocesses include the: (a) attentional process, (b) retention process, (c) production process, and (d) motivational process (Bandura, 1986). A schematic summary of the governing subprocesses of observational learning is shown in Figure 1.

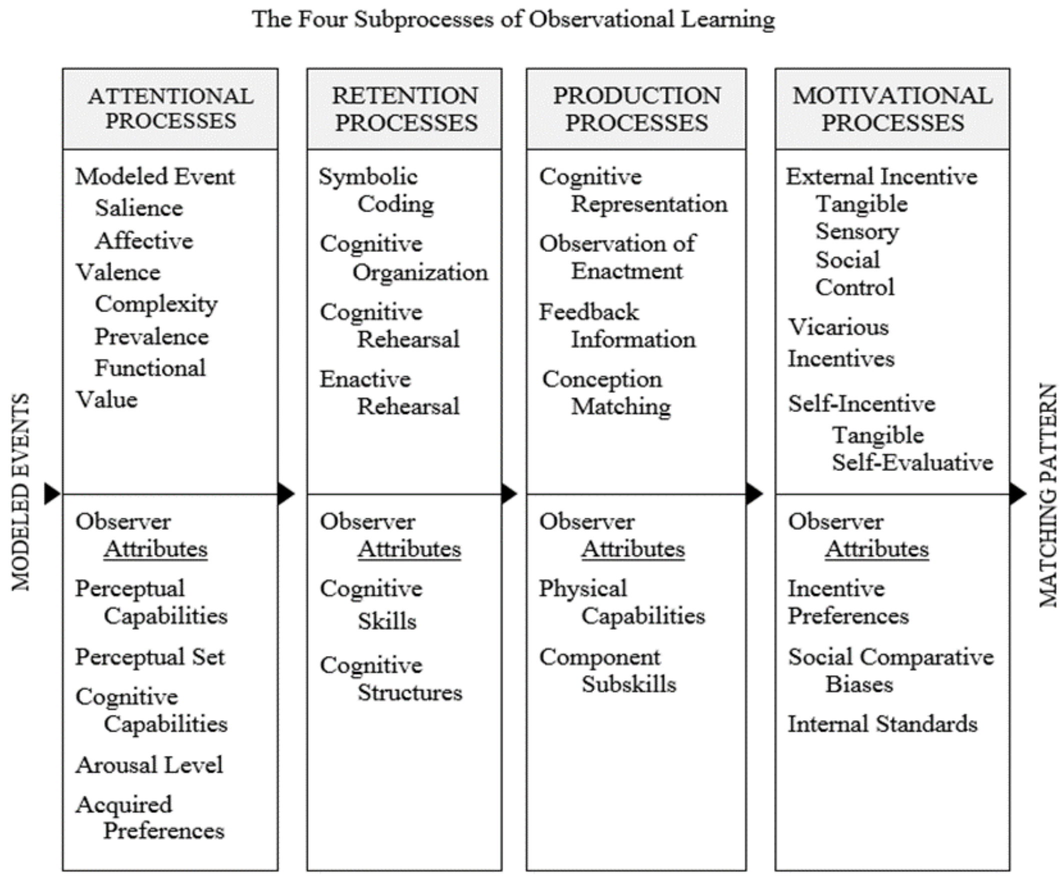

Figure 1. The four subprocesses of observational learning (Bandura, 1986, p. 52).

Attentional Processes

The first subprocess of Bandura's social learning theory is the attentional process. Bandura proclaimed that for people to learn through observation, they must attend to, and accurately identify the relevant cues of a modeled activity. "The attentional process determines "what is selectively observed" and "what information is extracted from ongoing-modeled events" (Bandura, 1986, p. 51). Difficulties in gaining and holding attention can often impede learning and hinder the performance of a modeled event (Bandura, 1986). For example, young children often have a limited ability to attend to multiple cues, identify relevant cues, and maintain attention. However, with maturation and experience children can acquire the ability to improve their attentional skills and become more proficient with observational learning.

On the contrary, children with autism often retain these deficits. The tendency to focus on limited cues and irrelevant details often limits their ability to acquire information from the environment and expand their cognitive competencies. To mitigate these tendencies, Bandura acknowledged the strategies employed by social scientists (Bandura, 1986). For example, Lovaas and Newsom (1976) concurred that modeling could be used to expand the behavioral and cognitive competencies of children with autism. Simply breaking down a complex task into smaller steps and providing reinforcement has shown to be an effective method of teaching behavioral and cognitive competencies.

When teaching children with autism, Schreibman (1975) acknowledged the need to exaggerate the relevant cues, then simultaneously fade the exaggeration, assess, and introduce new complexities. Koegel and Schreibman (1977) suggested providing information separately and then combining them into more complex patterns (as cited in

Bandura, 1986). Such procedures were highlighted, so children with autism could learn to attend to multiple cues simultaneously (Bandura, 1986).

Retention Processes

The second subprocess of Bandura's social learning theory is the retention process. To obtain the benefits of observational learning, individuals must have the cognitive ability to retain in memory the information of a modeled activity (Bandura, 1986). However, "the full content of most modeled activities is too copious and contains too many irrelevancies" (Bandura, 1986, p. 56). Therefore, modeled information must be transformed and restructured into symbolic codes that highlight the most relevant features of a modeled activity. The ability to symbolically code modeled information enables humans to learn most behavior through observation (Bandura, 1986; Bandura & Barab, 1973). Most often, this information is acquired through imaginal and verbal representations.

Imaginal representations are abstractions or general concepts of a modeled event. After repeated observations, the observer extracts distinct features and formulates long-lasting images of the behavior pattern (Bandura, 1986). "Visual memory plays a prominent role in observational learning during early periods of development when verbal competencies are lacking" (Bandura, 1986, p. 58). The second representational system is verbal representation. While verbal representation plays a major role in the knowledge acquired through modeling, it is often difficult to separate representational modes (e.g., imaginal, verbal).

Paivio (1975) showed that representational events frequently involve both imagery and verbal stimuli. Similarly, Rosenberg and Simon (1977) found that “words tend to evoke corresponding imagery, and images of events are often verbally cognized as well” (as cited in Bandura, 1986, p. 58). When visual and verbal stimuli convey similar meanings, people tend to integrate the information into a common conceptual representation. In addition to the imaginal and verbal coding of modeled information, Bandura (1986) acknowledged the importance of physical and cognitive rehearsal. Those who employ both physical and cognitive rehearsal are less likely to forget a modeled performance than those who do not employ both physical and cognitive rehearsal (Bandura, 1986).

Retention in young children can be challenging, as they must transform modeled information into a symbolic code, then restructure the information into a format that can be easily retrieved. It may be difficult for young children to master memory skills for the following reasons: (1) the process involves covert cognitive operations which are difficult to teach and improve upon with corrective feedback, (2) limited linguistics hinder the organization of mnemonics which are needed to reduce and organize modeled information, and (3) memory is often facilitated by relating new information to past experiences. Young children with limited experience often lack the knowledge base needed to comprehend new experiences (Bandura, 1986).

Despite these challenges, cognitive strategies can be facilitated with cognitive modeling. To aid in the development of memory tasks, “models can verbalize aloud the various mnemonic strategies they are using--verbally transforming, rehearsing, grouping, and semantically elaborating the information that is most relevant" (Bandura, 1986, p. 89).

Production Processes

The third subprocess of Bandura's social learning theory is the production process. This is when symbolic conceptions are converted into appropriate actions (Bandura, 1986). According to Bandura (1986), "Most modeled activities are abstractly represented as conceptions and rules of action which specify what to do" (p. 63). However, production involves conception-matching, a process "in which the incoming sensory feedback from enactments is compared to the conception. The behavior is then modified on the basis of the comparative information to achieve progressively closer correspondence between the conception and action" (Bandura, 1986, p. 64). The degree of observational learning can then be assessed through various measures. For example, verbal production is an assessment measure where the learner verbally describes the observed action (Bandura, & Jeffery, 1973; Bandura, Jeffery, & Bachicha, 1974; and Bandura, Ross, & Ross, 1963b). Recognition tests measure the learner's symbolic conception of an observed action. Recognition tests could be a simple comparison between two performances that vary slightly, or pictures that show the order of an observed action (Carroll & Bandura, 1985). Comprehension tests measure the learner's ability to identify or demonstrate the underlying rule of an observed action (Brown, 1976; Rosenthal & Zimmerman, 1978). Lastly, maximizing enactment tests measure the learner's ability to demonstrate all facets of the observed action with minimal constraints and positive reinforcement (Bandura, 1965; Bandura, Grusec, & Menlove, 1966).

As stated by Bandura (1986), for the production of a modeled event to occur, several factors must be taken into consideration. First, the learner must be provided frequent and ample opportunity to observe the modeled event. Second, the learner must be given adequate time to overtly practice the modeled event. Third, the learner must have the physical maturity (i.e., size, strength, coordination) to perform the modeled event accurately. Fourth, the learner must have the ability to process performance feedback. Bandura (1986) noted, “A common problem in learning is that people cannot fully observe their own behavior” (p. 66). Thus, resulting in the learner to rely greatly on feedback that is timely, specific, and informative. Both, intrinsic (e.g., visual, auditory, and kinesthetic) and extrinsic feedback (e.g., reports from an onlooker) can markedly facilitate accurate reproductions of modeled events (Bandura, 1986). However, for production to occur, the learner must be motivated to do so.

Motivational Processes

The last subprocesses of observational learning in the motivational processes. Within this processes, Bandura (1986) stated “. . . people do not enact everything they learn” (p. 68). Without proper incentive, a modeled event may not occur. Thus, Bandura (1986) acknowledged three forms of incentive: (a) direct, (b) vicarious, and (c) self-produced. Direct incentives are enticements that the observer seeks as favorable outcome from the modeled event. Direct incentives may appear as a tangible item, sensory stimulation, or a socially rewarding experience. Vicarious incentives are enticements when the learner witnesses a modeled event in which the model is rewarded. For example, the learner observes a student being praised for raising their hand during class.

Lastly, the most influential incentive source is self-produced. Bandura (1986) described self-produced incentives as those that "personal standards of conduct provide a further source of motivation” (Bandura, 1986, p. 68). For example, the learner begins to identify and regulate modeled events that are preferred and self-satisfying (Hicks, 1971; Slife & Rychlak, 1982; as cited in Bandura, 1986).

Nevertheless, for incentives to influence observational learning, individuals must have the cognitive development and experience to acknowledge its value. In young children who lack both the cognitive development and experience, valued incentives may be less salient (Bandura, 1986). However, with ongoing development and experience, young children can progress towards the more complex incentives of modeling (Bandura, 1986).

Review of Literature on Modeling and Motor Skill Performances

According to Bandura’s Social cognitive theory (1986), the ability to observe and learn from others can enable people to expand their knowledge and skills to perform an array of tasks. Over the past decades, numerous studies have examined the construct of observational learning and the effects of modeling on physical performance (Ashford et al., 2006; Gould & Roberts, 1982; McCullagh et al., 1989; Weiss, Ebbeck, & Wiese-Bjornstal, 1993).

Bouazizi et al. (2014) examined the effects of expert video models and video feedback on the development of complex gymnastics skills. One hundred and three adolescents participated in the study (mean age of 16.95 ± 0.9 years). Forty-nine males and 54 females were divided into two groups: (1) an experimental group that received video modeling and sessions of physical education gymnastics; and (2) a control group that only received sessions of physical education gymnastics. In an analysis of pre-post measures, the data showed similar scores between the groups on the pre-test. However, the performance scores of the video modeling group were significantly higher ($p \leq 0.001$) during the post-test. The study also indicated that within the video modeling group, females had higher performance scores than males. Bouazizi et al. (2014) concluded that video modeling and video feedback have great potential to increase the execution of skills that have already been learned (Bouazizi et al., 2014).

Doussoulin and Rehbein (2011) examined the effects of imagery, video modeling, and physical practice on motor skill performance. Sixty-four children ages 9-10 years participated in the investigation. Participants were assigned to one of three conditions: (1) imagery, (2) video modeling, or (3) physical practice. The Standardized Basic and Combined Movement Scale (SBCMS) was used to assess the run-and-throw task. Each participant was given two consecutive trials to run-and-throw a tennis ball towards a target (i.e., clown face) at a distance of 10 meters. The investigation used a pre-posttest design to compare the effectiveness of motor imagery, video modeling, and physical practice on motor skill training (i.e., throwing a ball towards a target). Post-test results showed improvement in the three groups. However, both the motor imagery and video modeling groups had significantly higher mean scores than the physical practice group. A two-way ANOVA with repeated measures showed a statistically significant main effect of training (F (1, 61) = 136.81, $p < .001$) as well as a significant training by groups interaction effect (F (2, 61) = 3.56, $p < .05$). No main effect for groups was found.

Researchers acknowledged that both imagery and modeling used cognitive representations, rehearsal, and skill execution to enhance learning and retention (Doussoulin & Rehbein, 2011).

O'Loughlin et al. (2013) examined the impact of video feedback on motivation, feedback, self-assessment, and learning. Twenty-three children ages 9-10 years participated in the study. This investigation took place in a primary physical education class over a 10-week period. The study was divided into two, five-week blocks. The first block focused on the free throw, chest pass, and dribble, while the second block focused on the bounce pass, jump shot, and lay up. The skills were introduced and practiced in a variety of game-like activities. Using Schwartz and Hartman's (2007) model for learning with digital video (i.e., saying, seeing, doing, and engaging), the participants self-assessed their learning in week 5 and week 10. Results showed video feedback had a positive impact on performance. The researchers also noted that the participants were motivated, engaged, and enjoyed the self-assessment process. O'Loughlin et al. (2013) concluded, "Feedback and self-assessment using digital video was found to improve skill performance and motivation in primary physical education" (O'Loughlin et al., 2013, p. 187). Though participants were motivated to use digital video, the feedback was only used to self-assess their performance according to a rubric. Opportunity to use the digital feedback to correct their performance was not provided (O'Loughlin et al., 2013).

To examine the effects of instructional self-talk and video on the development of the long jump, Panteli et al. (2013) recruited 69 beginner athletes to participate in the study. Twenty-six males and 43 females (mean age of 10.3 years) were randomly assigned to one of four groups: (1) self-talk, (2) video, (3) self-talk + video, and (4) a control group (no intervention). The self-talk group read written scripts containing relevant cue words pertaining to the long jump. The video group observed a skilled model perform the long jump. And, the self-talk + video group, combined the regiments of the first two groups (e.g., self-talk and video). The fourth group was the control group (practice only). All participants completed twenty-four, 90-minute practice sessions, three times per week, over an 8-week intervention period. Each training session included a 15-minute intervention program (i.e., self-talk, video, and self-talk + video). At the end of 8 weeks, the self-talk group reported significant improvement in the performance of the long jump. However, the video group and self-talk + video group reported significant improvement in the kinematic variables of the motor skill (i.e., high position of the center of mass during the takeoff phase of the long jump. This study adhered to a few recommendations of observational learning as depicted by Bandura (1986). For example, (a) a skilled model was used to demonstrate the long jump, (b) due to the age of the participants and the complexity of the motor task, multiple observations of the video model were provided, and (c) written scripts were used to assist with coding and sequencing relevant information. From this investigation, the researchers concluded that cognitive intervention techniques such as self-talk and video could support young children in learning of motor skill performances (Panteli et al., 2013).

Ste-Marie et al. (2011a) examined the effects of self-modeling on competitive gymnastics. Twenty-two females' ages 9-16 years participated in the study. Assessment data included performance scores, self-efficacy, and interview questions. The experiment took place over four balance beam competitions. Data were collected from two experimental competitions in which the gymnasts received the self-modeling video intervention and two control competitions in which the gymnasts did not receive the self-modeling video. Results indicated significantly higher balance beam scores when the gymnasts viewed the video versus when they did not view the video ($p < .025$). No differences in self-efficacy were reported using the quantitative measure. Consistent with the literature on observational learning Bandura (1986), the researchers provided each participant multiple observations of the modeled performance prior to competition (Ste-Marie et al., 2011a).

To examine the effects of feedforward self-modeling, Ste-Marie et al. (2011b) recruited 31 children ages 7-13 years from a summer trampoline camp. The purpose of the study was to: (1) examine the effects of feedforward self-modeling on the acquisition of trampoline skills, and (2) examine the effects of feedforward self-modeling on self-regulation. According to Ste-Marie et al. (2011b) feedforward self-modeling "…shows the learner performing at a higher skill level yet to be attained, or performing the skill in a more challenging context" (p. 1). Participants were provided instruction on two trampoline routines that consisted of five different skills. One routine used a feedforward self-modeling video while the other routine used only verbal instructions. From this investigation, data showed children acquired a better trampoline routine with feedforward self-modeling than verbal instructions alone. However, there no differences in any of the varied self-regulatory processes and beliefs that were measured (Ste-Marie et al., 2011b).

With regard to observational learning, participants were provided multiple observations of the feedforward self-model video, multiple verbal descriptions of the routine, and multiple practice trials. Previously stated, young children with limited experience often lack the knowledge base needed to comprehend new experiences (Bandura, 1986).

Rymal et al. (2010) studied the effects of video self-modeling on the self-regulatory processes of 10 competitive divers ages 10-17 years. Prior to the experiment, videos were created for each diver. The self-modeled video consisted of a 5-10 second dive that was repeated 5 times with a 1-2 second blank screen between each performance. Consistent with the literature on observational learning, the editing technique Rymal et al. (2010) used to create the self-modeled video was similar to the recommendations described by Bandura (1986). Participants watched the self-modeled video three times during the week prior to competition (i.e., home practice site, hotel, and competition site). The third observation of the video took place 10 minutes prior to competition. In addition to observing the video prior to competition, each participant completed two short, paper-pencil questionnaires. Rymal et al. (2010) noted that the questions were not theoretically based. However, they were analyzed using Zimmerman's (2000) self-regulation framework (i.e., forethought, performance control, and self-reflection phase).

Results of the investigation showed a number of self-regulatory processes were used by the participants. Seventy-five percent were in the forethought phase (i.e., thoughts, beliefs, feelings, and cognitions prior the event); 25% were in the self-reflection phase (i.e., thoughts, beliefs, feelings, and cognitions after the event); and no self-regulatory processes were identified in the performance control phase (i.e., thoughts, beliefs, feelings, and cognitions during the event). Rymal et al. (2010) also noted "…participants in this study used the video to gain information on what was done correctly and not what was done poorly" (p. 10). Participants stated the video helped them produce images of their performance. The researchers concluded self-modeling is a positive intervention that could be used during competition (Rymal et al., 2010).

Summary of Modeling and Motor Skill Performances

Albert Bandura's Social cognitive theory (1986) is one of the most dominant theoretical perspectives in modeling research. Numerous studies have examined the effects of modeling on the acquisition of motor skill performances (Ashford et al., 2006; Gould & Roberts, 1982; McCullagh et al., 1989; Weiss et al., 1993). Often cited in the literature are the four subprocesses of observational learning: (a) attention, (b) retention, (c) production, and (d) motivation (Bandura, 1986). As researchers continue to examine the subprocesses of observational learning, one must realize that the four subprocesses must coincide for observational learning to occur (Bandura, 1986). Bandura asserted, "A theory of observational learning must account for the failures of modeling as well as its successes. At any given instance, faulty modeling may result from deficiencies in any of the four subfunctions" (Bandura, 1986, p. 70). Bandura further concluded that many of the failures of observational learning come from attentional deficits (Bandura, 1986). For a summary of the literature on modeling motor skill performances, see Table 2.

Table 2. *Literature on Modeling Motor Skill Performances*

Study	Sample	Age	Design	Findings
Bouazizi et al. (2014)	103	16 yrs.	ANOVA; randomly complete block design	Results demonstrated effective learning by VM for the acquisition and improvement of gymnastic skills; girls had a greater performance than boys did after VM.
Doussoulin & Rehbein (2011)	64	9-10 yrs.	ANOVA; Repeated-measures analysis of variance	Training with motor imagery and modeling was more effective in obtaining a significantly higher final performance than physical practice alone (running-and-throwing a ball).
O'Loughlin et al. (2013)	22	9-10 yrs.	Qualitative Analysis	Video is an effective way to motivate children to learn skills and engage in the self-assessment process (basketball skills).
Panteli et al. (2013)	69	10 yrs.	ANCOVA; ANOVA; MANOVA; Repeated-measures	Self-talk group resulted in significantly higher performance improvement; however, observational learning (video) proved to be more effective when kinematic variables of the motor skill were assessed (long jump).

Note. FSM-feedforward self-modeling; VM-video modeling

Table 2 (continued)

Literature on Modeling Motor Skill Performances

Study	Sample	Age	Design	Findings
Rymal et al. (2010)	10	10-17 yrs.	Qualitative Analysis	Self-modeling video may influence many self-regulatory processes that could have a positive effect on a competitive athlete's performance (diving).
Ste-Marie et al. (2011a)	22	9-16 yrs.	2 Condition (FSM video vs. no video) x 2 Competition ANOVA with repeated measures on both factors; and qualitative analysis	Results showed that gymnasts achieved significantly higher beam scores when they viewed the FSM versus when they did not view the FSM; self-efficacy scores show no difference between conditions (balance beam competition).
Ste-Marie et al. (2011b)	27	7-13 yrs.	A 2 × 5 session (pre-test, 3 intervention sessions, post-test) repeated measures ANOVA	Children acquired a better trampoline performance when provided an FSM than just receiving verbal instructions during the acquisition phase (trampoline routine).

Note. FSM-feedforward self-modeling; VM-video modeling

SECTION III: Video Modeling and Autism Spectrum Disorder

This section will focus on video modeling as an instructional strategy to teach motor skill performances to children with autism. It will (a) provide an overview of video modeling, (b) define the four types of video modeling procedures, and (c) review the literature on video modeling as an instructional strategy to support children with autism. This section will conclude with a summary of video modeling as it pertains to physical activity and children with autism.

Overview of Video Modeling

According to Bandura (1986), “A major function of modeling is to transmit information to observers about how subskills can be synthesized into new patterns” (p. 70). Often the information is transmitted through the direct observation (i.e., live or in-vivo modeling) (Bandura, 1986). While direct observation has shown to be effective, it may be somewhat challenging for children with autism. Associated features of the disorder such as eye avoidance (Tanaka & Sung, 2016) and stimulus over-selectivity may impede a child’s ability to learn from direct observation (i.e., live or in-vivo modeling) (Charlop-Christy et al., 2000; Lovaas et al., 1971).

Eye avoidance is the act of looking away to elude the discomfort of making eye contact with another person. Eye avoidance can have “…cascading effects on the ability to encode and discriminate information about facial identity, expression, and intention and further interferes with social processing” (Tanaka & Sung, 2016, p.15). Difficulty in responding to multiple cues in the environment is often referred to as stimulus over-selectivity (Charlop-Christy et al., 2000; Lovaas et al., 1971). As Charlop-Christy et al.

(2000) explained, a child "…may focus on a miscellaneous cue, such as the model's clothes, instead of attending to relevant cues such as the actual target behavior" (p. 549). Such challenges can limit a child's ability to acquire information from the environment and expand their cognitive competencies (Bandura, 1986).

To help mitigate these challenges, Bandura (1986) proposed symbolic modeling. A method in which a modeled event is presented to the learner via television, films, and visual media. "There is little reason to believe that the symbolic processes are particularly different as a function of observing a live versus a filmed model" (Bandura & Barab, 1973; as cited in Thelen, Fry, Fehrenbach, & Frautschi, 1979, p. 701). "Symbolic modeling can convey most of the knowledge about skills, so that personal instruction can be devoted to perfecting and applying new competences" (Bandura, 1986, p. 70). A common form of symbolic modeling known today is video modeling. Video modeling is an instructional strategy in which the learner is provided a video representation of a targeted skill or behavior. The learner observes a modeled event on the video on a media device and then replicates the modeled event (Corbett, 2003).

Since the late 1990s, researchers have examined the effects of video modeling on children with autism (e.g., Ayres & Langone, 2005; Bellini & Akullian, 2007; D'Ateno, Mangiapanello, & Taylor, 2003; McCoy & Hermansen, 2007). Hence, a growing body of literature has shown video modeling to be an effective practice in teaching an array of skills and behaviors to children with autism (Wong et al., 2014). Results have shown video modeling to facilitate rapid skill acquisition, maintenance, and generalization across time, settings, people, and materials (Bellini & Akullian, 2007). Furthermore, video modeling is a time and cost-effective intervention that can facilitate observational learning to children with autism (Corbett, 2003).

Video Modeling and the Four Subprocesses of Observational Learning

Studies have shown video modeling to be effective in facilitating observational learning for children with autism (Corbett & Abdullah, 2005). The following sections will explore the benefits of video modeling, as they relate to the four subprocesses of observational learning (i.e., attentional, retention, production, and motivational).

Attentional. Within the attentional subprocesses, video modeling provides opportunity to learn through social modeling without face-to-face interaction (Corbett & Abdullah, 2005). By decreasing social demands, visual attention to the modeled event may increase. In a comparison study of video and in-vivo presentations, data showed children with autism spent more time visually attending to video presentations than in-vivo presentations (Cardon & Azuma, 2012). Another advantage of video modeling within the attentional subprocesses is that non-relevant stimuli can be removed from the modeled event. By eliminating irrelevant stimuli, the observer is more likely to attend to pertinent information (Corbett & Abdullah, 2005). In sum, video modeling can help mitigate eye avoidance (Tanaka & Sung, 2016) and stimulus over-selectivity in children with autism (Charlop-Christy et al., 2000; Lovaas et al., 1971). Thus, provide opportunity to observe and extract relevant information from a modeled event. Bandura (1986) asserted “The more often and the longer children attend to a models’ behavior, the higher their level of observational learning” (p. 53). Model type can also influence attention. Bandura (1986) explained that “sway of attraction” (p. 54) helps capture attention. Models that are attractive, interesting, rewarding, and similar in terms of physical appearance are recommended (Bandura, 1986).

Retention. Regarding the retention subprocesses, video modeling can provide repeated observations of a modeled event under the same condition (Corbett & Abdullah, 2005; Thelen et al., 1979). "As a result of repeated exposure to modeled events, observers extract distinctive features and form composite, enduring images of the behavior patterns" (Bandura, 1986, p. 56). Another advantage of video modeling is that it can integrate visual and verbal information of a modeled event. Bandura (1986) acknowledged the difficulties children have with retention. "While performing memory tasks, models can verbalize aloud the various mnemonic strategies they are using – verbally transforming, rehearsing, grouping, and semantically elaborating the information that is most relevant" (Bandura, 1986, p. 89).

Production. Within the production subprocesses of observational learning, there are several advantages of video modeling to support children with autism. For example, video modeling can (a) provide repeated observations, (b) breakdown complex performances into sub-skills, (c) be used with multiple learners, and (d) show segments of the event that cannot be observed during the actual performance (Bellini & Akullian, 2007; Cardon, 2016; Corbett & Abdullah, 2005; Thelen et al., 1979). Bandura (1986) asserted that observation alone does not facilitate learning. He acknowledged the importance of having (a) ample opportunity to observe a modeled event, (b) sufficient practice opportunity, (c) the physical ability to perform the task, and (d) the cognitive ability to process feedback (Bandura, 1986).

Motivational. Regarding the motivational subprocesses, studies have shown video modeling to be an inherently motivating and naturally reinforcing intervention for children with autism (Charlop-Christy et al., 2000; Corbett, 2003; Corbett & Abdullah, 2005; D'Ateno et al., 2003). In a survey of ninety families of children with autism, Shane and Albert (2008) reported that children with autism had strong preferences to electronic screen media, especially television. Furthermore, the study reported nearly half of the children with autism had the ability to activate and view preferred programs. One parent suggested repeated observations of video scripts was a need for sameness or a possible form of visual self-stimulation. The authors concluded that additional research is necessary to address the specific needs of children with autism, while making the most of their strong preference and motivation for electronic screen media (Shane & Albert, 2008).

Review of Literature on Video Modeling

There are four video modeling procedures shown to be effective in teaching individuals with autism. They include: (a) basic video modeling, (b) video self-modeling, (c) point-of-view modeling, and (d) video prompting (Franzone & Collet-Klingenberg, 2008).

Basic Video Modeling

Basic video modeling is a technique in which a peer, sibling, or adult model demonstrates a targeted skill or behavior. A video representation of the targeted behavior is presented to the learner with autism. After watching the video, the learner is provided an opportunity to imitate or "model" the behavior. Literature supports video modeling as an effective means to "…teach play skills, language skills, self-help skills, social communication skills, functional daily living skills, academic skills, and appropriate behaviors" (Cardon, 2016, p. 90) to children with autism.

Using a multiple-baseline design across participants, Macpherson, Charlop, and Miltenberger (2015) found video modeling to be an effective intervention to increase verbal compliment and compliment gestures of five children with autism. Four males and one female ages 9-11 years viewed a video representation of familiar adults modeling verbal compliments and compliment gestures (i.e., thumbs-up, fist pump, and clapping) during a kickball game. During the intervention phase of the experiment, participants watched a 30-second video of a familiar adult model demonstrating three pairs of verbal compliments and compliment gestures. Videos were shown once on a portable handheld device in a naturalistic environment (i.e., kickball game). Results from the study showed all participants had rapidly increased the use of verbal compliments and compliment gestures during a kickball game. Generalization of the observed treatment gains was reported as limited. The authors concluded that video modeling could effectively increase social skills of children with autism (Macpherson et al., 2015).

Boudreau and D'Entremont (2010) examined the efficacy of video modeling on the acquisition of pretend play skills. Two, 4-year old males with autism enrolled in an intervention agency participated in the investigation. Participants watched a video of an adult model playing with a toy set. Using a multiple-baseline across participants, the researchers reported rapid acquisition, generalization, and short-term maintenance of the modeled actions and scripted verbalizations for both participants. Researchers believed the repeated observations of the video and reinforcement may have been a contributing factor. Results of this investigation support video modeling with the rapid acquisition of pretend play skills to young children with autism (Boudreau & D'Entremont, 2010).

Video Self-Modeling

Video self-modeling (VSM) is a technique in which learners observe themselves successfully performing a targeted behavior. Bandura's (1986) social cognitive theory suggested that people learn best from models that most closely resemble themselves. Therefore, having oneself as the model optimizes this approach. However, video self-modeling is more time-consuming. Creating a self-modeling video often requires editing and the need for more advanced technical skills. All evidence of inappropriate behavior and adult prompting must be removed from the video clip (Cardon, 2016). Nevertheless, video self-modeling is well-documented.

Cihak, Wright, and Ayres (2010) examined the effects of self-modeling static-picture prompts via a handheld computer and video self-modeling on increasing task engagement and decreasing teacher prompts. Three middle school students' ages 11-13 years participated in the investigation. All participants were male and diagnosed with high-functioning autism. Prior to the intervention, the participants had high levels of off-task behavior and required high levels of teacher prompts. Using a multiple-probe across-setting with an embedded A-B-A-B design, data were collected during the first 15 minutes of class. Occurrences of student's task engagement were recorded using a continuous 15-second partial-interval recording technique. The number of occurrences was calculated as percentages and documented accordingly. Results from this investigation showed self-modeling static-picture prompts and self-modeling demonstrated an increase in task engagement and a decrease in teacher-directed prompts for all three students. Furthermore, the classroom teacher supported the video modeling process (Cihak et al., 2010).

In an investigation of four preschool children with pervasive developmental disorders-not otherwise specified autism (PDD-NOS), Buggey, Hoomes, Sherberger, and Williams (2011) examined the effects of video self-modeling on social initiations during playground time. The investigation took place on the playground of a preschool facility. Two males and two females, ages 3.6 to 4.6 years participated in the study. The self-modeling videos featured the participant socially interacting with peers. Presentations ranged between 2.5 to 3.5-minutes. The videos included titles, transitions, and audio insertions (i.e., clapping, music, and voiceover). Frequency data were collected daily during playground time for 15-minutes, and each participant was observed at least once per day. Using a single-subject multiple-baseline design across-participants, data revealed three of the four participants increased the frequency of their social initiations. Classroom teachers favored the intervention and commented that the students loved to watch their videos (Buggey et al., 2011).

Point-of-View Video Modeling

Point-of-view video modeling (POVM) is a modeling procedure in which a video recording is taken from the first person perspective. Often, only the model’s hands are observed manipulating the materials to complete the task (Cardon, 2016). Prior to creating a point-of-view video model, consideration should be given to the complexity of the targeted skill and the learner's ability level. Individuals may struggle with retention and cognitive acquisition, therefore prompting may be a more viable option. However, prompting is more time intensive in regards to video creation and delivery (Mason, Davis, Boles, & Goodwyn, 2013). In a review of the literature, it was reported that a vast majority of the studies using point-of-view modeling targeted independent living skills. The targeted living skills included using an ATM machine, making popcorn, making purchases, using an iPod, putting out a fire, making food, setting the table, cleaning task, and zipping a jacket. Targeted behavior skills included engaging in play with toys and making appropriate eye contact with scripted verbal exchanges (Mason et al., 2013).

Dupere, MacDonald, and Ahearn (2013) found point-of-view video modeling as an effective means to enhance scripted actions and script vocalizations in three children with autism. Two males and one female ages 5-6 years participated in the study. An adult modeled various play actions and vocalization from the child's point of view in three pretend play scripts (i.e., boat, train, and zoo). During the intervention phase of the experiment, each participant was asked to watch the point-of-view video twice consecutively on a portable DVD player prior to playtime. The order in which the videos were presented varied across sessions. A multiple-probe design across play script was used in the investigation. Results showed that scripted actions and vocalizations increased during training, and were maintained during the post-training sessions for all three participants. Findings support point-of-view video modeling is an effective strategy in teaching pretend play to children (Dupere et al., 2013).

Shrestha, Anderson, and Moore (2013) examined the effects of point-of-view video modeling in a forward-chaining procedure to teach a self-help skill (e.g., serving himself an afternoon snack). A four-year-old male with mild autism participated in the study. All sessions were conducted in the kitchen and dining area of the family home. The targeted skill was divided into three phases: (a) set-up, (b) eating, and (c) clean-up, and was comprised of 13 steps total. Videos were created for each phase of the targeted skill and the participant's mother modeled the event. Phase I explained Steps 1-4 and with a duration of 2-minutes and 6-seconds. Phase II explained Steps 1-10 and with a duration of 3-minutes and 28-seconds. Lastly, Phase III explained Steps 1-13 and with a duration of 3-minutes and 45-seconds. All three videos included verbal reinforcement (i.e., great job) at the end of the presentation.

Using a single-subject design, data were collected at baseline, intervention, generalization, and follow-up. Results showed an increase in the number of steps completed during the intervention phase. However, generalization to other snacks was limited. Shrestha et al. (2013) concluded that point-of-view video modeling in a forward-chaining procedure was effective in teaching a child to serve himself or herself a snack without prompting (Shrestha et al., 2013).

Video Prompting

The fourth type of video modeling procedure is video prompting (VP). This type of video modeling records each step of a skills task. Pauses are built into the video to allow time for the learner to complete one step before viewing subsequent steps (McCoy

& Hermansen, 2007). Several studies have used video prompting as a means to teach motor skills and physical activity to children and adolescents with autism.

Gies (2012) examined the effects of video prompting on teaching a line dance to six adolescents. Seven adolescents diagnosed with high functioning autism participated in the study. Participants, ages of 12-16 years, included six males and one female. The study took place at a summer camp that supported the needs of children and adolescents with autism. All participants were purposely selected, and met the established entry criteria. Those selected to participate in the study were taught the Cupid Shuffle. The dance consisted of non-locomotor and locomotor movements that were choreographed to music. Participants were asked to watch the video clips and model the steps. Music was replaced with voiceover instructions and data were collected 1-5 times per week over a four-week period. Each session lasted approximately 20 minutes. Using a 4-level least-to-most prompting system, participants were given positive reinforcement (e.g., praise or high-five) for the successful completion of a step. Results indicated six of seven participants acquired all the steps to the Cupid Shuffle dance as a result of the video prompting intervention. The author concluded that video prompting could be effective in teaching individuals with autism physical activity (Gies, 2012). With regard to the constructs of observational learning, this study aligned with several recommendations as presented by Bandura (1986). The study utilized a task analysis to breakdown a complex task into smaller steps (Bandura, 1986; Lovaas & Newsom, 1976). In addition, the study utilized feedback, reinforcement, and verbal instruction to support retention, production, and motivation.

Using a multiple-baseline-experimental design across subjects, Gruber (2008) examined the effects of graduated guidance and video-modeling procedures to teach yoga skills to children. Two males and one female ages 3-4 years participated in the study. A certified yoga instructor modeled a 24-step response chain of two hatha yoga poses (e.g., Half Moon Pose and Cobra Pose). However, a different model was used during generalization probes. The video included visual demonstrations and verbal instructions for each of the steps. Parents were trained by the researcher on the use of graduated guidance and reinforcement procedures. The study used a most-to-least procedure with a time delay and reinforcement that consisted of social praise and a preferred edible or activity. Findings from this investigation showed all participants matched the response chain with 71% accuracy or better and one participant generalized these skills in the presence of a live model (Gruber, 2008). With regard to the constructs of observational learning, this study also aligned with several recommendations as presented by Bandura (1986). The study utilized a task analysis to breakdown a complex task into smaller steps (Bandura, 1986; Lovaas & Newsom, 1976). The study also utilized feedback, reinforcement, and verbal instruction to support retention, production, and motivation.

Kourassanis et al. (2014) examined peer-video modeling as an intervention to teach two common childhood social games (e.g., Hokey-Pokey and Duck, Duck, Goose). Two children participated in the study. A 5-year-old female diagnosed with Pervasive Developmental Disorder-Not Otherwise Specified (PDD-NOS) and a 6-year-old male diagnosed with autism. This study took place at a center that provided applied behavior analytic (ABA) therapy, social skills groups, and parent training. Kourassanis et al.

(2014) used a multiple-baseline design across two social games to assess the effects of peer-video modeling intervention and praise on chained gross motor behaviors. Video presentations were approximately 40 seconds in duration. The models were typically developing males and females, approximately the same age as the participants. Data were collected on the number of correct responses as outlined in a task analysis of the games. Findings from the investigation showed improved performance of chained gross motor behaviors across two social games. The authors concluded that peer-video modeling is an effective method of teaching chained social game behaviors to young children with autism (Kourassanis et al., 2014). With regard to the constructs of observational learning, this study used a peer video model similar in appearance to the participants. Models similar in terms of physical appearance can increase attention to the modeled performance (Bandura, 1986). In addition, the study utilized a task analysis to teach social games to young children. Breaking down complex tasks into smaller step aligns with the recommendations of Bandura (1986), and Lovaas and Newsom (1976).

Trocki-Ables (2014) examined the effects of video modeling and primary reinforcers on push-up performance. Five males, ages 8-10 years participated in the study. All participants were diagnosed with autism and had a secondary speech disability. While all participants attended general physical education, three participants received no support and two participants attended general physical education with a paraprofessional. A peer video model was used to demonstrate the correct form of a push-up. Push-up performance was based on the FITNESSGRAM (Welk & Meredith, 2010) and primary reinforcers were selected by the parent from a menu of snack choices.

Using a randomized alternating-treatment design, data were collected on the number of push-ups performed under three conditions: (a) video modeling, (b) reinforcement, (c) controlled (no intervention). While push-up performance increased across all three conditions, results indicated three of the five participants demonstrated their best push-up performance under the video modeling treatment. The author concluded that video modeling, as well as reinforcement, could improve physical fitness skills in physical education for males with autism (Trocki-Ables, 2014). With regard to the constructs of observational learning, this study used a peer video model similar in appearance to the participants. According to Bandura (1986), models similar in physical appearance can increase attention to the modeled events (Bandura, 1986). In addition to the peer model, the study utilized a task analysis to teach social games to young children. Breaking down complex tasks into smaller step aligns with the recommendations of Bandura (1986), and Lovaas and Newsom (1976).

Yanardag et al. (2013) examined, both, the effects of video prompting on teaching aquatic play skills and the effects of aquatic exercise training on the motor performance of children with autism. Three children with autism participated in the study. All participants were between the ages of 6-8 years. The experiment took place at a university indoor swimming pool in a one-to-one format. Sessions were administered three times a week for 12 weeks with each session lasting one hour. Task analyses were created for each aquatic play skills (i.e., kangaroo, cycling, and snake). Each aquatic play skill consisted of three steps from a point-of-view perspective. Video clips ranged between 6-30 seconds with an average duration of 11-seconds. All video presentations were shown on a laptop computer. Using a multiple-probe design across behaviors and participants, data were collected on the percentage of correct steps in performing the aquatic play skills and pre-post scores of the MABC-2 (Henderson et al., 2007) (i.e., manual dexterity, aiming and catching, and balance). Results from the investigation showed that all participants increased their targeted aquatic play skill with video prompting and motor performance scores over the 12-week session. The authors concluded that video prompting was effective in teaching aquatic play skills to children with autism and aquatic exercise training increased motor performance scores (Yanardag et al., 2013). With regard to the constructs of observational learning, this study utilized a task analysis to teach aquatic play skill to young children. Breaking down complex tasks into smaller step aligns with the recommendations of Bandura (1986), and Lovaas and Newsom (1976).

Summary of Video Modeling Motor Skills and Autism

While "most human behavior is learned through the observation of a model" (Bandura, 1986, p. 47), children with autism seem to lack the necessary skills to benefit from observational learning. Eye avoidance (Tanaka & Sung, 2016) and stimulus over-selectivity (Charlop-Christy et al., 2000; Lovaas et al., 1971) may limit their ability to acquire information from the environment. However, Bandura (1986) proposed symbolic modeling, a method in which a modeled event is presented to the learner via television, films, and visual media. A common form of symbolic modeling known today is video modeling. Video modeling has been recognized by the National Autism Center (NAC, 2015) and the National Professional Development Center (Wong et al., 2014) as an effective evidence-based practice in teaching children with autism. The four types of modeling, (i.e., basic video modeling, video self-modeling, point-of-view modeling, and video prompting) have all been utilized to teach an array of targeted skills and behaviors. While much of the literature has focused on social-communication skills and behaviors, only a few studies have examined the effects of video modeling on movement and physical activity. The activities include line dancing (Gies, 2012), yoga (Gruber, 2008), social games (Kourassanis et al., 2014), push-ups (Trocki-Ables, 2014), and aquatic play skills (Yanardag et al., 2013). While the literature supports video modeling as an effective strategy in teaching motor skill performances to children with autism, additional research is needed. For a summary of the literature on video modeling motor skills to children with autism, see Table 3.

Table 3. *Literature on Video Modeling Motor Skills to Children with Autism*

Study	Sample	Age	Targeted skill	Modeling procedure	Setting	Research design
Gies (2012)	7 (F-1; M-6)	12-16 yrs.	Dance: hip-hop	VP	Summer camp	Single-case design
Gruber (2008)	3 (F-1; M-2)	3-4 yrs.	Fitness: yoga	VP	Home	Single-case design
Kourassanis et al. (2014)	2 (F-1; M-1)	5-6 yrs.	Games: play skills	VP	Treatment center	Single-case design
Trocki-Ables (2014)	5 (F-0; M-5)	8-10 yrs.	Fitness: push-ups	VP	Home	Single-case design
Yanardag et al. (2013)	3 (F-1; M-2)	6-8 yrs.	Aquatics: play skills	VP	Training facility	Single-case design

Note. In-vivo – live modeling; VM – video modeling; VSM – video self- modeling; POV – point-of-view video modeling; VP – video prompting.

SECTION IV: Eye-Tracking Technology

This section of the literature review will focus on eye-tracking technology. It will (a) provide an overview of eye-tracking technology, (b) examine the underlying mechanism of eye-tracking technology, and (c) review the literature on eye-tracking technology as it relates to autism. This section will conclude with a summary of the eye-tracking technology as it pertains to this study.

Overview of Eye-Tracking Technology

Eye-tracking is a technique that provides a robust, quantitative measure of where someone is visually attending (Shic, 2013). The actual device used to measure and record the information is called an eye-tracker (Bergstrom & Schall, 2014). As a research instrument, eye-trackers have become more accessible and have grown in popularity amongst researchers from an array of disciplines (Holmqvist et al., 2011). “Usability analysts, sports scientists, cognitive psychologists, reading researchers, psycholinguists, neurophysiologists, electrical engineers, and others all have a vested interest in eye-tracking for different reasons” (Holmqvist et al., 2011, p. 1). Unlike the devices used in the late 1800s and early 1900s, modern-day eye-tracking devices “are relatively non-invasive and easily tolerated experimental technology” (Shic, 2013, p. 1208).

There are two main types of eye-tracking devices. The devices are either mobile or remote. Mobile eye-trackers are worn as eyewear and measure where an individual is visually attending in the environment. Remote eye-trackers attach to the front of a computer and measure where an individual is visually attending on a computer monitor (i.e., images, videos, websites). Both remote and mobile eye-trackers are designed to receive and transmit eye-tracking data to a computer with compatible eye-tracking analysis software (Holmqvist et al., 2011). However, some devices may differ in regards to set-up, application, obtrusiveness, freedom of movement, and ease of analysis. The type of device used in a study is often dependent upon the research questions and design. Mobil eye-trackers are recommended for observations in real-life or virtual environments. Remote eye-trackers are recommended for observations of screen-based stimuli in lab settings such as pictures, videos, and websites (Bojko, 2013).

Both, mobile and remote eye-trackers record eye movements such as fixations and saccades. Fixations are eye movements that steady the retina over an area of interest on the visual stimuli (Duchowski, 2007). Saccades are rapid movements of the eye from one fixation to another. Fixations and saccades are the most common measures in eye-tracking technology (Bojko, 2013). Depending on the sophistication of the eye-tracking device and software utilized in the experiment, additional measures such as fixation count, fixation duration, number of saccades, number of visits to specific areas of interest, sequence patterns, and smooth pursuits can be examined (Bojko, 2013; Duchowski, 2007; Holmqvist et al., 2011).

The Underlying Mechanism of Eye-Tracking Technology

To understand the underlying mechanism of eye-tracking technology, an overview of the human visual system is provided (see Figure 2). The visual process begins with a reflection of light from an object. The light travels through the cornea, the pupil and to the lens of the eye. The lens inverts the light, and the object is projected upside down on the retina located at the back of the eye. The retina, which is filled with millions of light-sensitive cells called rods and cones, transforms the incoming light into electrical signals. These electrical signals are then sent via the optic nerve to the visual cortex for processing (Duchowski, 2007; Holmqvist et al., 2011). In regards to the underlying mechanism of eye-tracking, a very small but important part of the retina is called the fovea (see Figure 2). The fovea is highly concentrated with cones and provides full acuity (Duchowski, 2007). However, foveal vision only spans about 2° of the visual field, which is "roughly the size of your thumb nail at arm's distance." (Holmqvist et al., 2011, p. 21). For that reason, the eye must continuously move to see objects with full acuity. Six muscles control the eye and are responsible for horizontal (yaw), vertical (pitch), and torsional (roll) movements. On average humans make 3-5 eye movements every second (Holmqvist et al., 2011). Eye-trackers record these movements to determine where a person is visually attending (Bergstrom & Schall, 2014).

Both mobile and remote eye-trackers utilize the same underlying mechanism. The process begins with a near-infrared light projected towards the pupil of the eye via the eye-tracking device (Bojko, 2013). The light, which is undetected by the human eye, creates four reflections known as Purkinje Reflections. These reflections are known as P^1, P^2, P^3, and P^4. The first two reflections, P^1 and P^2, reflect off the anterior and posterior sides of the cornea while P^3 and P^4 reflect off the anterior and posterior sides of the eye lens (Crane, 1994; Duchowski, 2007). Of the four reflections, P^1 offers the brightest reflection. Often referred to as the pupil and corneal reflection, it plays a vital role in modern eye-tracking technology (see Figure 3).

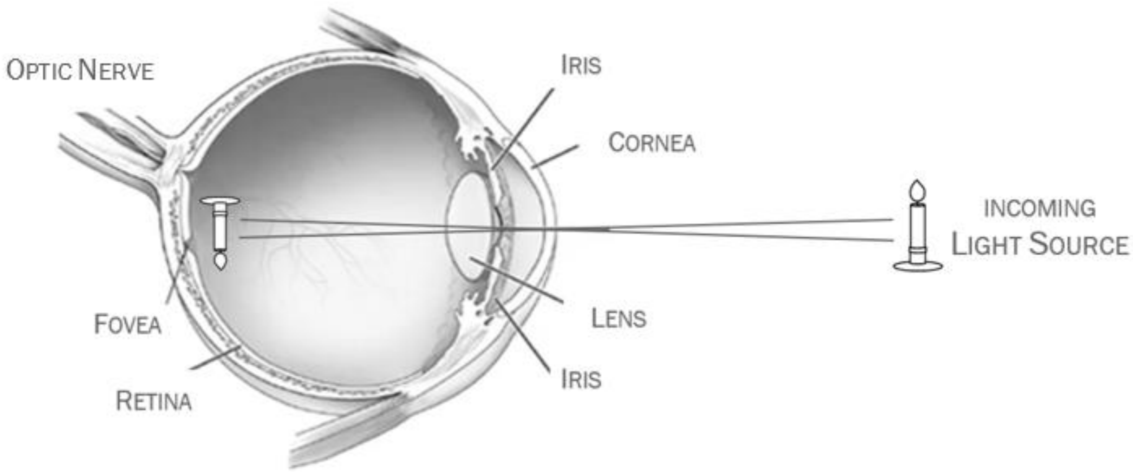

Figure 2. An overview of the Human Visual System.

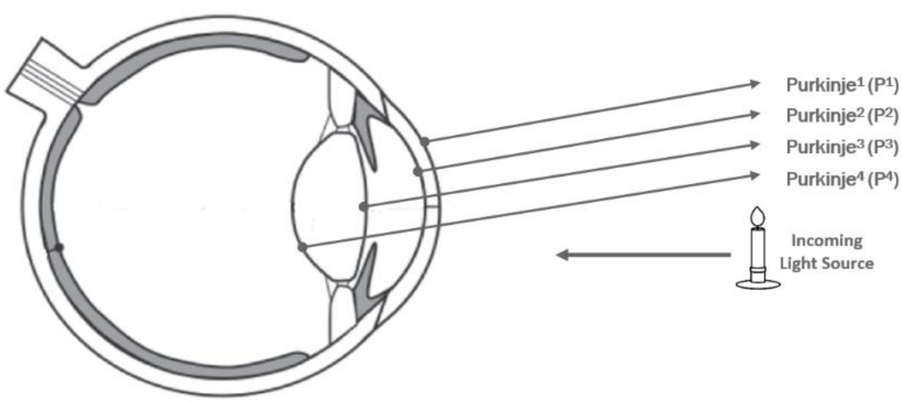

Figure 3. The Four Purkinje Reflections and the Pupil-Corneal Reflection.

The pupil and corneal reflection, also known as the pupil-corneal reflection, is the most dominating method of estimating the point of gaze. First, optical sensors within the eye-tracking device detect the eye. Second, the pupil-corneal reflection is analyzed via image-processing algorithms. Finally, once the device is calibrated, the eye-tracking software transforms the gaze location into the x and y coordinates and generates a data file. The file provides raw data samples, which consist of the x–y coordinates of every measured point of gaze (POG) along with an associated timestamp (Holmqvist et al., 2011). Once the data are collected and analyzed, they can be presented as raw data (e.g., Excel spreadsheet) or visual illustrations such as gaze plots or heat maps. Gaze plots are visual illustrations of fixations and saccades onto a visual stimulus (i.e., image, video, or webpage). Circles within the gaze plot represent areas of fixation. The size of the circle portrays duration (e.g., the larger the circle, the longer the duration). Saccades are the rapid lines of movement from one fixation to another. Another means to visually illustrate eye-tracking measures are heat maps. Heat maps use color to show fixation and duration of a visual stimulus. Lastly, data can be analyzed by creating predetermined areas of interest (AOI) on the visual stimulus (Bojko, 2013). AOIs are defined regions of a display (i.e., picture or video) from which quantitative data can be collected (Holmqvist et al., 2011).

In essence, this non-invasive method of detecting eye movement is one reason why the technology has gained popularity amongst researchers studying neuropsychiatric conditions and special populations. Precise measurements of the eye can easily be obtained without ever touching the participant (Shic, 2013). Oftentimes, participants forget the eye-tracker even exists (Holmqvist et al., 2011). Nevertheless, “eye-tracking has been and continues to be a powerful methodology for understanding the nature of ASD” (Shic, 2013, p.1209).

Additional Considerations of Eye-Tracking Technology

Once the type of device to be used in the study has been determined (e.g., mobile or remote), careful consideration must be given to the technical specifications of the device. Bojko (2013) suggested further investigation of the following technical specifications: (a) sampling rate, (b) accuracy and precision, (c) head box size (remote eye-trackers), and (d) recording system (e.g., monocular or binocular).

Sampling Rate. One of the most important features of an eye-tracking device is the sampling rate. Measured in hertz (Hz), this is the number of times the eye-tracker records the individual’s gaze point per second (Bojko, 2013). For example, if the eye-tracker has a sampling rate of 120 Hz, then 120 data points per second will be collected. A 15-second recording will record 1800 data points.

Accuracy and Precision. Careful consideration must also be given to the accuracy and precision of the eye-tracking device. Accuracy is defined as the average difference between the recorded gaze position and the actual gaze position. Precision is defined as the eye tracker's ability to reliably reproduce the measure. Most eye-trackers range between .5 - 1 degree for accuracy and .01 – 1 degree for precision (Bojko, 2013).

Head Box Size. Head box size is another technical specification to consider for remote eye-trackers. The head box indicates the freedom in which the head can move inside an imaginary box with set dimensions. If the head remains within the head box, the eye-tracker will continue to collect data. Most head box sizes range from 7-9 inches (height), 12-17 inches (width), and 8-12 inches (depth). Mobile eye-trackers do not have a head box size because there are no movement restrictions (Bojko, 2013).

Recording System. Monocular or binocular recording systems must also be considered. While monocular recording system is more affordable, binocular recording systems increase accuracy and precision due to the averaging of the data from both eyes. Another advantage of the binocular recording system is that if one eye moves outside the head box, information continues to be recorded from the other eye (Bojko, 2013).

Review of Literature on Eye-Tracking Technology and Autism

Eye-tracking investigations have been documented as far back as the late 1800s, (e.g., the works of Edmund Huey, 1898). However, only recently has the technology been used to examine individuals with autism (Klin et al., 2002; Pelphrey et al., 2002; Van der Geest, Kemner, Verbaten, & van Engeland, 2002). While much of the literature on eye-tracking technology and autism has focused on the social characteristics of the disorder, only a few studies have used eye-tracking technology to examine motor skill performances of this population (Vivanti & Dissanayake, 2014; Vivanti et al., 2011; Vivanti et al., 2008).

Several studies have used eye-tracking technology to examine infants and toddlers either with or at-risk for autism. In an investigation of 334 toddlers, ages 10-49 months, Pierce et al. (2015) used remote eye-tracking to examine fixation duration and the number of saccades within an area of interest. The study included 115 toddlers with autism, 20 toddlers with autism features, 57 toddlers with developmental delay, 53 toddlers with other conditions, 64 toddlers with typical development, and 25 unaffected toddlers with siblings diagnosed with autism. Eye-tracking measures were recorded to quantify the visual attention of toddlers toward dynamic (i.e., moving and changing) geometric images (DGI) and dynamic social images (DSI). Measures were recorded as the participants watched a movie containing geometric and social images side by side. The movie included 28 scenes with each scene lasting 2 to 4 seconds in duration. Total presentation time was 60 seconds and did not include audio. Results from the investigation showed toddlers with autism had a strong preference for moving geometric images over social images when compared to toddlers with typical development, language delay, developmental delay, and unaffected toddlers with siblings diagnosed with autism. The study concluded that "enhanced visual preference for geometric repetition may be an early developmental biomarker of an ASD subtype with more severe symptoms" (Pierce et al., 2015, p. 1).

Similarly, Shic et al. (2011) used remote eye-tracking to examine adult-child play interaction of 78 toddlers aged 20 months. The participants included 28 toddlers with autism, 16 toddlers with developmental delay, and 34 toddlers with typical development. Each participant viewed a 30-second video of adult-child play interaction. Shic et al. (2011) hypothesized that toddlers with autism would spend less time attending to the actors in the video and more time attending to the toys and objects in the background.

The experiment took place in a dark, soundproof room with little or no visual distractions. Each participant sat in a car seat positioned 75cm in front of a 24-inch monitor. The experimenter and the child were separated by a curtain while a parent sat 6 feet behind the participant. The procedure began with a presentation of a children's video to help ease the participant. This was followed by a 5-point eye-tracking calibration procedure and the 30-second adult-child play interaction video. Results from the investigation found toddlers with autism showed less attention to the activities of others and focused more on background objects (e.g., toys) when compared to typically developing toddlers and toddlers with developmental delay. It was noted that disruptions in observing the social activities of others might hinder future opportunities for observational learning.

In an investigation of 76 two-year-old infants, (Klin et al., 2009) used eye-tracking technology to examine the eye gaze and preferential attention to biological motion. The study included 21 participants with ASD, 29 participants with typical development, and 16 with developmental delays. The ASD and TD groups were matched on chronological and nonverbal mental age equivalents. Using a remote eye-tracker and point-light video display, results indicated children with autism focused less on upright biological motion and had a greater preference for animated cartoons with audio.

Sasson and Touchstone (2014) also used remote eye-tracking to examine a similar age group. This investigation compared 15 preschoolers with autism and 15 typically developing preschoolers' ages 24-62 months on a paired preference task of face and object stimuli. The task consisted of twenty slides of social and object images side by side. Each participant sat on the lap of a parent or teacher approximately 60cm from the computer screen. A 5-point calibration procedure was used to set the eye-tracking device. All participants were informed that pictures of people and objects would appear on the screen. The paired images (i.e., face and object stimuli) were then presented individually to each participant in random order. The paired images appeared on the screen for 5 seconds. An attention-getting stimulus (i.e., animation with sound) was used to re-orient the participant back to center before the appearance of the next set of paired images. The attention-getting stimulus ensures all scanning patterns begin at an equal distance between the paired images (Sasson & Touchstone, 2014). While co-varying verbal and nonverbal developmental quotients, the study found both groups had a similar visual response pattern to faces paired with objects unrelated to circumscribed images (CI). However, preschoolers with autism attended significantly less to faces presented with CI related objects than typically developing preschoolers. These findings were consistent across the three metrics of preference, prioritization, and duration. The investigation concluded that the social attention of preschoolers appears to be modulated by the salience of competing, non-social stimuli, which may affect the development of both social and non-social characteristics of the disorder (Sasson & Touchstone, 2014).

In an investigation of 67 children ages 4-7 years, Falck-Ytter et al. (2013) utilized remote eye-tracking technology to examine the gaze performance of children viewing other children in a semi-naturalistic social scene. Thirty-nine children with autism were compared to 28 typically developing children. The participants viewed six short (< 20-seconds) video in which two young children performed a predefined script in a semi-naturalistic social scene (i.e., sitting at a table with one toy). While the videos followed the same social script, the intensity and toy varied. Audio was included in the video, but the actors did not speak. Results from the investigation found children with autism tend to look at other children differently than typically developing children (i.e., not looking at the face of the other children) (Falck-Ytter et al., 2013).

In a comparison study, Klin et al. (2002) compared the visual fixation patterns of 15 male participants with autism to 15 males without autism. All participants ranged between 15.4 and 17.9 years. Using eye-tracking technology, each participant watched five, 30-60 second video clips of Edward Albee's "Who's Afraid of Virginia Wolf?" Data were collected from intense social scenes of the movie on four regions (i.e., mouth, eyes, body, and objects). Results from the investigation showed significant between-group differences in the four regions. The authors concluded that "individuals with autism demonstrate abnormal patterns of social visual pursuit consistent with reduced salience of eyes and increase salience of mouths, bodies, and objects" (Klin et al., 2002, p. 809).

To understand circumscribed attention of children with autism, Sasson et al. (2008) recruited 53 participants, ages 6-17 years. Twenty-nine participants were diagnosed with autism, and 24 participants were identified as typically developing. The authors described circumscribed interests as hallmark characteristics of autism – a type of repetitive behavior in which there is an intense focus on a narrow range of subjects. Using eye-tracking technology, Sasson et al. (2008) compared the visual attention of children with autism to the typically developing control group. Twelve picture arrays were created, each containing 24 images. The arrays had varying ratios of social images (i.e., pictures of people with visible faces); high autism interest images (i.e., trains, vehicles, blocks, and electronics); and low autism interest images (clothing, furniture, plants, and bags). The procedure took place in a university laboratory setting with the participant seated approximately 60 cm away from a 17-inch computer monitor. Once the eye-tracker calibration process was complete, picture arrays were presented to the participant. Each array was displayed for 10 seconds and a cross-hair appeared in the center of the screen between each array. *Note.* A cross-hair is an eye-tracking technique used to ensure that all visual patterns began at the same point for each array (see Figure 4). Once the eye-tracking procedure was complete, the following measures were retrieved and analyzed: (a) exploration (the number of images examined), (b) perseveration (the duration of time the images were examined), and (c) detail orientation (the number of times each image was examined). The data from this investigation showed atypical patterns of visual attention in children with autism when compared to the typically developing control group. Visual attention in children with ASD was more circumscribed (indicated by the exploration of fewer images overall), more perseverative (indicated by longer fixation times per image explored), and more detail-oriented (indicated by a greater number of discrete fixations on explored images). The overall reduction in visual exploration found in ASD can thus be explained by a tendency in these children to fixate longer on the items they explored. Visual perseveration and detail

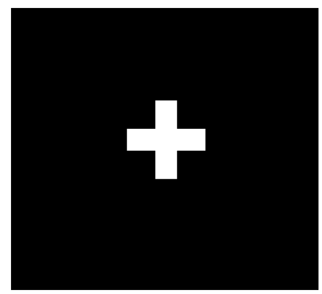

Figure 4. Photograph of the "cross-hair" placed in the center of the monitor.

orientation may, act as mechanisms for reduced visual exploration in autism and suggests that salient items may disproportionately “capture” and “trap” attention in children with ASD (Sasson et al., 2008).

Gillespie-Smith, Riby, Hancock, and Doherty-Sneddon (2014) analyzed the fixation measures of objects and faces within picture communication symbols. Picture communication symbols (PCS) are cartoon-like images, used to convey information to children with autism. Twenty-one children diagnosed with autism were compared to three typically developing matched groups: chronological age-matched (CA) (n = 21); verbal ability age-matched (VA) (n = 21); and non-verbal ability age-matched (NVA) (n = 21). Age of the participants ranged between 9-16 years. Participants were seated approximately 50cm from a computer monitor and a 5-point calibration procedure was used to ensure the accuracy of the eye-tracker. Once the calibration was completed, picture communication symbols were presented in random order to each of the participants. The symbols included images of faces and objects, and areas of interest (AOIs) were assigned to the images prior to the experiment. Each experiment took place at either the home or school of the participant and lasted approximately 10-12 minutes. Results from the investigation found children with autism to have similar fixation patterns on face and object areas compared to typically developing matched groups (Gillespie-Smith et al., 2014)

As technology continues to advance, researchers are integrating additional biometric measures to their eye-tracking experiments. Wagner, Hirsch, Vogel-Farley, Redcay and Nelson (2013) used eye-tracking technology to examine emotional face processing in adolescents with autism and typical development. Thirty-eight adolescents' ages 13-21 years participated in the investigation. The participants included 18 adolescents with autism and 20 typically developing adolescents. Participants were seated approximately 60 cm from a 17-inch computer monitor. A 5-point calibration procedure was used to ensure the accuracy of the eye-tracker. Once the calibration was completed, five sets of facial images were presented to each participant in a randomized order. Each set included a female image of happy, fearful, and neutral expressions. The set of images were displayed for 5 seconds each, with a 2-second inter-stimulus interval (i.e., blank white screen) between sets. Areas of interest (AOIs) were placed over the images to depict where the participant visually attended to the image (i.e., face, eye, and mouth regions). Each participant was simply asked to scan the faces as they appeared on the screen. Results of this investigation showed both the ASD group and the TD group as having similar scanning of emotional faces (Wagner et al., 2013).

While most of the literature using eye-tracking technology has focused on the social aspects of the disorder, Vivanti et al. (2008) used a mobile eye-tracking device to determine if differences in visual attention to various types of motor actions. Thirty-one children and adolescents participated in the investigation. The participants included 18 individuals, ages 8-15 years with high-functioning autism, and 13 individuals between ages 8-14 years with typical development. Due to the nature of the experiment (i.e., required movement), participants used mobile eye-tracking technology. The headgear was referred to as a "space helmet" which matched accordingly to the room, which was decorated with stars and planets. Each participant was seated in a chair at a table approximately 20 inches from an 18-inch computer monitor. Once the 9-point calibration procedure was completed, verbal instructions on the imitation task were provided. ‘‘You will see some video clips showing a person performing an action. Watch the screen carefully. At the end of each clip, after the action is done and the screen turns black, you will imitate what you saw the person do in the clip” (Vivanti et al., 2008, p. 191). To ensure comprehension of the task procedure, three practice trials were provided. The experiment included 12 video clips of an adult modeling various motor actions. The model maintained neutral emotions, and all actions were demonstrated in a slow and distinct manner without verbal instruction.

Using eye-tracking technology, each participant watched twelve, 7-19 second video clips of a model demonstrating various actions. The actions included non-meaningful gestures and non-meaningful actions on objects. Non-meaningful gestures were described as hand slaps arm, arm flexes at elbow, hand/fist on table, hand moves across forehead, arm moves across chest, and the hand moves from shoulder to front. Meaningful actions on objects were described as drawing a line, brushing arm with lint brush, flatten dough with rolling pin, stamping an inkpad, and striking a xylophone with force. Results from the investigation showed the two groups had similar patterns of visual attention to the action areas of the model (e.g., arm movements). However, the group with autism had decreased attention to the model’s face during the demonstration and reduced imitative precision (Vivanti et al., 2008).

Summary of Literature on Eye-Tracking Technology and Autism

Eye-tracking technology has become increasingly accessible (Holmqvist et al., 2011). The robust, quantitative measure of eye movement (Shic, 2013) has improved in terms of speed, accuracy, user-friendliness, and affordability (Duchowski, 2007). The non-invasive method of detecting eye movement is yet another reason the technology has gained popularity amongst researchers studying neuropsychiatric conditions and special populations. Precise measurements of the eye can easily be obtained without touching the participant (Shic, 2013). "Currently, there is a great deal of interest in using eye-tracking technology for understanding autism, and much of this effort is aimed at understanding the specific individual behavioral and cognitive characteristics that affect visual scanning of social information in autism" (Shic, 2013, p. 1212). It is hoped that eye-tracking research will help us understand the visual attention patterns of individuals with autism, as well as predict interventions that will be most efficacious (Shic, 2013). For a summary of the literature on eye-tracking technology and children with autism, see Table 4.

Table 4. *Literature on Eye-Tracking Technology and Children with Autism*

Study	Sample	Participants	Eye-tracker	Stimuli	Assessments	Findings
Falck-Ytter et al. (2013)	57 4-7 yrs.	ASD; TD	remote; 60Hz; 17" monitor	6-20s videos	ABC; WPPSI-III; VABS-II	Found that young children with ASD looked less at other children
Gillespie-Smith et al. (2014)	84 9-16 yrs.	ASD; CA; VA; NVA	remote; 50Hz; 5pt calibration	20-3s still images	BPVS II; RCPM; ASDS; CARS; SCQ	Children with ASD demonstrated similar fixation patterns on face and object areas compared with TD matched groups
Klin et al. (2009)	76 2 yrs.	ASD; DD; TD	Remote; 60Hz; 5pt calibration	point-light displays	ADI-R; ADOS; MSEL	Two-year-old infants with ASD focused more on animated cartoons with audio than upright biological motion.

Note. ABC-Autistic Behavior Checklist (Krug, Arick, & Almond, 1980); ADI-R: The Autism Diagnostic Interview-Revised Rutter et al., 2005); ADOS-Autism Diagnostic Observation Schedule (Lord et al., 2012); ASDS-Asperger Syndrome Diagnostic Scale (Myles, Simpson, & Bock, 2001); BPVS II-British Picture Vocabulary Scale, second edition (Dunn, Dunn, Whetton, & Burley, 1997); CARS-Childhood Autism Rating Scale (Schopler et al., 2002; Schopler et al., 2010); MSEL-Mullen Scales of Early Learning (Mullen, 1995); RCPM-Raven's Coloured Progressive Matrices (Raven, Court, & Raven, 1990); SCQ-Social Communication Questionnaire (Rutter et al., 2003); VABS-II-Vineland Adaptive Behavior Scales-second edition (Sparrow et al., 2005); WPPSI-III -Wechsler Preschool and Primary Scale of Intelligence, third edition (Wechsler, 1967, 2002).

Table 4 (continued)

Literature on Eye-Tracking Technology and Children with Autism

Study	Sample	Participants	Eye-tracker	Stimuli	Assessments	Findings
Pierce et al. (2015)	334 10-49 mons.	ASD, ASD features; DD; TD; unaffected siblings w/ASD	remote: 120Hz; 17" monitor	28 images 2-4s; total viewing time 60s	ADOS; MSEL; VABS-II	Toddlers with autism had a strong preference for moving geometric images over social images when compared to toddlers with TD
Sasson et al. (2008)	53 6-17 yrs.	ASD, TD	remote; 50 Hz;17" monitor	12 static arrays; 10s	ADI-R; ADOS; CARS; Leiter-R; SCQ; SRS;	Atypical patterns of visual attention in ASD; more circumscribed, more perseverative, and more detail-oriented.
Sasson & Touchstone (2014)	30 24-62 mons.	ASD; TD	remote; 60Hz; 5pt calibration; 24" monitor	20 paired images	ADOS; MSEL	ASD showed disproportionately reduced gaze to faces paired with CI-related objects

Note. ADOS-Autism Diagnostic Observation Schedule (Lord et al., 2012); ADI-R: The Autism Diagnostic Interview-Revised Rutter, Le Couteur, & Lord, 2003); CARS-Childhood Autism Rating Scale (Schopler et al., 2002; Leiter-R-Leiter International Performance Scale-Revised (Roid & Miller, 2002); MSEL-Mullen Scales of Early Learning (Mullen, 1995); SCQ-Social Communication Questionnaire (Rutter et al., 2003); SRS-Social Responsiveness Scale (Constantino & Gruber, 2005).

Table 4 (continued)

Literature on Eye-Tracking Technology and Children with Autism

Study	Sample	Participants	Eye-tracker	Stimuli	Assessments	Findings
Shic et al. (2011)	78 20 mons.	ASD; TD; DD	remote; 60Hz; 5pt calibration; 24" monitor	One 30s video	ADOS; MSEL	ASD less attention to the activities of others; increased focused on background objects (e.g., toys); looked less at people's heads and more at their bodies
Vivanti et al. (2008)	31 8-15 yrs.	ASD; TD	mobile head-gear; 60Hz; 9pt calibration; 18" monitor	Twelve 7-19s videos	ADOS-3; BOT-2; SCQ; VABS-II;	ASD had similar patterns of visual attention to TD children; ASD looked to the action region the same amount of time, decreased attention to the face region
Wagner et al. (2013)	38 13-21 yrs.	ASD; TD	remote; 60Hz; 5pt calibration; 17" monitor	Fifteen 5s images with a 2s inter-stimuli	ADOS; K-BIT-2; SCQ	Showed very similar overall scanning of emotional faces

Note. ADOS-Autism Diagnostic Observation Schedule (Lord et al.,, 2012); BOT-2- Bruininks–Oseretsky Test of Motor Proficiency–second edition (Bruininks & Bruininks, 2005); K-BIT-2-Kaufman Brief Intelligent Test, second edition (Kaufman & Kaufman, 2004); SCQ-Social Communication Questionnaire (Rutter et al., 2003); VABS-II-Vineland Adaptive Behavior Scales-second edition (Sparrow et al., 2005).

Summary of Literature Review

Though autism is often characterized by social and communication deficits and unique patterns of behaviors (DSM-5; APA, 2013), there has been a growing body of literature on the motor deficits and delays of children with autism. Finding ways to support this population in the acquisition of motor skill performances can be quite challenging. While modeling has been widely accepted as an effective means to convey relevant information to the learner (Ashford et al., 2006), the approach can be problematic for some children with autism (i.e., eye avoidance and stimulus over-selectivity). However, Bandura (1986) proposed symbolic modeling, a method in which modeled events are presented to the learner via television, films, and visual media. A common form of symbolic modeling is video modeling (Corbett, 2003).

Video modeling has been recognized by the National Professional Development Center (Wong et al., 2014) and the National Autism Center (NAC, 2015) as an effective evidence-based practice to teach children with autism. Recently, there has been a growing interest in the use of video modeling to teach motor skill performances to children with autism. Studies have shown video modeling as an effective strategy in the acquisition of line dancing (Gies, 2012), yoga (Gruber, 2008), social games (Kourassanis et al., 2014), push-ups (Trocki-Ables, 2014), and aquatic play skills (Yanardag et al., 2013). Though video modeling has shown success, there is very limited research on where and how children with autism visually attend to video-modeled demonstrations.

Eye-tracking is a robust, quantitative measure of where someone is visually attending (Shic, 2013). This technology has led researchers to identify differences in the gaze patterns of children with autism and typically developing children. While much of the literature has focused on the core features of autism, the purpose of this investigation was to extend the literature to include motor skill performances. Using eye-tracking technology, this investigation examine the visual attention patterns of children with autism as they view video-modeled demonstrations of motor skill performances. Findings from this investigation may enhance the design, creation, and presentation of video-modeled motor skill performances.

CHAPTER III: METHODOLOGY

The purpose of this study was to examine the visual attention patterns of children with autism as they observed video-modeled demonstrations of motor skill performances. Prior to the investigation, approval was obtained from the Institutional Review Board (IRB) at the University of Southern Mississippi in Hattiesburg, Mississippi (see Appendix A). An IRB Authorization Agreement (IAA) Form was obtained by the University of Virginia in Charlottesville, Virginia (see Appendix B). Each phase of the investigation is presented accordingly: (a) preliminary procedures, (b) data collection, and (c) data analysis.

Phase I - Preliminary Procedures

This section will describe the following preliminary procedures: (a) model selection, (b) recording scene, (c) motor skill performances, and (d) creation of the visual stimuli.

Model Selection

Each motor skill performance was modeled by an adult male in his early twenties. The model was selected by the principal investigator based on his physical characteristics (i.e., gender, age, and motor competence). Studies have shown models similar in appearance to the observers are more likely to be emulated (Bandura, 1986; Bussey & Bandura, 1984). For this reason, the model demonstrating the motor skill performances was male, youthful in appearance, and had the physical ability to demonstrate the four motor skill performances. Throughout each recording, the model wore a plain navy blue t-shirt, navy blue shorts, white socks, and gray sneakers. Wristbands and watches were removed prior to video recording. This was deemed necessary as young children may have attentional deficits that inhibit their ability to differentiate between relevant and irrelevant information (Bandura, 1986).

Recording Scene

Video recordings of the model took place in a university classroom. The background consisted of a white wall with a 3-inch brown trim and a green turf-like carpet. The model was positioned in the center of the video and an 18-inch, orange plastic cone was placed to the model's left side. The purpose of the cone was to determine if a non-relevant object would capture the visual attention of the observers. According to Shic et al. (2011), young children with autism showed less attention to the activities of others and focused more on background objects (e.g., toys) when compared to young children with typical development. In addition to the cone, the following equipment items also appeared in the motor skill performances: a 6-inch, red, lightweight ball; a 9-inch, red, playground ball; and adult size tennis racquet. All items were similar in color to reduce variability amongst the motor skill performances.

Motor Skill Performances

Four continuous motor skill performances were selected for the investigation. They included (a) ball toss, (b) basketball, (c) soccer, and (d) tennis. These motor skill performances were selected for the following reasons: (1) the motor skills were age appropriate in terms of motor development; (2) the motor skills were all continuous movements, which made the set-up of the AOIs more conducive to the principal investigator's level of experience with eye-tracking technology, (3) each motor skill performance was set-up in a similar format to reduce variability amongst the presentations, and (4) utilizing a similar set-up, allowed the principal investigator to apply AOIs that were comparable in size and location. These procedures were applied to reduce variability amongst the performances. The four motor skill performances are described accordingly:

Ball Toss. For the ball toss activity, the model stood face forward with his feet shoulders width apart. Hands were positioned approximately 18 inches apart at waist height and the ball alternated from the left hand to the right hand for 15 seconds.

Basketball. For the basketball activity, the model stood face forward with his feet shoulders width apart and knees slightly bent. The model continuously dribbled the basketball at the height of 24 inches for 15 seconds. Throughout the video recording, the model focused on the ball and did not look up at the camera.

Soccer. For the soccer activity, the model stood face forward with his feet shoulders width apart. The model placed his right foot on top of the ball and continuously rounded the ball with a 12-inch area for 15 seconds. Throughout the video recording, the model focused on the ball and did not look up at the camera.

Tennis. For the tennis activity, the model stood face forward with his feet shoulders width apart. The model held an adult size tennis racquet at waist height off to the right side of his body. The model continuously tapped the ball in the air at approximately 10 to 12 inches for 15 seconds. Throughout the video recording, the model focused on the ball and did not look up at the camera (see Figure 5).

Creating the Visual Stimuli

Pinnacle Studio 18 Ultimate^{TM} was used to create the four, 15-second videos of the motor skill performances, as previously described. Each video was edited and timed accordingly. Once completed, each motor skill performance video was duplicated and a yellow highlight arrow was added to the action area. A total of eight motor skill performance videos were then uploaded to the Tobii Studio software (Tobii Technology Inc., Stockholm, Sweden). The videos included four non-highlighted videos (see Figure 5) and four highlighted videos (see Figure 6).

Figure 5. Illustrations of the four non-highlighted motor skill performances. From left to right: ball toss, basketball, soccer, and tennis.

Figure 6. Illustrations of the four highlighted motor skill performances. From left to right: ball toss, basketball, soccer, and tennis.

Using the timeline feature in Tobii Studio, four randomized videos of the motor skills were created and identified by letters A, B, C, and D (see Table 5). Videos A and B represented the non-highlighted condition while videos C and D represented the highlighted condition (e.g., a yellow arrow pointing towards the action area). The motor skill performances were randomly assigned and appeared twice in each video (e.g., once in Block 1 and once in Block 2). None of the motor skill performances appeared consecutively. Lastly, each participant was assigned to either a non-highlighted video condition (i.e., Video A or B) or a highlighted video condition (i.e., Video C or D).

According to Bandura (1986), young children often have a limited ability to attend to multiple cues, identify relevant cues, and maintain attention, which can impede learning and hinder the performance of a modeled event. With regard to Research Questions 2, 4, and 6, this investigation examined the effects of attentional highlighting (i.e., a yellow arrow). The purpose of the yellow arrow was to guide the participant's attention to relevant cues and essential information of the action area. According to de Koning, Tabbers, Rikers, and Paas (2009), attentional cues (i.e., highlighting) may help direct attention to relevant information to improve learning. The attentional highlight arrows used in the present study were equal in size and placed to the left of the action area to reduce variability amongst the video presentations.

Another strategy used in creating the visual stimuli, was to provide a defined start and finish to the task (e.g., watching the video). Each video began with a 3-second prompt (e.g., let's begin) this informed the participant that the experiment was about to begin. A cross-hair "+" then appeared in the center of the screen for three seconds prior to each motor skill performance. This technique ensured that all visual scanning patterns began at the same location for each participant (Sasson & Elison, 2012). The video observation concluded with a 3-second slide of the words "The End" (see Figure 7).

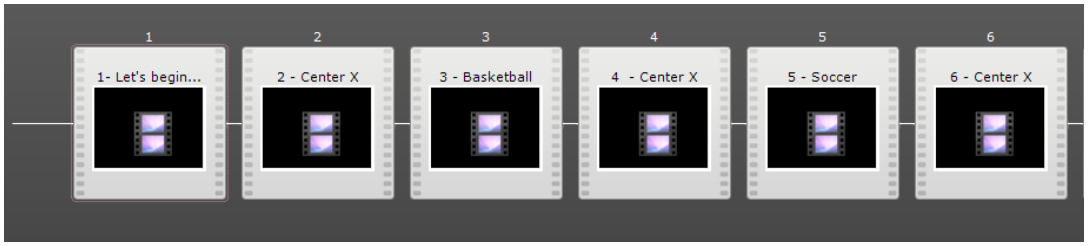

Figure 7. Illustration of the video presentation timeline in the eye-tracker.

The areas of interest (AOIs) were colored coded and identified accordingly. Red AOIs represented the action area, green AOIs represented the cone area, and blue AOIs represented the head area. All head and cone AOIs were identical in regards to size and location for each set of videos (i.e., non-highlighted and highlighted video). The eye-tracking software provided x and y coordinates that ensured each AOI was digitally replicated. Though the action AOIs varied in size and location, all AOIs were distinctly separated to prevent overlapping. While the AOIs are illustrated in Figure 8, the AOIs were not visible to the participant during the video presentation.

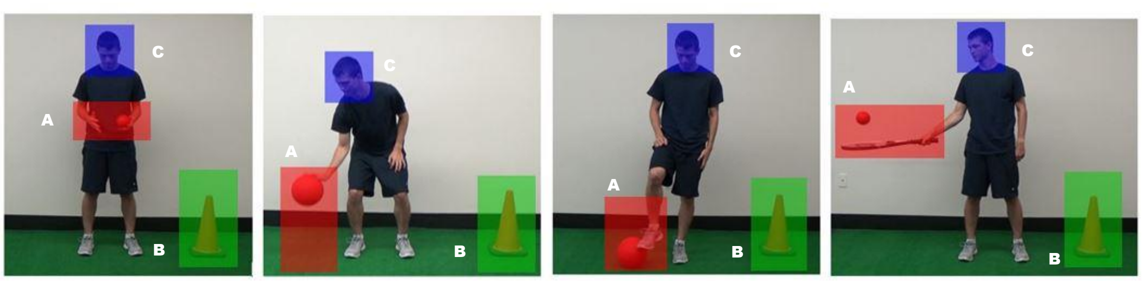

Figure 8. Illustrations of the three areas of interest (AOIs) were (a) action, (b) cone, and (c) head. All AOIs were similar in regards to the size and location for each video (i.e., the non-highlighted and highlighted videos).

Table 5. *Randomized Sequencing of the Motor Skill Performance Videos*

		Block 1	Block 2
Condition	Assigned videos	4-15 second videos Total time: 1 minute	4-15 second videos Total time: 1 minute
Non-Highlighted Videos	Video A	basketball, soccer, tennis, ball toss	soccer, basketball, ball toss, tennis
	Video B	tennis, ball toss, basketball, soccer	ball toss, tennis, soccer, basketball
Highlighted Videos	Video C	soccer, tennis, ball toss, basketball	tennis, soccer, basketball, ball toss
	Video D	ball toss, basketball, soccer, tennis	basketball, ball toss, tennis, soccer

Phase II: Data Collection Procedure

Participants

Thirty-five males, ages 8-12 years participated in the study. Fourteen participants were diagnosed with autism and twenty-one participants were identified as typically developing children. The participants with autism had a professional diagnosis of the disorder as reported by the parent/caregiver. An a priori power analysis was performed to determine the optimal number of participants needed to maximize the probability of rejecting a false null hypothesis. Based on the G*Power 3 analysis (Faul, Erdfelder, Lang, & Buchner, 2007) indicated that for a *t*-test with an effect size of .80, $a = .05$, and power of .80, a total sample size of 52 was required for this study. Prior to data collection, the following documents were reviewed and signed: (a) USM IRB Parent Consent Form (see Appendix C), (b) USM IRB Minor Assent Form (see Appendix D), (c) Parent / Guardian Letter of Consent (see Appendix E), and (d) Research Participant Demographic Information Form (see Appendix F).

Inclusion Criteria

All participants met the following inclusion criteria: (a) male, (b) ages 8-12 years, (c) understood verbal instructions, (d) had the visual acuity to watch a computer monitor at a distance of 20 inches, (e) successfully complete a 5-point eye-tracking calibration procedure, (f) maintain proper body positioning during the eye-tracking procedure, and (g) visually attend to a 2-minute video of motor skill performances. This information was reported on the Research Participant Demographic Information Form.

Setting

This study took place at a university-based facility. Data were collected in two adjoining rooms that were identified as the Meeting Room and the Eye-Tracking Lab. Both rooms were interiorly located, away from daily distractions (i.e., main entrances, lobby areas, and classrooms) and had no natural lighting.

Meeting Room. The meeting room was a 16 x 13 feet carpeted area. The room consisted of a table and six chairs, a white board, a bookshelf, a small refrigerator, and an artificial plant (see Appendix G).

Eye-Tracking Lab. The eye-tracking lab was an 11 x 8.5 feet carpeted area. The eye-tracking lab consisted of a 5 x 1.5 feet table for the computer display monitor and recording laptop, two chairs without wheels, a small wooden bench, a filing cabinet, a floor lamp, and a small area rug. The room was sparsely decorated to minimize the chance of the participant's attention being drawn away from the visual display. All testing equipment (e.g., electrical cords, wires, computer devices, and recording materials) and supplies were discrete and secured during the testing procedure (see Appendix H).

To minimize distractions within the testing environment, the principal investigator's laptop served as a partition between the eye-tracking computer and the participant's computer monitor. Also, an 8.5 x 11-inch illustration of the motor skills performances was posted for the parent/caregiver to review and a small quiet reminder sign was posted in the lab (see Appendix I).

Equipment and Materials

Social Communication Questionnaire–Lifetime (SCQ). The SCQ is a brief assessment instrument designed to evaluate the communication skills and social functioning of children with and without autism. The SCQ offers a cost-effective means to determine if an individual should be referred for a complete diagnostic evaluation. The SCQ can be used to evaluate individuals over the age of 4.0 year, provided their mental age over 2.0 years. The SCQ is comprised of 40 yes-no questions and was completed by the parent/caregiver with supervision. Estimated time of complete <10 minutes (Rutter et al., 2003).

Vineland Adaptive Behavior Scales-Third Edition (VABS-3). The VABS-3 is a common assessment instrument used to measure personal and social skills for everyday living. The scales are divided into four domains-communication, daily living skills, socialization, physical activity. The VABS-3 can be administered to individuals from birth to 90 years of age. However, the VABS-3 Parent/Caregiver Form used in this experiment is designed for individuals between 3 and 21 years of age (Sparrow et al., 2016).

Eye-Tracker. The Tobii Pro X3-120 (Tobii Technology Inc., Stockholm, Sweden) (see Figure 9) is an ultra-slim screen-based eye-tracker that utilizes the corneal reflection eye-tracking method to record eye movement. The Tobii Pro X3-120 is discrete in design and has the following specifications: a sampling rate of 120 Hz; binocular tracking, a freedom head movement area of 50 cm x 90 cm 50 cm x 40 cm (19.7" x 15.7", with an operating distance of 50-90 cm (19.6-35.4"). Furthermore, the Tobii Pro X3-120 offers 2, 5, and 9-point calibration options.

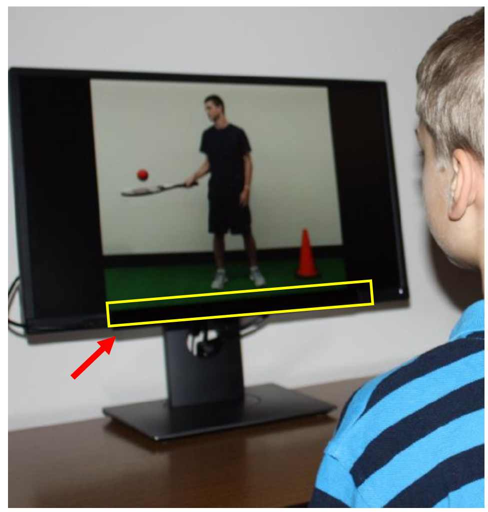

Figure 9. Photograph of the Tobii Pro X3-120 Remote Eye-tracker.

Eye-Tracking Analysis Software. The Tobii Studio Software was used with the Tobii Pro X3-120. The software platform presents the visual stimuli, records eye movement, and provides an analysis of eye tracking data.

Microsoft Office Software. Microsoft Word, Excel, and PowerPoint Software were used to create, analysis, and disseminate the findings of this study.

Video Editing Software. The Pinnacle Studio 18 Ultimate™ was used to edit the four motor skill performance videos (i.e., ball toss, basketball, soccer, and tennis) and to add the attentional highlight arrows.

Statistical Software. IBM SPSS Statistics Version 25 (IBM Corp, 2017) was used to analyze the data obtained from the study.

Display Monitor. Dell 22 Monitor (P2217H) had a viewable image size of 21.5", a maximum resolution of 1920 x 1080 at 60Hz, and a 16:9 aspect ratio. The display monitor also included adjustability features such as tilt, pivot, swivel, and a height-adjustable stand.

Laptop Computer. Dell Inspiron Convertible (2-in-1) 17.3-inch laptop was used in the investigation. The touch-screen laptop met the requirements needed to operate the Tobii Pro X3-120 eye-tracker and analysis software. The system included the Windows 10 operating system; 1920 x 1080 resolution; a 7th Gen Intel® Core™ i7-7500U mobile processor; 16GB system memory; 1TB hard drive, and an NVIDIA GeForce GTX 940MX graphics.

Video Camera. The Sony HDR-CX405 Handycam® with Exmor R® CMOS Sensor was used to record the motor skill performances. All video recordings took place inside a university classroom.

External Portable Hard Drive. The WD-My Passport Ultra 1TB External USB 3.0/2.0 Portable Hard Drive was used to protect and secure the data collected from the investigation. The device featured password protection and 256-bit AES encryption to safeguard the data.

Tripod. The BENRO T880EX Digital Video/Photo Tripod was used to stabilize the video recordings of the motor skill performances.

Turf-like Carpet. A 6 x 8 ft. green turf carpet was used to ensure consistency in the design of the video presentations for future research.

Tape Measure. A mini tape measure was used in the design of the lab to ensure the proper positioning of the participant during the collection of eye-tracking data (i.e., distance from the participant to eye-tracker and computer monitor).

Video Stimuli. Eight video clips of an adult model demonstrating four motor skill performances. Each video clip is detailed in the preliminary procedures of this chapter.

Visual Supports. Visual supports were readily available to assist the participants during the experiment, if necessary. The visual supports included a laminated picture of the Proper Positioning for the Eye-Tracker (see Appendix J), and handheld device to simulate the 5-point calibration procedure. The small handheld device was created by the principal investigator as a means to illustrate the 5-point calibration procedure (see Appendix K).

Sports Equipment. The sports equipment used to create the four video-modeled motor skill performances (i.e., ball toss, basketball, soccer, and tennis) included one 6-inch, red lightweight ball; one 9-inch, red playground ball; an adult size tennis racquet, and an 18-inch, orange, plastic cone.

Play Items. To provide a safe and welcoming environment, participants were provided a basket of items that included storybooks, coloring books, puzzles, toy cars, crayons, colored pencils, and markers. Each participant was given the opportunity to play with the toys while the parent/caregiver completed the consent/assent forms, demographic information sheet, and assessment questionnaires.

Gift Certificates. Thirty-five $15 gift cards were purchased and awarded to each participant at the completion of the visit.

Measures

Adaptive Behavior and Social Communication Measures. The following assessment instruments were used in the investigation to obtain measures of adaptive behavior, social communication, and to verify group membership.

1. Adaptive Behavior. Vineland Adaptive Behavior Scales, 3rd Edition (VABS-3) Parent/Caregiver Interview Form (Sparrow et al., 2016).
2. Social Communication. Social Communication Questionnaire–Lifetime (SCQ). Estimated time of completion <10 minutes (Rutter et al., 2003).

Eye-Tracking Measures. The Tobii Pro X3-120 Eye-Tracker and the Tobii Studio Software was used to collect and analyze the following eye-tracking measures:

1. Time to First Fixation – time in seconds to the first fixation (i.e., AOI).
2. Total Visit Duration – the duration of time in seconds spent within each AOI.
3. Visit Count – the number of visits and re-visits to an AOI.

Independent and Dependent Variables

This study examined two independent variables and three dependent variables.

Independent Variables:

1. Group (autism spectrum disorder and typically developing children).
2. Conditions (highlighted and non-highlighted videos).

Dependent Variables:

1. Time to First Fixation (TFF) is the measure of time (seconds) from the onset of a visual stimulus to the participant's first fixation to an AOI (Tobii Studio, 2016).
2. Total Visit Duration (TVD) measures the length of time (seconds) the eye attends to a specific area of the visual stimuli (Bergstrom & Schall, 2014). TVD has been recognized as one of the most widely used measures in eye-tracking research (Holmqvist et al., 2011).
3. Total Visit Count (VC) measures the number of visits and re-visits to an AOI. A visit ends when the eyes move outside the AOI (Tobii Studio, 2016).

Recruiting Procedure

Once IRB approval was obtained, educational settings and community-based programs (i.e., schools, clinical settings, recreational facilities, and community centers) were identified (see Appendix L and Appendix M). Both, educational-based and community-based programs expressing interest in supporting the investigation were contacted by the principal investigator and meetings were scheduled to discuss the details of the recruiting process. If agreed, written approval was obtained from the program director to publicize the study. In addition to the advertisement within the local community, flyers were posted throughout the university (see Appendix N), and email postings were distributed via an approved university resource.

Data Collection Procedure

Parents/caregivers that expressed interest in the study were contacted by the principal investigator. After a brief overview of the study and a description of the data collection procedure, appointments were scheduled and site directions were provided. Though the study was advertised as a one 30-minute visit, appointments were scheduled for 60 minutes to ensure enough time was allotted to complete the tasks (i.e., forms, questionnaires, and eye-tracking data collection). To ensure safe and successful data collection, the following protocol was established.

Parents/caregivers and the participant were greeted at the front of the building. After a brief introduction, the group was escorted to the second floor, and a tour of the meeting room and the eye-tracking lab was provided. The meeting was set up prior to the arrival room (see Figure 10). All forms, documents, and writing utensils were readily available. A small basket of play items (i.e., storybooks, coloring books, puzzles, toy cars, crayons, colored pencils, and markers) was placed on the table within reach of the participant. The eye-tracking lab was also set up prior to arrival. Seating arrangements for both the meeting room and eye-tracking lab were clearly identified prior to data collection (i.e., parents/caregivers, participant, and researcher). Data collection began in the meeting room. Upon entry, the participant was permitted to explore the basket of play items as the researcher provided the

Figure 10. Photo of the meeting room.

parent/caregiver an overview of the study and assistance with the completion of forms, documents, and the Social Communication Questionnaire (SCQ). Note: The Vineland-3 Adaptive Behavior Skills assessment was completed after the eye-tracking data were collected to shorten the wait time for the participant to enter the eye-tracking lab. Participants were assigned to a group (e.g., autism or typically developing group) and condition (e.g., highlighted or non-highlighted video group). For an overview of the data collection procedure see Appendix O. For example of the data collection form see Appendix P.

The following data collection protocol was established.

1. A presentation of the University of Southern Mississippi Institutional Approval Form and the University of Virginia IRB Authorization Agreement Form.
2. Summary and review of the University of Southern Mississippi Institutional Review Board (IRB) Parental Consent Form (parent/caregiver's signed consent attained).
3. Summary and review of the University of Southern Mississippi Institutional Review Board (IRB) Minor Assent Form (parent/caregiver's signed consent attained); and summary and review of the document in developmentally appropriate language to the participant (participant's signed assent attained).
4. Summary and review of the University of Virginia Parent - Letter of Consent (parent/caregiver has signed consent).
5. Research Participant Demographic Information Form (completed by the parent/caregiver).

6. Social Communication Questionnaire (SCQ) (completed by the parent/caregiver).
7. Eye-tracking Data Collection was completed by the participant in the eye-tracking lab with the parent/caregiver present.
8. Vineland Adaptive Behavior Scales™ – Third Edition (completed by the parent/caregiver).

Eye-Tracking Procedure

Upon entry to the eye-tracking lab (see Figure 11), the principal investigator reviewed the eye-tracking procedure and the seating arrangement. The participant was directed to the computer monitor and the parents/caregivers to the wooden bench approximately 5 feet behind the participant. The principal investigator sat at the end of the table in front of the laptop computer. Estimated time of the eye-tracking procedure was five minutes.

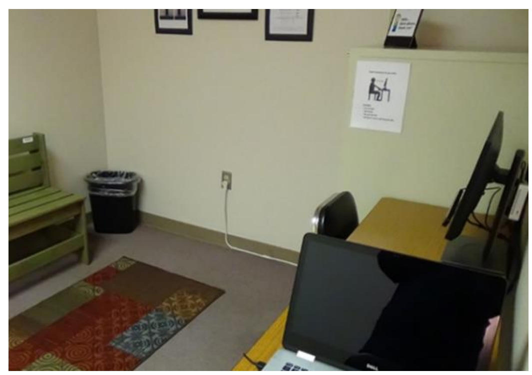

Figure 11. Photo of the eye-tracking lab.

The following eye-tracking data collection protocol was established.

1. The participant sat in a comfortable chair approximately 20 inches from the computer monitor. A visual task card was posted to the left of the participant. The card illustrated proper positioning during the eye-tracking procedure. The information was reviewed with the participant prior to calibration and the video presentation. The principal investigator: “Ok (name of participant) just a few reminders as you watch the video. Sit up straight, eyes forward, keep your head

still, and try not to move or talk during the video. Do you have any questions?" Waited for a reply.

2. Once the participant was properly positioned, the principal investigator reviewed the 5-point calibration procedure with the participant. The principal investigator: "Now, a red dot will appear and move across the screen. Do your best to follow the red dot with your eyes and try not to move your head." A demonstration was provided using the Eye-Tracking Calibration Simulator, a visual support created by the principal investigator. The calibration simulator was a handheld device made of a thin white board, a red dot, and two small magnets. The principal investigator could demonstrate the calibration procedure according to the needs of the participant. The principal investigator: "Remember, sit up straight, and keep your eyes forward and your head still. Try not to move or talk during the video. Ready, follow the red dot with your eyes." If a successful calibration was not attained after three attempts, the participant was provided a short break, positive reinforcement, and opportunity to try again. Once the eye-tracker was successfully calibrated, the participant was provided positive reinforcement and the experiment began. The principal investigator: "Nice job (name of participant), we are now ready to watch the video."
3. The principal investigator: "Please watch the screen carefully. Remember, sit up straight, and keep your eyes forward and your head still. Each video will play for 15 seconds and there are eight videos. The entire video presentation will only last 2 minutes. Also, when a plus sign (i.e., +) appears on the center of the screen,

please look at the letter and wait for the next video to begin. Do you have any questions? (questions addressed) Remember, try not to move or talk during the video. Ready begin." The video was then presented to the participant. The seating arrangement inside the eye-tracking lab permitted the principal investigator to monitor the participant, observe the parent/caregiver, and record the eye-tracking data.

4. Once the eye-tracking data were collected, the data were coded, and saved to the laptop computer and a password-protected external hard drive. The participant was provided positive reinforcement and a thank you for their time. The principal investigator: "Thank you (name of participant) nice job!"
5. The participant and the parent/caregiver were then escorted back to the meeting room and the parent/caregiver was asked to complete the Vineland-3 questionnaire. The principal investigator decided to separate the administration of the parent/caregiver questionnaires. Therefore, the Social Communication Questionnaire (SCQ) was administered prior to the eye-tracking procedure and the Vineland-3 (VABS-3) questionnaire was administered after the eye-tracking procedure. This format provided the parent/caregiver a short break in completing the documents. It also lessened the time the participant waited to attend to the eye-tracking task.
6. Upon completion of the VABS-3 questionnaire, the principal investigator reassured the parents/caregivers that all data would be secured and kept confidential. The principal investigator acknowledged the parental support; and

provided the participant with a Thank You Card that included a $15 gift card (see Appendix Q). The principal investigator then escorted the group to the main entrance of the building.

Phase III: Data Analysis

Overview

Data were collected on age, social-communicative measures, three adaptive behavior measures (i.e., communication, daily living skills, and social behavior) and three eye-tracking metrics. The eye-tracking metrics included: (a) time to first fixation, (b) total visit duration, and (c) visit count. All data were collected, coded, and secured in SPSS Version 25.

Statistical Assumptions

Prior to the comparison of group means, the following statistical assumptions were assessed to determine the appropriateness of conducting a parametric or non-parametric data analyses: (a) independence, (b) continuous variables, (c) normality, and (d) homogeneity of variance. Normality was assessed through visual inspection of skewness and kurtosis, histograms, and the Shapiro-Wilk test (Shapiro & Wilk, 1965). Equality of variance was determined by the Levene's test ($p > .05$) (Levene, 1960; Nordstokke & Zumbo, 2010; Nordstokke, Zumbo, Cairnes, & Saklofske, 2011). Boxplots and Normal Q-Q plots were also examined to identify outliers within the data set. Outliers were defined as scores exceeding three or more standard deviations from the mean.

Data Analysis

Group comparisons that met the statistical assumptions were examined by using parametric data analyses (i.e., independent samples *t*-tests). Group comparisons that did not meet the assumptions were analyzed using non-parametric data analyses, (i.e., Mann-Whitney *U* test). According to Carver and Nash (2011), the Mann-Whitney *U* test is a non-parametric version of the independent samples *t*-test. Unlike the independent samples *t*-test, the Mann-Whitney *U* test does not assume a normal distribution or homogeneity of variance.

To quantify the differences between the group means, measures of effect size were reported as Hedge's *g* (Hedges & Olkin, 1985) for independent samples *t*-tests and Cohen's (1988) for the Mann-Whitney *U* tests. Effect sizes were measured and interpreted accordingly: (a) Hedge's *g* effect size measures - small [0.2], medium [0.5], and large [0.8]; and (b) *r* effect size measures - small [0.10], medium [0.30], and large [0.50] (Cohen, 1988, p. 532). Hedge's *g* and Cohen's *d* are similar measures of effect size for small samples ($n < 20$) (Lakens, 2013) and unequal sample sizes (Safran et al., 2012).

Four-Step Preliminary Analysis of the Eye-Tracking Data

A four-step preliminary analysis was conducted for each of the eye-tracking metrics: (1) time to first fixation (seconds), (2) total visit duration (seconds), and (3) visit count (number). The purpose of the preliminary analysis was to examine and prepare the data for further analyses. Due to the small sample size and widespread variability amongst the data, the preliminary analysis was conducted to increase the "*n*" and to reduce the variability amongst all the data sets (i.e., videos A through D). An overview of the four-step preliminary analysis is shown in Table 6 and is followed by a brief description of each step of the preliminary analysis.

Table 6. *Overview of the four-step preliminary analysis*

Step 1. Videos analyzed in the order as presented to the participant.

	Block 1				Block 2			
Video A (NH) ASD (*n*=3); TD (*n*=6)	BB	SOC	TEN	BT	SOC	BB	BT	TEN
Video B (NH) ASD (*n*=4); TD (*n*=5)	TEN	BT	BB	SOC	BT	TEN	SOC	BB
Video C (H) ASD (*n*=3); TD (*n*=5)	SOC	TEN	BT	BB	TEN	SOC	BB	BT
Video D (H) ASD (*n*=3); TD (*n*=4)	BT	BB	SOC	TEN	BB	BT	TEN	SOC

Step 2. Videos analyzed by order of the motor skill performances.

Video A (NH) ASD (*n*=3); TD (*n*=6)	BT_1	BT_2	BB_1	BB_2	SOC_1	SOC_2	TEN_1	TEN_2
Video B (NH) ASD (*n*=4); TD (*n*=5)	BT_1	BT_2	BB_1	BB_2	SOC_1	SOC_2	TEN_1	TEN_2
Video C (H) ASD (*n*=3); TD (*n*=5)	BT_1	BT_2	BB_1	BB_2	SOC_1	SOC_2	TEN_1	TEN_2
Video D (H) ASD (*n*=3); TD (*n*=4)	BT_1	BT_2	BB_1	BB_2	SOC_1	SOC_2	TEN_1	TEN_2

Step 3. Collapsed by motor skill performances (BT1 + BT2 = BT).

Video A (NH) ASD (*n*=6); TD (*n*=12)	BT	BB	SOC	TEN
Video B (NH) ASD (*n*=8); TD (*n*=10)	BT	BB	SOC	TEN
Video C (H) ASD (*n*=6); TD (*n*=10)	BT	BB	SOC	TEN
Video D (H) ASD (*n*=6); TD (*n*=8)	BT	BB	SOC	TEN

Step 4. Collapsed by conditions (videos A + B = NH / C+D = H).

Non-Highlighted Condition (NH)	BT	BB	SOC	TEN
ASD (*n*=14)	1.466	1.334	1.753	1.025
TD (*n*=22)	0.069	0.306	0.369	0.360
Highlighted Condition (H)				
ASD (*n*=12)	0.365	0.488	0.903	0.495
TD (*n*=18)	0.123	0.404	0.432	0.354

Note. TFF measures are in seconds; BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; ASD-autism spectrum disorder, TD-typically development; and NH-non-highlighted video, H-highlighted video.

The Four-Step Preliminary Analysis

Step 1. Videos analyzed in the order as presented to the participant.

Explanation: The raw data of the eight motor skill performances were examined as they were presented to the participant during the experiment (e.g., two blocks in a randomized order) (see Table 7). Descriptive statistics and graphic illustrations were inspected to determine if order effect influenced the group means. For example, a trend in the data that may have evidenced boredom or fatigue in watching the videos over a 2-minute period.

Table 7. *Step 1. Videos analyzed in the order as presented to the participant*

	Block 1				Block 2			
Video A (NH) ASD (*n*=3); TD (*n*=6)	BB	SOC	TEN	BT	SOC	BB	BT	TEN
Video B (NH) ASD (*n*=4); TD (*n*=5)	TEN	BT	BB	SOC	BT	TEB	SOC	BB
Video C (H) ASD (*n*=3); TD (*n*=5)	SOC	TEN	BT	BB	TEN	SOC	BB	BT
Video D (H) ASD (*n*=3); TD (*n*=4)	BT	BB	SOC	TEN	BB	BT	TEN	SOC

Note. BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; ASD-autism spectrum disorder, TD-typically development; and NH-non-highlighted video, H-highlighted video. *Step 1 – videos were analyzed in the order as presented to the participant (*n* = number of participants).

Step 2. Videos analyzed by order of the motor skill performances.

Explanation: The raw data of the eight motor skill performances were examined with the motor skill performances presented in the following order: BT1, BT2; BB1, BB2; SOC1, SOC2; and TEN1, TEN2 (see Table 8). Descriptive statistics and graphic illustrations were inspected to determine if order effect influenced the group means. For example, a trend in the data that may have evidenced boredom or fatigue in watching the videos over a 2-minute period.

Table 8. *Step 2. Videos analyzed by order of the motor skill performances*

Video A (NH) ASD (*n*=3); TD (*n*=6)	BT_1	BT_2	BB_1	BB_2	SOC_1	SOC_2	TEN_1	TEN_2
Video B (NH) ASD (*n*=4); TD (*n*=5)	BT_1	BT_2	BB_1	BB_2	SOC_1	SOC_2	TEN_1	TEN_2
Video C (H) ASD (*n*=3); TD (*n*=5)	BT_1	BT_2	BB_1	BB_2	SOC_1	SOC_2	TEN_1	TEN_2
Video D (H) ASD (*n*=3); TD (*n*=4)	BT_1	BT_2	BB_1	BB_2	SOC_1	SOC_2	TEN_1	TEN_2

Note. BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; ASD-autism spectrum disorder, TD-typically development; and NH-non-highlighted video, H-highlighted video. *Step 2 – videos were analyzed by order of the motor skill performance (*n* = number of participants).

Step 3. Collapsed by motor skill performances ($BT_1 + BT_2 = BT$).

Explanation: To increase the (*n*) and reduce the variability of the data sets, the raw data (i.e., time measured in seconds) of each motor skill performance was collapsed into a single item. For example, BT_1 and BT_2 were collapsed into the single category. As a result of this step, four motor skill performances (i.e., BT, BB, SOC, and TEN) were identified (see Table 9).

Table 9. *Step 3. Collapsed by motor skill performances ($BT_1 + BT_2 = BT$)*

Video A (NH) ASD (*n*=6); TD (*n*=12)	BT	BB	SOC	TEN
Video B (NH) ASD (*n*=8); TD (*n*=10)	BT	BB	SOC	TEN
Video C (H) ASD (*n*=6); TD (*n*=10)	BT	BB	SOC	TEN
Video D (H) ASD (*n*=6); TD (*n*=8)	BT	BB	SOC	TEN

Note. BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; ASD-autism spectrum disorder, TD-typically development; and NH-non-highlighted video, H-highlighted video. *Step 3 – videos were collapsed by motor skill performances (*n* = total number of observations).

Step 4. Collapsed by condition (videos A + B = NH and C + D = H).

Explanation: The raw data of videos A & B (non-highlighted) were collapsed and videos C & D (highlighted) were collapsed to create two conditions (i.e., non-highlighted and highlighted) conditions for each group (i.e. ASD and TD). As a result of this step, four groups were identified and coded accordingly: (a) ASD non-highlighted condition (ASD-NH) (*n* = 14), (b) TD non-highlighted condition (TD-NH) (*n* = 22), (c) ASD highlighted condition (ASD-H) (*n* = 12), and (d) TD highlighted condition (TD-H) (*n* = 18) (see Table 10).

Table 10. *Step 4. Collapsed by condition (videos A + B = NH and C + D = H)*

Non-Highlighted Condition (NH)	BT	BB	SOC	TEN
ASD (*n*=14)	1.466	1.334	1.753	1.025
TD (*n*=22)	0.069	0.306	0.369	0.360
Highlighted Condition (H)				
ASD (*n*=12)	0.365	0.488	0.903	0.495
TD (*n*=18)	0.123	0.404	0.432	0.354

Note. BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; ASD-autism spectrum disorder, TD-typically development; and NH-non-highlighted video, H-highlighted video. *Step 4 – videos were collapsed by condition (*n* = total number of observations).

Note. The four-step preliminary analysis was performed for each eye-tracking metrics (i.e., time to first fixation, total visit duration, and visit count). Findings of preliminary analyses are presented as written summaries, tables, and graphic illustrations. To reduce the number of tables and graphic illustrations in the next chapter, the four-step preliminary analyses for Time to First Fixation, Total Visit Duration, and Visit Count are presented in the Appendices. For Time to First Fixation, see Appendix R, Total Visit Duration see Appendix S and Visit Count see Appendix T.

CHAPTER IV: RESULTS

Eye-tracking is a technique that provides a robust quantitative measure of where someone is visually attending (Shic, 2013). Visual attention is defined as the narrow high-resolution field of foveal vision often measured in eye-tracking research. Common measures of visual attention include time to first fixation (TFF), total visit duration (TVD), and visit count (VC) (Tobii Studio, 2016). The purpose of this study was to compare the visual attention patterns of children with autism to typically developing children as they observed video-modeled demonstrations of four motor skill performances. Understanding the visual attention patterns of children with autism may lead to more innovative ideas in the design, creation, and presentation of video-modeled motor skill performances.

This chapter is divided into the following sections: (a) statistical assumptions, (b) descriptive statistics, and (c) results related to time to first fixation (TFF), total visit duration (TVD), and visit count (VC). The findings of this investigation are presented as written summaries, tables, and graphic illustrations.

Statistical Assumptions

Prior to mean group comparisons, Boxplots, and Normal Q-Q plots were examined to identify outliers within the data sets. Outliers were defined as scores exceeding three or more standard deviations from the mean. The results of this investigation indicated no outliers were identified in the data (i.e., scores that exceed three or more standard deviations from the mean). The following statistical assumptions were also assessed to determine the appropriateness of conducting a parametric or non-parametric data analyses. The assumptions included: (a) independence, (b) continuous variables, (c) normality, and (d) homogeneity of variance.

The first two assumptions (i.e., independence and continuous variables) were met by research design (e.g., the study included two independent groups, random sampling, and the data collected were on a continuous scale). Normality was assessed by visual inspection of skewness and kurtosis, histograms, and the Shapiro-Wilk test (Shapiro & Wilk, 1965); and homogeneity of variance was assessed by the Levene's test (Levene, 1960).

Throughout this investigation, mean group comparisons that met the statistical assumptions for parametric data analysis (i.e., independent samples *t*-test) are indicated by a superscript ([a]). Henceforth, mean group comparisons that did not meet the assumptions for a parametric data analysis were analyzed by a non-parametric analysis (i.e., Mann-Whitney *U* test). According to Carver and Nash (2011), the Mann-Whitney *U* test is a non-parametric version of the independent samples *t*-test. Unlike the independent samples *t*-test, the Mann-Whitney *U* test does not assume a normal distribution or homogeneity of variance.

Due to the number of multiple comparisons made in this investigation, the *p*-value was adjusted to .01. According to Armstrong (2014), when several dependent or independent statistical tests are performed on a single data set, *p*-values are often adjusted to decrease the likelihood of making a type I error (e.g., a false-positive or rejecting the null hypothesis when it is true).

Descriptive Statistics

Thirty-five children participated in the study. All participants were male and ranged between the ages of 8-12 years. The ASD group was comprised of 14 participants diagnosed with autism spectrum disorder, and the TD was comprised of 21 participants identified as typically developing children. With regard to race and ethnicity, 94% of the participants were Caucasian (*n* = 33), 3% were African-American (*n* = 1), and 3% were Asian (*n* = 1). All participants met the following inclusion criteria: (a) male, (b) ages 8-12 years, (c) could comprehend verbal instructions, (d) had the visual acuity to watch a computer monitor at a distance of 20 inches, (e) successfully completed a 5-point eye-tracking calibration procedure, (f) maintained proper body positioning during the eye-tracking procedure, and (g) could visually attend to a 2-minute video of motor skill performances. No participants were eliminated from the study based on the inclusion criteria.

Chronological age

For the purpose of establishing the ASD (*n* = 14) and TD (*n*=21) groups, between-group comparisons were made on chronological age, social communication, and adaptive behavior to identify similarities and differences between the groups. As for chronological age, results of an independent samples *t*-test indicated no statistically significant differences were found between the ASD group (M = 10.32, SD = 1.06) and the TD group (M = 10.47, SD = 1.45), t (33) = .35, p = .732.

Social Communication Questionnaire (SCQ)

Results of the Mann-Whitney *U* test indicated a statistically significant difference between the ASD group (M = 23.43, SD = 8.35) and the TD group (M = 4.52, SD = 4.05), U = 15.50, Z = - 4.437, p < .001. The higher mean score of the ASD group indicated greater deficits in social communication.

Vineland Adaptive Behavior Scale-3 (VABS-3)

For the VABS-3, results indicated statistically significant differences between the ASD and TD groups across all three adaptive behavior measures (i.e., communication, daily living skills, and social skills). As for communication, the results of an independent samples *t*-test indicated the ASD group (M = 68.86, SD = 18.84) had a significantly lower mean score than the TD group (M = 102.86, SD = 12.32), t (33) = 6.47, p < .001. Unlike the SCQ assessment item, lower mean scores on the VABS-3 assessment item indicate greater deficits in adaptive behavior.

For daily living skills, the results of an independent samples *t*-test indicated the ASD group (M = 68.43, SD = 20.92) had a statistically significant lower mean score (i.e., greater deficits with daily living skills) than the TD group (M = 103.76, SD = 16.47), t (33) = 5.58, p < .001. As for social skills, the Shapiro-Wilk tests indicated that the null hypothesis of a normal distribution could not be assumed for the TD groups (p = .030). For this reason, the Mann-Whitney *U* test was used to compare the groups. Results of the Mann-Whitney *U* test indicated the ASD group (M = 66.00, SD = 20.84) had a statistically significant lower mean score than the TD (M = 99.10, SD = 15.14), U = 23.50, Z = - 4.162, p < .001. For a summary of results, see Table 11.

Table 11. *Descriptive Statistics Means and Standard Deviations*

	ASD Group (n = 14)		TD Group (n = 21)				
	Mean (*SD*)	Range	Mean (*SD*)	Range	*U / t*	*Z / df*	*p*
Chronological age	10.32 (1.06)	8-12 yrs.	10.47 (1.45)	8-12 yrs.	0.35	33	.732
VABS-3 Communication	68.86 (18.84)	26-107	102.86 (12.32)	81-121	6.47	33	< .001*
VABS-3 Daily Living	68.43 (20.92)	33-115	103.76 (16.47)	79-140	5.58	33	< .001*
VABS-3 Social Skills	66.00 (20.84)	28-109	99.10 (15.14)	82-139	23.50	-4.162	< .001*
SCQ	23.43 (8.35)	2-33	4.52 (4.05)	0-15	15.50	-4.437	< .001*
Race and Ethnicity: 31 Caucasian, 1 Asian, and 1 African-American.							

Note. Standard deviations are in parentheses.
*Significant at $p < .05$.

Initially, thirty-five children participated in the study. However, two participants were excluded from the investigation for the following reasons. One participant from the TD group deviated from the established protocol (e.g., admitted to intentionally looking at the center of the screen throughout the experiment). After visual inspection of the participant's eye-tracking data, the principal investigator confirmed increased fixations to the center of the screen throughout the recording. For this reason, this participant's data were not included in the analysis.

Also, one participant from the ASD group was excluded from the investigation. While the participant adhered to the established protocol and visually attended to the video, this participant's eye-tracking data were not recorded for some unknown reason. The technical issue may have been due to a unique goggle-type corrective eyewear worn by the participant during the experiment. As a result of these events, a total of 33 children participated in this investigation. Thirteen participants were diagnosed with ASD, and 20 participants were identified as typically developing children.

Preliminary Analysis of the Eye-Tracking Data

A preliminary analysis was conducted on each of the eye-tracking metrics: (a) time to first fixation, (b) total visit duration, and (c) visit count. The purpose of the preliminary analysis was to examine the impact of the small sample sizes and to determine how to best increase the *n* and reduce the variability amongst the data. For a detailed summary of the preliminary analysis for time to first fixation see Appendix R; for total visit duration see Appendix S; and for visit count see Appendix T.

Summary of Results for Time to First Fixation (TFF)

Time to First Fixation (TFF)

Time to First Fixation (TFF) is the measure of time (seconds) from the onset of a visual stimulus to the participant's first fixation to an area of interest (AOI) (Tobii Studio, 2016). AOIs are defined regions from which quantitative data are collected (Holmqvist et al., 2011). In this investigation, three AOIs (i.e., action, cone, and head) were built into each of the motor skill performance videos. Quantitative data from the AOIs were collected and analyzed to address the following research questions:

RQ 1: During the presentation of a motor skill performance, how does the group mean TFF (seconds) of children with autism compare to typically developing children?

H_0: There are no differences in the group mean TFF (seconds) of children with autism when compared to typically developing children.

RQ 2: During the presentation of a motor skill performance, how does the group mean TFF (seconds) of the non-highlighted condition compare to the highlighted condition?

H_0: There are no differences in the group mean TFF (seconds) between the non-highlighted and highlighted conditions.

Note. All mean group comparisons for TFF are summarized in Table 12. Written summaries, tables, and graphic illustrations are provided for the following group comparisons: (a) ASD-NH and TD-NH, (b) ASD-H and TD-H, (c) ASD-NH and ASD-H, and (d) TD-NH and TD-H. See Appendix R for the preliminary analysis for TFF.

Summary of Results for Time to First Fixation (TFF)

Table 12. *Summary of Results for Time to First Fixation (TFF)*

Motor Skills	ASD-NH (*n* =14)	TD-NH (*n*=22)	*diff.*	*U* / *t*	*Z* / *df*	*p*	*ES* [b c]
BT	1.466 (3.287)	0.069 (0.121)	+1.397	89.0	-2.126	.033	0.354[c]
BB	1.334 (1.634)	0.306 (0.159)	+1.028	93.0	-1.981	.048	0.330[c]
SOC	1.753 (2.511)	0.369 (0.113)	+1.384	96.5	-1.590	.112	0.265[c]
TEN	1.025 (2.241)	0.360 (0.111)	+0.665	149.0	-0.162	.871	0.027[c]
	ASD-H (*n*=12)	TD-H (*n*=18)					
BT	0.365 (0.419)	0.123 (0.215)	+0.242	56.0	-2.322	.020	0.424[c]
BB	0.488 (0.442)	0.404 (0.257)	+0.084	96.0	-0.508	.611	0.093[c]
SOC	0.903 (1.158)	0.432 (0.280)	+0.471	106.5	-0.064	.949	0.012[c]
TEN	0.495 (0.257)	0.354 (0.128)	+0.141	66.0	-1.780	.075	0.325[c]
	ASD-NH (*n*=14)	ASD-H (*n*=12)					
BT	1.466 (3.287)	0.365 (0.419)	+1.101	72.5	-0.306	.759	0.060[c]
BB	1.334 (1.634)	0.488 (0.442)	+0.846	65.0	-0.978	.328	0.192[c]
SOC	1.753 (2.511)	0.903 (1.158)	+0.850	63.0	-0.816	.414	0.160[c]
TEN	1.025 (2.241)	0.495 (0.257)	+0.530	65.5	-0.952	.341	0.187[c]
	TD-NH (*n*=22)	TD-H (*n*=18)					
BT	0.069 (0.121)	0.123 (0.215)	-0.054	178.0	-0.653	.514	0.103[c]
BB	0.306 (0.159)	0.404 (0.257)	-0.098	168.5	-0.803	.422	0.127[c]
SOC	0.369 (0.113)	0.432 (0.280)	-0.063	185.0	-0.354	.723	0.056[c]
TEN	0.360 (0.111)	0.354 (0.128)	+0.006	176.0	-0.599	.549	0.095[c]

Note. TFF measures are in seconds; Standard deviations are in parentheses; *diff.* = between group mean differences; Motor skills performances: BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; Groups: ASD-NH = ASD-non-highlight, TD-NH = TD-non-highlight, ASD-H = ASD-highlight, TD-H = TD-highlight. *Significant $p < .01$.
[a] = p-value computed by the independent samples t-test.
[b] = Hedge's g for an independent samples t-test (small=0.2, medium=0.5, large=0.8)
[c] = Cohen's for a Mann-Whitney U test (small=0.1, medium=0.3, large=0.5)

Non-Highlighted ASD and TD Group Comparisons for TFF

With regard to Time to First Fixation (TFF), results indicated that the ASD-NH group (n = 14) had a higher group mean than the TD-NH group (n = 22) across all four motor skill performances. The higher group mean indicated longer durations (e.g., slower time) to the first fixation for the ASD-NH group.

Results of the Mann-Whitney U test analyses indicated the following: For BT, the ASD-NH group (M = 1.466) was higher than the TD-NH group (M = 0.069), U = 89.0, Z = -2.126, p = .033, and Cohen's (1988) indicated a medium effect size, r = 0.354. For BB, the ASD-NH group (M = 1.334) was higher than the TD-NH group (M = 0.306), U = 93.0, Z = -1.981, p = .048; and a medium effect size, r = 0.330. For SOC, the ASD-NH group (M = 1.753) was higher than the TD-NH group (M = 0.369), U = 96.5, Z = -1.590, p = .112, and a small effect size, r = 0.265. For TEN, the ASD-NH group (M = 1.025) was higher than the TD-NH group (M = 0.360), U = 149.0, Z = - 0.162, p = .871, and no meaningful effect size was found, r = 0.027.

Results indicated there were no statistically significant differences in TFF between the ASD and TD groups in the non-highlighted condition. All p-values were greater than .01. Based on these findings, the null hypothesis could not be rejected. However, measures of effect size indicated small to medium effect sizes for three of the four motor skill performances. A summary of results are shown in Table 13 and graphically illustrated in Figure 12.

Table 13. *Non-Highlighted ASD and TD Group Comparisons for TFF*

Motor Skills	ASD-NH (*n* =14)	TD-NH (*n*=22)	*diff.*	*U / t*	*Z / df*	*p*	*ES* [b c]
BT	1.466 (3.287)	0.069 (0.121)	+1.397	89.0	-2.126	.033	0.354[c]
BB	1.334 (1.634)	0.306 (0.159)	+1.028	93.0	-1.981	.048	0.330[c]
SOC	1.753 (2.511)	0.369 (0.113)	+1.384	96.5	-1.590	.112	0.265[c]
TEN	1.025 (2.241)	0.360 (0.111)	+0.665	149.0	-0.162	.871	0.027[c]

Note. TFF measures are in seconds; Standard deviations are in parentheses; *diff.* = between group mean differences; Motor skills performances: BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; Groups: ASD-NH = ASD-non-highlight, TD-NH = TD-non-highlight, ASD-H = ASD-highlight, TD-H = TD-highlight. *Significant $p < .01$.

[a] = p-value computed by the independent samples t-test.

[b] = Hedge's g for an independent samples t-test (small=0.2, medium=0.5, large=0.8)

[c] = Cohen's for a Mann-Whitney U test (small=0.1, medium=0.3, large=0.5)

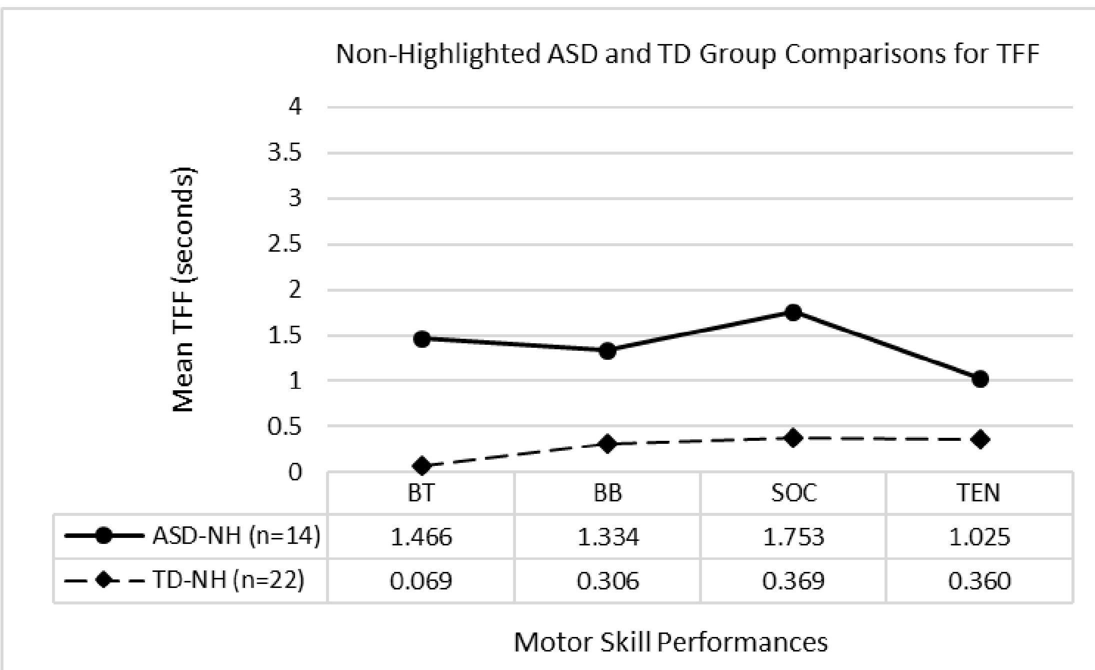

Figure 12. Non-Highlighted ASD and TD Group Comparisons for TFF.

Highlighted ASD and TD Group Comparisons for TFF

With regard to Time to First Fixation (TFF), results indicated that the ASD-H group ($n = 12$) had a higher group mean than the TD-H group ($n = 18$) across the four motor skill performances. The higher group mean indicated longer durations (e.g., slower time) to the first fixation for the ASD-H group. No statistically significant differences ($p < .01$) were reported between the groups for TFF across the four motor skill performances.

Results of the Mann-Whitney *U* test analyses indicated the following: For BT the ASD-H group ($M = 0.365$) was higher than the TD-H group ($M = 0.123$), $U = 56.0$, $Z = -2.322$, $p = .020$, and Cohen's (1988) indicated a medium effect size, $r = 0.424$. For BB, the ASD-H group ($M = 0.488$) was slightly higher than the TD-H group ($M = 0.404$), $U = 96.0$, $Z = -0.508$, $p = .611$, no meaningful effect size was found, $r = 0.093$. For SOC, the ASD-H group ($M = 0.903$) was higher than the TD-H group ($M = 0.432$), $U = 106.5$, $Z = -0.064$, $p = .949$, no meaningful effect size was found, $r = 0.012$. For TEN, the ASD-NH group ($M = 0.495$) was higher than the TD-H group ($M = 0.354$), $U = 66.0$, $Z = -1.780$, $p = .075$, and a medium effect size, $r = 0.325$.

Results indicated there were no statistically significant differences in TFF between the ASD and TD groups in the highlighted condition. All *p*-values were greater than .01. Based on these findings, the null hypothesis could not be rejected. However, measures of effect size indicated medium effect sizes for two of the four motor skill performances. A summary of results are shown in Table 14 and graphically illustrated in Figure 13.

Table 14. *Highlighted ASD and TD Group Comparisons for TFF*

Motor Skills	ASD-H (*n*=12)	TD-H (*n*=18)	*diff.*	*U / t*	*Z / df*	*p*	*ES* [b c]
BT	0.365 (0.419)	0.123 (0.215)	+0.242	56.0	-2.322	.020	0.424[c]
BB	0.488 (0.442)	0.404 (0.257)	+0.084	96.0	-0.508	.611	0.093[c]
SOC	0.903 (1.158)	0.432 (0.280)	+0.471	106.5	-0.064	.949	0.012[c]
TEN	0.495 (0.257)	0.354 (0.128)	+0.141	66.0	-1.780	.075	0.325[c]

Note. TFF measures are in seconds; Standard deviations are in parentheses; *diff.* = between group mean differences; Motor skills performances: BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; Groups: ASD-NH = ASD-non-highlight, TD-NH = TD-non-highlight, ASD-H = ASD-highlight, TD-H = TD-highlight. *Significant $p < .01$.
[a] = p-value computed by the independent samples t-test.
[b] = Hedge's g for an independent samples t-test (small=0.2, medium=0.5, large=0.8)
[c] = Cohen's for a Mann-Whitney U test (small=0.1, medium=0.3, large=0.5)

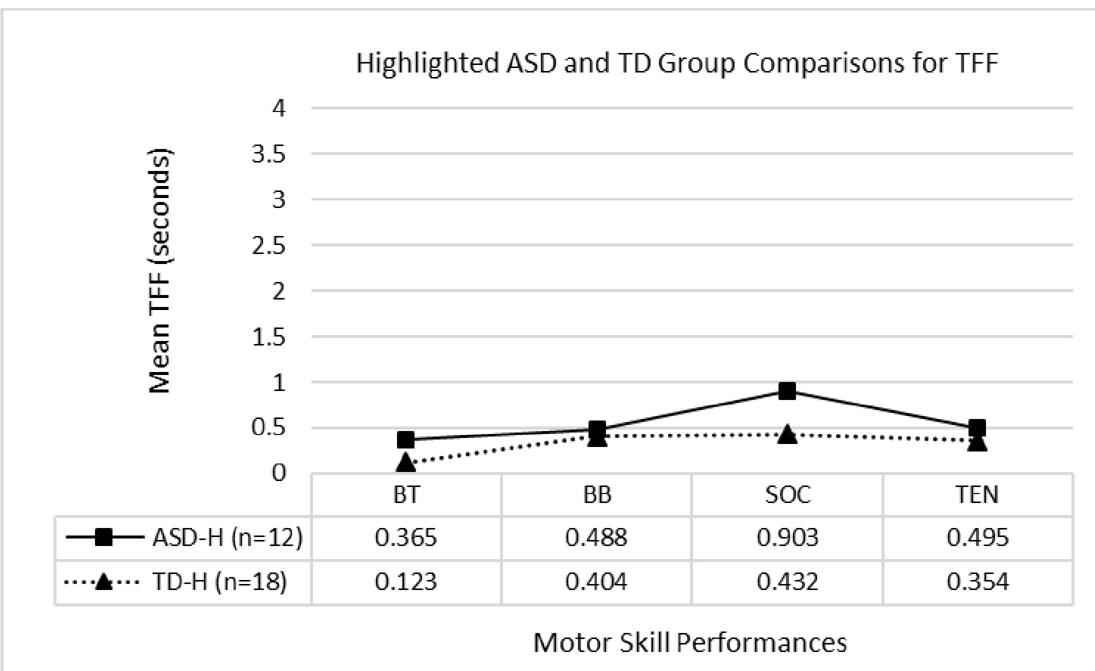

Figure 13. Highlighted ASD and TD Group Comparisons for TFF.

Non-Highlighted and Highlighted ASD Group Comparisons for TFF

With regard to Time to First Fixation (TFF), results indicated that the ASD-NH group (n = 14) had a higher group mean than the ASD-H group (n = 12) across the four motor skill performances. The higher group means indicated longer durations (e.g., slower times) to the first fixation for the ASD-NH group.

Results of the Mann-Whitney *U* test analyses indicated the following: For BT the ASD-NH group (M = 1.466) was higher than the ASD-H group (M = 0.365), U = 72.5, Z = -0.306, p = .759, and Cohen's (1988) indicated no meaningful effect size, r = 0.060. For BB, the ASD-NH group (M = 1.334) was higher than the ASD-H group (M = 0.488), U = 65.0, Z = -0.978, p = .328, and a small effect size, r = 0.192. For SOC, the ASD-NH group (M = 1.753) was higher than the ASD-H group (M = 0.903), U = 63.0, Z = -0.816, p = .414, and a small effect size, r = 0.160. For TEN, the ASD-NH group (M = 1.025) was higher than the ASD-H group (M = 0.495), U = 65.5, Z = -0.952, p = .341, and a small effect size, r = 0.187.

Results indicated there were no statistically significant differences in TFF between the non-highlighted and highlighted ASD groups. All p-values were greater than .01. Based on these findings, the null hypothesis could not be rejected. However, measures of effect size indicated small effect sizes for three of the four motor skill performances. A summary of results are shown in Table 15 and graphically illustrated in Figure 14.

Table 15. *Non-Highlighted and Highlighted ASD Group Comparison for TFF*

Motor Skills	ASD-NH (*n*=14)	ASD-H (*n*=12)	*diff.*	*U / t*	*Z / df*	*p*	*ES* [b c]
BT	1.466 (3.287)	0.365 (0.419)	+1.101	72.5	-0.306	.759	0.060[c]
BB	1.334 (1.634)	0.488 (0.442)	+0.846	65.0	-0.978	.328	0.192[c]
SOC	1.753 (2.511)	0.903 (1.158)	+0.850	63.0	-0.816	.414	0.160[c]
TEN	1.025 (2.241)	0.495 (0.257)	+0.530	65.5	-0.952	.341	0.187[c]

Note. TFF measures are in seconds; Standard deviations are in parentheses; *diff.* = between group mean differences; Motor skills performances: BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; Groups: ASD-NH = ASD-non-highlight, TD-NH = TD-non-highlight, ASD-H = ASD-highlight, TD-H = TD-highlight. *Significant $p < .01$.

[a] = *p*-value computed by the independent samples *t*-test.

[b] = Hedge's *g* for an independent samples *t*-test (small=0.2, medium=0.5, large=0.8)

[c] = Cohen's for a Mann-Whitney *U* test (small=0.1, medium=0.3, large=0.5)

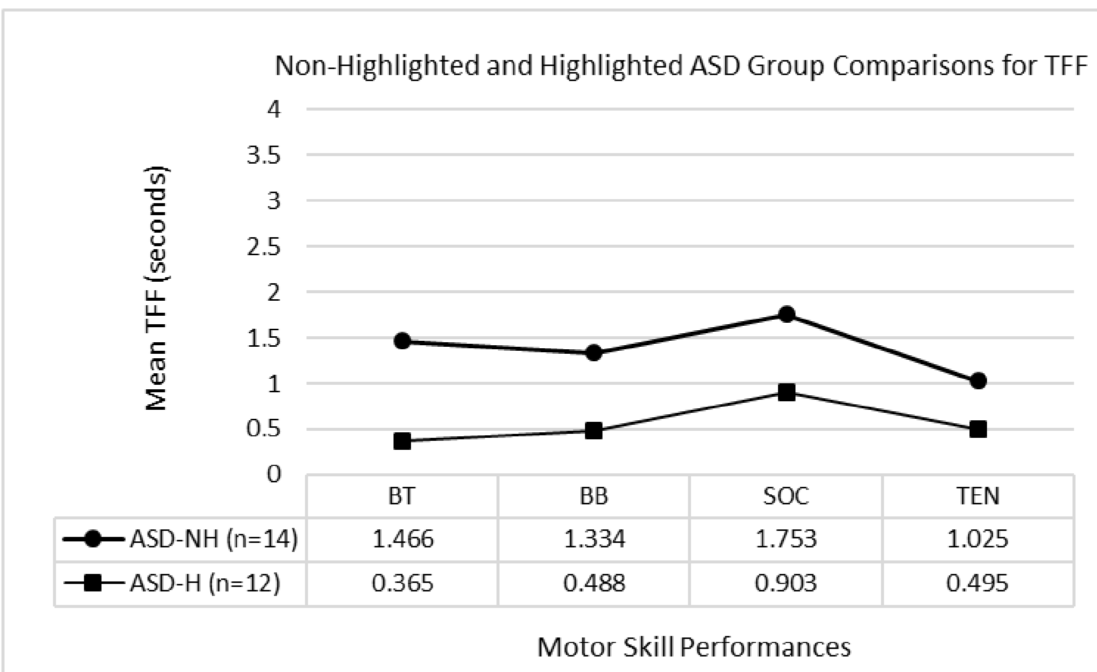

Figure 14. Non-Highlighted and Highlighted ASD Group Comparisons for TFF.

Non-Highlighted and Highlighted TD Group Comparisons for TFF

With regard to Time to First Fixation (TFF), results indicated that the TD-NH group (n =22) had a lower group mean than the TD-H group (n = 18) on three of the four motor skill performances (i.e., BT, BB, and SOC). The lower group means indicated shorter durations (e.g., faster times) to the first fixation for the TD-NH group.

Results of the Mann-Whitney U test indicated the following: For BT the TD-NH group (M = 0.069) was lower than the TD-H group (M = 0.123), U = 178.0, Z = -0.653, p = .514, and Cohen's (1988) indicated a small effect size, r = 0.103. For BB, the TD-NH group (M = 0.306) was lower than the TD-H group (M = 0.404), U = 168.5, Z = -0.803, p = .422, and a small effect size, r = 0.127. For SOC, the TD-NH group (M = 0.369) was lower than the TD-H group (M = 0.432), U = 185.0, Z = -0.354, p = .723, and no meaningful effect size was found, r = 0.056. For TEN, the TD-NH group (M = 0.360) was slightly higher than the TD-H group (M = 0.354), U = 176.0, Z = -0.599, p = .549, and no meaningful effect size was found, r = 0.095.

Results indicated there were no statistically significant differences in TFF between the non-highlighted and highlighted TD groups. All p-values were greater than .01. Based on these findings, the null hypothesis could not be rejected. However, measures of effect size indicated small effect sizes for two of the four motor skill performances. A summary of results are shown in Table 16 and graphically illustrated in Figure 15.

Table 16. *Non-Highlighted and Highlighted TD Group Comparisons for TFF*

Motor Skills	TD-NH (*n*=22)	TD-H (*n*=18)	*diff.*	*U / t*	*Z / df*	*p*	*ES* [b c]
BT	0.069 (0.121)	0.123 (0.215)	-0.054	178.0	-0.653	.514	0.103[c]
BB	0.306 (0.159)	0.404 (0.257)	-0.098	168.5	-0.803	.422	0.127[c]
SOC	0.369 (0.113)	0.432 (0.280)	-0.063	185.0	-0.354	.723	0.056[c]
TEN	0.360 (0.111)	0.354 (0.128)	+0.006	176.0	-0.599	.549	0.095[c]

Note. TFF measures are in seconds; Standard deviations are in parentheses; *diff.* = between group mean differences; Motor skills performances: BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; Groups: ASD-NH = ASD-non-highlight, TD-NH = TD-non-highlight, ASD-H = ASD-highlight, TD-H = TD-highlight. *Significant $p < .01$.

[a] = *p*-value computed by the independent samples *t*-test.

[b] = Hedge's *g* for an independent samples *t*-test (small=0.2, medium=0.5, large=0.8)

[c] = Cohen's for a Mann-Whitney *U* test (small=0.1, medium=0.3, large=0.5)

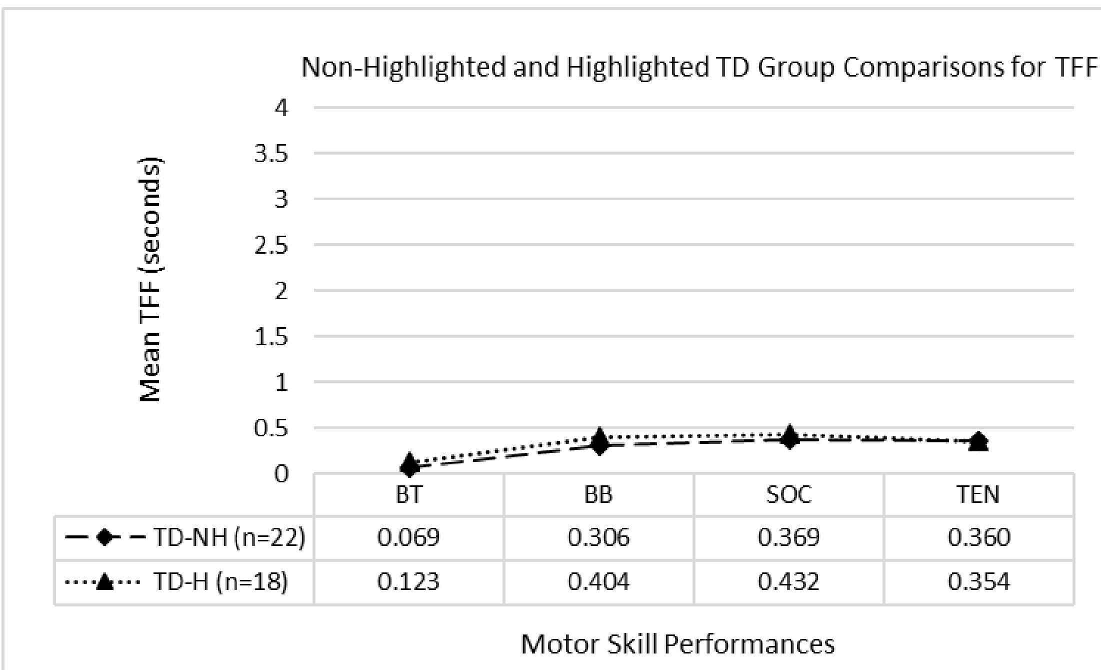

Figure 15. Non-Highlighted and Highlighted TD Group Comparisons for TFF.

Summary of Results for Total Visit Duration (TVD)

Total Visit Duration (TVD)

Total Visit Duration (TVD) is the measure of time (seconds) that an individual visually attends to a specific area of the visual stimuli. Specific areas of interest are often referred to as areas of interest or AOIs (Bergstrom & Schall, 2014). AOIs are defined regions of a display from which quantitative data are collected (Holmqvist et al., 2011). In this investigation, three AOIs (i.e., action, cone, and head) were built into each of the motor skill performance videos and were not visible to the participants. AOI results are presented separately (i.e., action, cone and head) to address the following research questions:

RQ 3: During the presentation of a motor skill performance, how does the group mean TVD (seconds) of children with autism compare to typically developing children?

H_0: There are no differences in the group mean TVD (seconds) of children with autism when compared to typically developing children.

RQ 4: During the presentation of a motor skill performance, how does the mean TVD (seconds) of the non-highlighted condition compare to the highlighted condition?

H_0: There are no differences in the mean TVD (seconds) between the non-highlighted and highlighted conditions.

Note. All mean group comparisons for TVD are summarized in Table 17. Written summaries, tables, and graphic illustrations are provided for the following group comparisons: (a) ASD-NH and TD-NH, (b) ASD-H and TD-H, (c) ASD-NH and ASD-H, and (d) TD-NH and TD-H. The same format is followed for the Cone AOI and the Head AOI. See Appendix S for the preliminary analysis for TVD.

Summary of Results for Total Visit Duration (TVD) Action AOI

Total Visit Duration (TVD) is the measure of time in seconds that an individual visually attends to a specific area of the visual stimuli. For a summary of results for TV the action area of interest see Table 17.

Table 17. *Summary of Results for Total Visit Duration (TVD) Action AOI*

Motor Skills	ASD-NH (*n*=14)	TD-NH (*n*=22)	*diff.*	*U / t*	*Z / df*	*p*	*ES* [b c]
BT_{action}	6.881 (4.923)	10.616 (3.114)	-3.735	83.0	-2.304	.021	0.384[c]
BB_{action}	6.156 (5.684)	9.012 (4.406)	-2.856	103.0	-1.655	.098	0.276[c]
SOC_{action}	5.417 (4.936)	8.154 (3.309)	-2.737	99.0	-1.785	.074	0.298[c]
TEN_{action}	6.744 (4.530)	10.880 (3.322)	-4.136	69.0	-2.759	.006*	0.460[c]
	ASD-H (*n*=12)	TD-H (*n*=18)					
BT_{action}	8.583 (4.121)	9.954 (3.242)	-1.371	-1.018	28	.317[a]	0.379[b]
BB_{action}	8.108 (4.462)	8.792 (2.839)	-0.684	100.0	-0.339	.735	0.062[c]
SOC_{action}	7.028 (4.800)	9.898 (3.118)	-2.870	70.0	-1.609	.108	0.294[c]
TEN_{action}	10.034 (4.311)	11.529 (2.878)	-1.495	92.0	-0.677	.498	0.124[c]
	ASD-NH (*n*=14)	ASD-H (*n*=12)					
BT_{action}	6.881 (4.923)	8.583 (4.121)	-1.702	-0.946	24	.354[a]	0.372[b]
BB_{action}	6.156 (5.684)	8.108 (4.462)	-1.952	62.0	-1.132	.258	0.222[c]
SOC_{action}	5.417 (4.936)	7.028 (4.800)	-1.611	-0.840	24	.409[a]	0.331[b]
TEN_{action}	6.744 (4.530)	10.034 (4.311)	-3.290	49.0	-1.801	.072	0.353[c]
	TD-NH (*n*=22)	TD-H (*n*=18)					
BT_{action}	10.616 (3.114)	9.954 (3.242)	+0.662	-0.656	38	.516[a]	0.209[b]
BB_{action}	9.012 (4.406)	8.792 (2.839)	+0.220	184.0	-0.381	.703	0.060[c]
SOC_{action}	8.154 (3.309)	9.898 (3.118)	-0.744	-1.702	38	.097[a]	0.541[b]
TEN_{action}	10.880 (3.322)	11.529 (2.878)	-0.649	179.5	-0.503	.615	0.080[c]

Note. TVD measures are in seconds; Standard deviations are in parentheses; *diff.* = between group mean differences; Motor skills performances: BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; Groups: ASD-NH = ASD-non-highlight, TD-NH = TD-non-highlight, ASD-H = ASD-highlight, TD-H = TD-highlight. *Significant $p < .01$.

[a] = *p*-value computed by the independent samples *t*-test.

[b] = Hedge's *g* for an independent samples *t*-test (small=0.2, medium=0.5, large=0.8)

[c] = Cohen's for a Mann-Whitney *U* test (small=0.1, medium=0.3, large=0.5)

Non-Highlighted ASD and TD Group Comparisons for TVD Action

With regard to the action AOI, results indicated that the ASD-NH group (n = 14) had a lower group mean than the TD-NH group (n=22) across the four motor skills performances. The lower group means indicated shorter durations (e.g., less time) spent visually attending to the action AOI.

Results of the Mann-Whitney U test indicated the following: For BT_{action}, the ASD-NH group (M = 6.881) was lower than the TD-NH group (M = 10.616), U = 83.0, Z = -2.304, p = .021, and Cohen's (1988) indicated a medium effect size, r = 0.384. For BB_{action}, the ASD-NH group (M = 6.156) was lower than the TD-NH group (M = 9.012), U = 103.0, Z = -1.655, p = .098, and a small effect size, r = 0.276. For SOC_{action}, the ASD-NH group (M = 5.417) was lower than the TD-NH group (M = 8.154), U = 99.0, Z = -1.785, p = .074, and a small effect size, r = 0.298. However, for $TEN_{action,}$ the ASD-NH group (M = 6.744) was found to be significantly lower than the TD-NH group (M = 10.880), U = 69.0, Z = -2.759, p = .006, and a medium effect size, r = 0.460.

Results indicated there were no statistically significant differences in TVD to the action AOI between the ASD and TD groups in the non-highlighted condition for three of the four motor skill performances (i.e., BT, BB, and SOC). The p-values were greater than .01. Based on these findings, the null hypothesis could not be rejected. However, measures of effect size indicated small to medium effect sizes across the four motor skill performances. A summary of results for the action AOI are shown in Table 18 and graphically illustrated in Figure 16.

Table 18. *Non-Highlighted ASD and TD Group Comparisons for TVD Action*

Motor Skills	ASD-NH (*n*=14)	TD-NH (*n*=22)	*diff.*	*U / t*	*Z / df*	*p*	*ES* [b c]
BT_{action}	6.881 (4.923)	10.616 (3.114)	-3.735	83.0	-2.304	.021	0.384[c]
BB_{action}	6.156 (5.684)	9.012 (4.406)	-2.856	103.0	-1.655	.098	0.276[c]
SOC_{action}	5.417 (4.936)	8.154 (3.309)	-2.737	99.0	-1.785	.074	0.298[c]
TEN_{action}	6.744 (4.530)	10.880 (3.322)	-4.136	69.0	-2.759	.006*	0.460[c]

Note. TVD measures are in seconds; Standard deviations are in parentheses; *diff.* = between group mean differences; Motor skills performances: BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; Groups: ASD-NH = ASD-non-highlight, TD-NH = TD-non-highlight, ASD-H = ASD-highlight, TD-H = TD-highlight. *Significant $p < .01$.
[a] = *p*-value computed by the independent samples *t*-test.
[b] = Hedge's *g* for an independent samples *t*-test (small=0.2, medium=0.5, large=0.8)
[c] = Cohen's for a Mann-Whitney *U* test (small=0.1, medium=0.3, large=0.5)

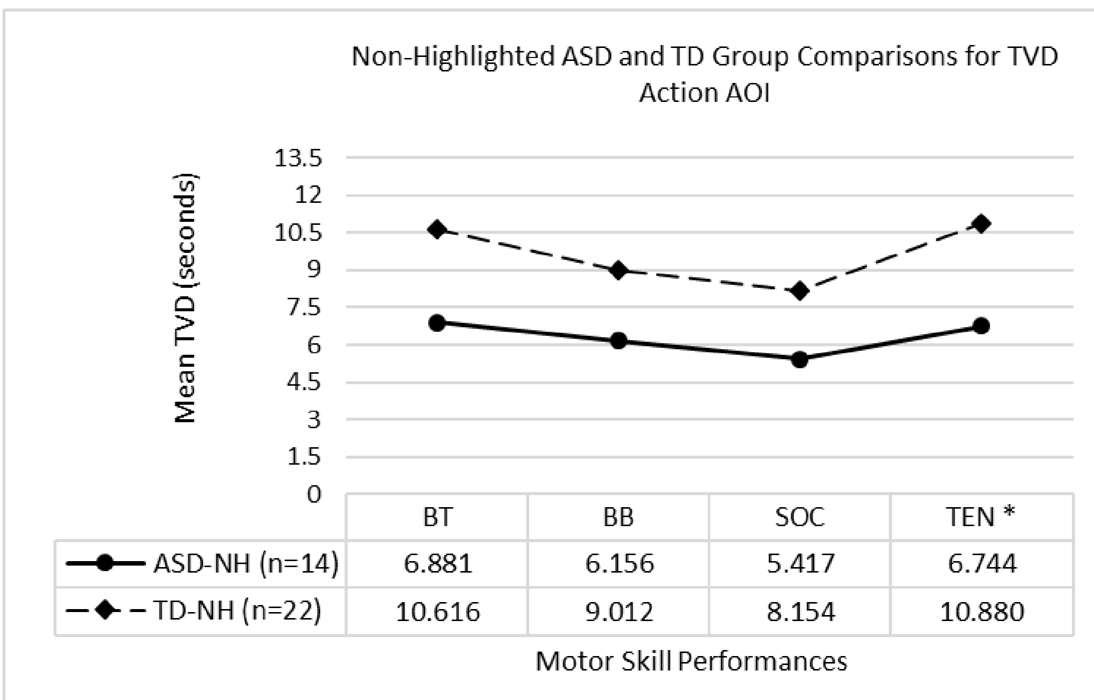

Figure 16. Non-Highlighted ASD and TD Group Comparisons for TVD Action.

Highlighted ASD and TD Group Comparisons for TVD Action

With regard to the action AOI, results indicated that the ASD-H group (*n* = 12) had a lower group mean than the TD-H group (*n* =18) across the four motor skills performances (see Table 26). The lower group means indicated shorter durations (e.g., less time) spent visually attending to the action AOI.

Results of an independent samples *t*-test indicated the following: For BT_{action}, the ASD-H group (M = 8.583) was lower than the TD-H group (M = 9.954), t (28) = -1.018, p = .317, and Hedge's g (Hedges & Olkin, 1985) indicated a small effect size, g = 0.379. The Mann-Whitney U test indicated the following results: For BB_{action}, the ASD-H group (M = 8.108) was slightly lower than the TD-H group (M = 8.792), U = 100.0, Z = -0.339, p = .735, and Cohen's (1988) indicated no meaningful effect size, r = 0.062. For SOC_{action}, the ASD-H group (M = 7.028) was lower than the TD-H group (M = 9.898), U = 70.0, Z = -1.609, p = .108, and a small effect size, r = 0.294. For TEN_{action}, the ASD-H group (M = 10.034) was lower than the TD-H group (M = 11.529), U = 92.0, Z = -0.677, p = .498, and a small effect size, r = 0.124.

Results indicated there were no statistically significant differences in TVD to the action AOI between the ASD and TD groups in the highlighted condition. All *p*-values were greater than .01. Based on these findings, the null hypothesis could not be rejected. However, measures of effect size indicated small effect sizes for three of the four motor skill performances. A summary of results for the action AOI are shown in Table 19 and graphically illustrated in Figure 17.

Table 19. *Highlighted ASD and TD Group Comparisons for TVD Action*

Motor Skills	ASD-H (*n*=12)	TD-H (*n*=18)	*diff.*	*U / t*	*Z / df*	*p*	*ES* [b c]
BT_{action}	8.583 (4.121)	9.954 (3.242)	-1.371	-1.018	28	.317[a]	0.379[b]
BB_{action}	8.108 (4.462)	8.792 (2.839)	-0.684	100.0	-0.339	.735	0.062[c]
SOC_{action}	7.028 (4.800)	9.898 (3.118)	-2.870	70.0	-1.609	.108	0.294[c]
TEN_{action}	10.034 (4.311)	11.529 (2.878)	-1.495	92.0	-0.677	.498	0.124[c]

Note. TVD measures are in seconds; Standard deviations are in parentheses; *diff.* = between group mean differences; Motor skills performances: BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; Groups: ASD-NH = ASD-non-highlight, TD-NH = TD-non-highlight, ASD-H = ASD-highlight, TD-H = TD-highlight. *Significant $p < .01$.

[a] = *p*-value computed by the independent samples *t*-test.

[b] = Hedge's *g* for an independent samples *t*-test (small=0.2, medium=0.5, large=0.8)

[c] = Cohen's for a Mann-Whitney *U* test (small=0.1, medium=0.3, large=0.5)

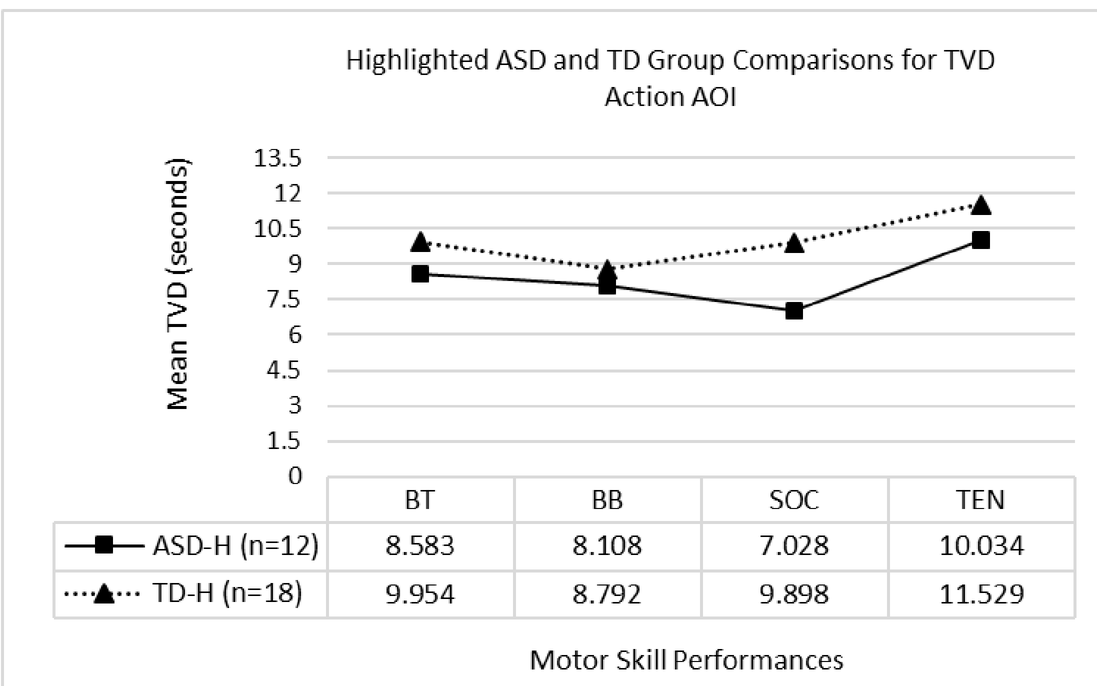

Figure 17. Highlighted ASD and TD Group Comparisons for TVD Action.

Non-Highlighted and Highlighted ASD Group Comparisons for TVD Action

With regard to the action AOI, results indicated that the ASD-NH (*n* = 14) had a lower group mean than the ASD-H group (*n* = 12) across the four motor skills performances. The lower group means indicated shorter durations (e.g., less time) spent visually attending to the action AOI.

Results of an independent samples *t*-test indicated the following: For $BT_{action,}$ the ASD-NH group (*M* = 6.881) was lower than the ASD-H (*M* = 8.583), *t* (24) = -0.946, *p* = .354, and Hedge's *g* (Hedges & Olkin, 1985) indicated a small effect size, *g* = 0.372. For BB_{action}, the Mann-Whitney *U* test indicated the ASD-NH group (*M* = 6.156) was lower than the ASD-H (*M* = 8.108), *U* = 62.0, *Z* = -1.132, *p* = .258, and Cohen's (1988) indicated a small effect size, *r* = 0.222. For SOC_{action}, an independent samples *t*-test indicated the ASD-NH group (*M* = 5.417) was lower than the ASD-H (*M* = 7.028), *t* (24) = -.840, *p* = .409, and a small effect size, *g* = 0.331. For TEN_{action}, the Mann-Whitney *U* test indicated the ASD-NH group (*M* = 6.744) was lower than the ASD-H (*M* = 10.034), *U* = 49.0, *Z* = -1.801, *p* = .072, and a medium effect size, *r* = 0.353.

Results indicated there were no statistically significant differences in TVD to the action AOI between the non-highlighted and highlighted ASD group. All *p*-values were greater than .01. Based on these findings, the null hypothesis could not be rejected. However, measures of effect size indicated small to medium effect sizes across the four motor skill performances. A summary of results for the action AOI are shown in Table 20 and graphically illustrated in Figure 18.

Table 20. *Non-Highlighted and Highlighted ASD Group Comparisons for TVD Action*

Motor Skills	ASD-NH (*n*=14)	ASD-H (*n*=12)	*diff.*	*U / t*	*Z / df*	*p*	*ES* [b c]
BT_{action}	6.881 (4.923)	8.583 (4.121)	-1.702	-0.946	24	.354[a]	0.372[b]
BB_{action}	6.156 (5.684)	8.108 (4.462)	-1.952	62.0	-1.132	.258	0.222[c]
SOC_{action}	5.417 (4.936)	7.028 (4.800)	-1.611	-0.840	24	.409[a]	0.331[b]
TEN_{action}	6.744 (4.530)	10.034 (4.311)	-3.290	49.0	-1.801	.072	0.353[c]

Note. TVD measures are in seconds; Standard deviations are in parentheses; *diff.* = between group mean differences; Motor skills performances: BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; Groups: ASD-NH = ASD-non-highlight, TD-NH = TD-non-highlight, ASD-H = ASD-highlight, TD-H = TD-highlight. *Significant $p < .01$.
[a] = *p*-value computed by the independent samples *t*-test.
[b] = Hedge's *g* for an independent samples *t*-test (small=0.2, medium=0.5, large=0.8)
[c] = Cohen's for a Mann-Whitney *U* test (small=0.1, medium=0.3, large=0.5)

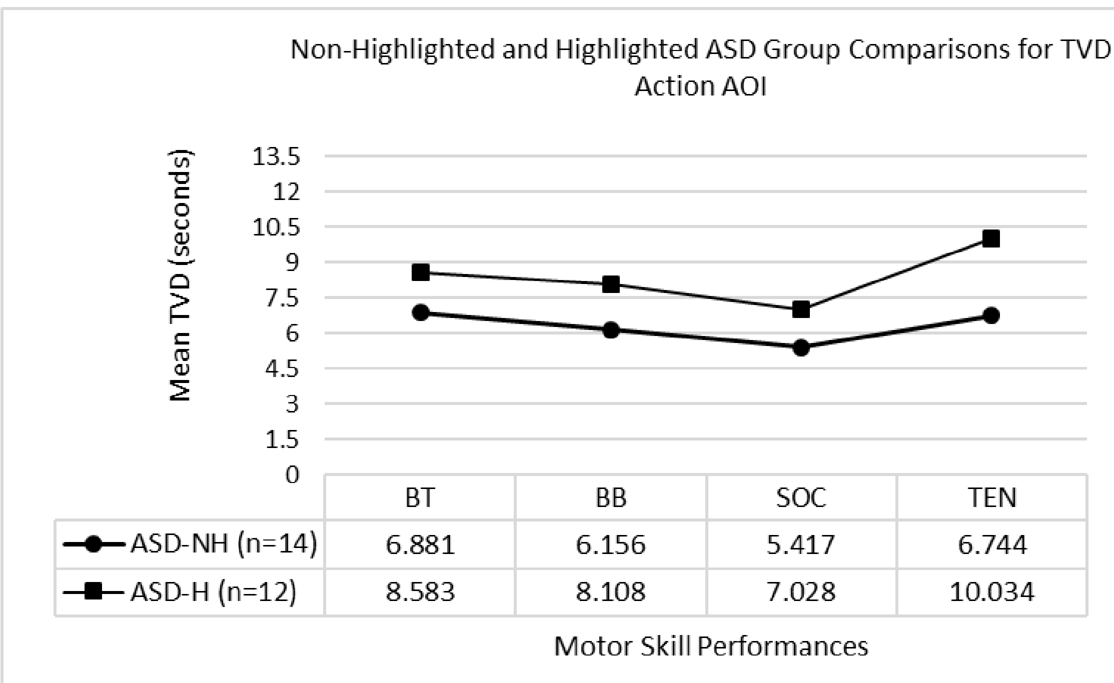

Figure 18. Non-Highlighted and Highlighted ASD Group Comparisons for TVD Action.

Non-Highlighted and Highlighted TD Group Comparisons for TVD Action

With regard to the action AOI, results indicated that the TD-NH group (*n* = 22) had a lower group mean than the TD-H (*n* = 18) on two of the four motor skills performances (i.e., SOC_{action} and TEN_{action}). The lower group means indicated shorter durations (e.g., less time) spent visually attending to the action AOI.

Results of an independent samples *t*-test indicated the following: For BT_{action}, the TD-NH group (M = 10.616) was higher than the TD-H (M = 9.954), t (38) = 0.656, p = .516, and Hedge's g (Hedges & Olkin, 1985) indicated a small effect size, g = 0.209. For BB_{action}, the Mann-Whitney U test indicated the TD-NH group (M = 9.012) was higher than the TD-H (M = 8.792), U = 184.0, Z = -0.381, p = .703, and Cohen's (1988) indicated no meaningful effect size, r = 0.060. For SOC_{action}, an independent samples *t*-test indicated the TD-NH group (M = 8.154) was lower than the TD-H (M = 9.898), t (38) = -1.702, p = .097, and a medium effect size, g = 0.541. For TEN_{action}, the Mann-Whitney U test indicated the TD-NH group (M = 10.880) was lower than the TD-H (M = 11.529), U = 179.5, Z = -0.503, p = .615, and no meaningful effect size was found, r = 0.080.

Results indicated there were no statistically significant differences in TVD to the action AOI between the non-highlighted and highlighted TD group. All *p*-values were greater than .01. Based on these findings, the null hypothesis could not be rejected. However, measures of effect size indicated small to medium effect sizes for two of the four motor skill performances. A summary of results for the action AOI are shown in Table 21 and graphically illustrated in Figure 19.

Table 21. *Non-Highlighted and Highlighted TD Group Comparisons for TVD Action*

Motor Skills	TD-NH (*n*=22)	TD-H (*n*=18)	*diff.*	*U / t*	*Z / df*	*p*	*ES* [b c]
BT_{action}	10.616 (3.114)	9.954 (3.242)	+0.662	-0.656	38	.516[a]	0.209[b]
BB_{action}	9.012 (4.406)	8.792 (2.839)	+0.220	184.0	-0.381	.703	0.060[c]
SOC_{action}	8.154 (3.309)	9.898 (3.118)	-0.744	-1.702	38	.097[a]	0.541[b]
TEN_{action}	10.880 (3.322)	11.529 (2.878)	-0.649	179.5	-0.503	.615	0.080[c]

Note. TVD measures are in seconds; Standard deviations are in parentheses; *diff.* = between group mean differences; Motor skills performances: BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; Groups: ASD-NH = ASD-non-highlight, TD-NH = TD-non-highlight, ASD-H = ASD-highlight, TD-H = TD-highlight. *Significant $p < .01$.
[a] = *p*-value computed by the independent samples *t*-test.
[b] = Hedge's *g* for an independent samples *t*-test (small=0.2, medium=0.5, large=0.8)
[c] = Cohen's for a Mann-Whitney *U* test (small=0.1, medium=0.3, large=0.5)

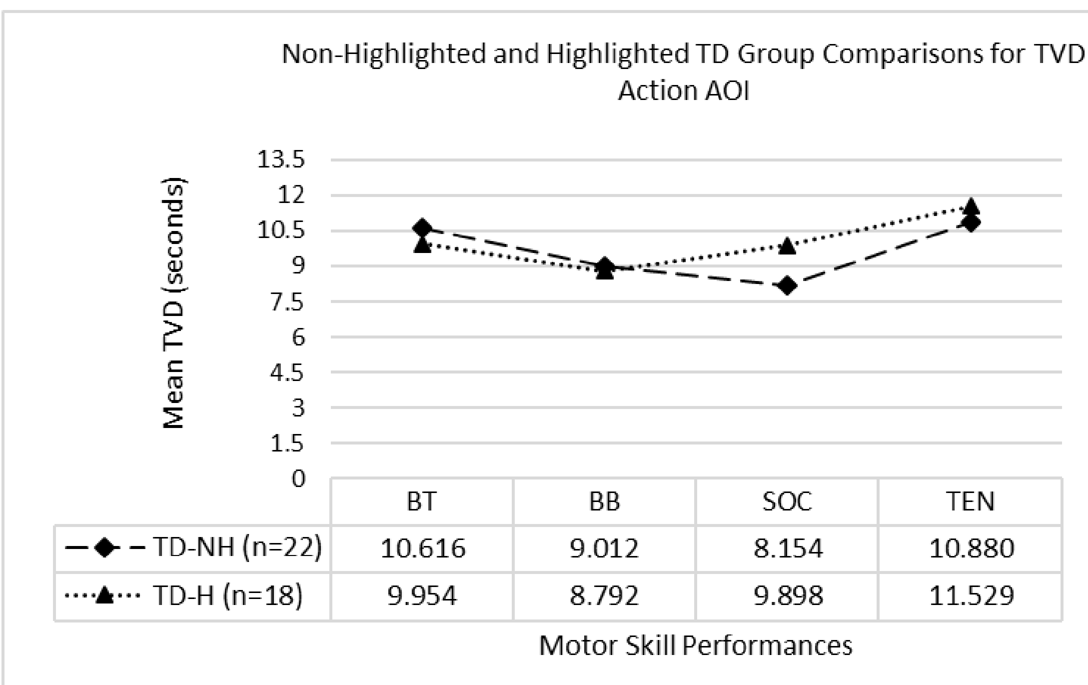

Figure 19. Non-Highlighted and Highlighted TD Group Comparisons for TVD Action.

Summary of Results for Total Visit Duration (TVD) Cone AOI

Total Visit Duration (TVD) is the measure of time in seconds that an individual visually attends to a specific area of the visual stimuli. For a summary of results for TVD to the cone area of interest see Table 22.

Table 22. *Summary of Results for Total Visit Duration (TVD) Cone AOI*

Motor Skills	ASD-NH (*n*=14)	TD-NH (*n*=22)	*diff.*	*U / t*	*Z / df*	*p*	*ES* [b c]
BT_{cone}	0.366 (0.527)	0.251 (0.634)	+0.115	122.5	-1.163	.245	0.194[c]
BB_{cone}	0.337 (0.484)	0.452 (1.290)	-0.115	137.0	-0.641	.521	0.107[c]
SOC_{cone}	0.891 (2.298)	0.380 (0.748)	+0.511	126.5	-0.966	.334	0.161[c]
TEN_{cone}	0.275 (0.494)	0.283 (0.520)	-0.008	150.0	-0.159	.874	0.027[c]
	ASD-H (*n*=12)	TD-H (*n*=18)					
BT_{cone}	0.116 (0.242)	0.214 (0.379)	-0.098	103.5	-0.227	.820	0.041[c]
BB_{cone}	0.050 (0.152)	0.216 (0.406)	-0.166	92.0	-0.914	.361	0.167[c]
SOC_{cone}	0.081 (0.129)	0.096 (0.197)	-0.015	102.0	-0.326	.744	0.060[c]
TEN_{cone}	0.020 (0.069)	0.082 (0.197)	-0.062	97.5	-0.752	.452	0.137[c]
	ASD-NH (*n*=14)	ASD-H (*n*=12)					
BT_{cone}	0.366 (0.527)	0.116 (0.242)	+0.250	61.5	-1.287	.198	0.252[c]
BB_{cone}	0.337 (0.484)	0.050 (0.152)	+0.287	57.0	-1.698	.089	0.333[c]
SOC_{cone}	0.891 (2.298)	0.081 (0.129)	+0.810	54.0	-1.680	.093	0.329[c]
TEN_{cone}	0.275 (0.494)	0.020 (0.069)	+0.255	65.0	-1.420	.156	0.278[c]
	TD-NH (*n*=22)	TD-H (*n*=18)					
BT_{cone}	0.251 (0.634)	0.214 (0.379)	+0.037	193.5	-0.147	.883	0.023[c]
BB_{cone}	0.452 (1.290)	0.216 (0.406)	+0.236	191.5	-0.218	.827	0.034[c]
SOC_{cone}	0.380 (0.748)	0.096 (0.197)	+0.284	159.5	-1.258	.209	0.199[c]
TEN_{cone}	0.283 (0.520)	0.082 (0.197)	+0.201	164.5	-1.198	.231	0.189[c]

Note. TVD measures are in seconds; Standard deviations are in parentheses; *diff.* = between group mean differences; Motor skills performances: BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; Groups: ASD-NH = ASD-non-highlight, TD-NH = TD-non-highlight, ASD-H = ASD-highlight, TD-H = TD-highlight. *Significant $p < .01$.

[a] = p-value computed by the independent samples t-test.

[b] = Hedge's g for an independent samples t-test (small=0.2, medium=0.5, large=0.8)

[c] = Cohen's for a Mann-Whitney U test (small=0.1, medium=0.3, large=0.5)

Non-Highlighted ASD and TD Group Comparisons for TVD Cone

With regard to the cone AOI, results indicated that the ASD-NH group (*n* = 14) had a lower group mean to the cone AOI than the TD-NH group (*n* = 22) on two of the four motor skills performances (i.e., BB_{cone} and TEN_{cone}). The lower group means indicated shorter durations (e.g., less time) spent visually attending to the cone AOI.

Results of the Mann-Whitney *U* test indicated the following: For BT_{cone}, the ASD-NH group (M = 0.366) was higher than the TD-NH group (M = 0.251), U = 122.5, Z = -1.163, p = .245, and Cohen's (1988) indicated a small effect size, r = 0.194. For BB_{cone}, the ASD-NH group (M = 0.337) was lower than the TD-NH group (M = 0.452), U = 137.0, Z = -0.641, p = .521, and a small effect size, r = 0.107. For SOC_{cone}, the ASD-NH group (M = 0.891) was higher than the TD-NH group (M = 0.380), U = 126.5, Z = -0.966, p = .334, and a small effect size, r = 0.161. For TEN_{cone}, the ASD-NH group (M = 0.275) was slightly lower than the TD-NH group (M = 0.283), U = 150.0, Z = -0.159, p = .874, and no meaningful effect size was found, r = 0.027.

Results indicated there were no statistically significant differences in TVD to the cone AOI between the ASD and TD groups in the non-highlighted condition. All *p*-values were greater than .01. Based on these findings, the null hypothesis could not be rejected. However, measures of effect size indicated small effect sizes for three of the four motor skill performances. A summary of results for the cone AOI are shown in Table 23 and graphically illustrated in Figure 20.

Table 23. *Non-Highlighted ASD and TD Group Comparisons for TVD Cone*

Motor Skills	ASD-NH (*n*=14)	TD-NH (*n*=22)	*diff.*	*U* / *t*	*Z* / *df*	*p*	*ES* [b c]
BT_{cone}	0.366 (0.527)	0.251 (0.634)	+0.115	122.5	-1.163	.245	0.194[c]
BB_{cone}	0.337 (0.484)	0.452 (1.290)	-0.115	137.0	-0.641	.521	0.107[c]
SOC_{cone}	0.891 (2.298)	0.380 (0.748)	+0.511	126.5	-0.966	.334	0.161[c]
TEN_{cone}	0.275 (0.494)	0.283 (0.520)	-0.008	150.0	-0.159	.874	0.027[c]

Note. TVD measures are in seconds; Standard deviations are in parentheses; *diff.* = between group mean differences; Motor skills performances: BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; Groups: ASD-NH = ASD-non-highlight, TD-NH = TD-non-highlight, ASD-H = ASD-highlight, TD-H = TD-highlight. *Significant $p < .01$.

[a] = *p*-value computed by the independent samples *t*-test.

[b] = Hedge's *g* for an independent samples *t*-test (small=0.2, medium=0.5, large=0.8)

[c] = Cohen's for a Mann-Whitney *U* test (small=0.1, medium=0.3, large=0.5)

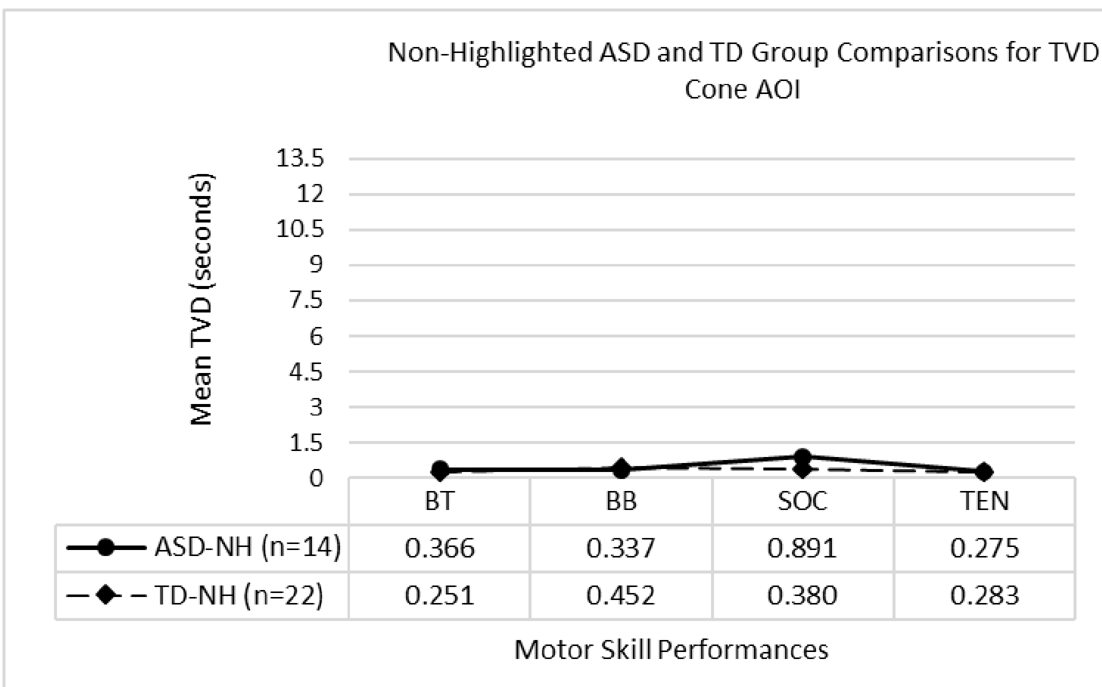

Figure 20. Non-Highlighted ASD and TD Group Comparisons for TVD Cone.

Highlighted ASD and TD Group Comparisons for TVD Cone

With regard to the cone AOI, results indicated that the ASD-H group (n = 12) had a lower group mean than the TD-H group (n = 18) across the four motor skills performances. The lower group means indicated shorter durations (e.g., less time) spent visually attending to the cone AOIs.

Results of the Mann-Whitney U test indicated the following: For BT_{cone}, the ASD-H group (M = 0.116) was lower than the TD-H group (M = 0.214), U = 103.5, Z = -0.227, p = .820, and Cohen's (1988) indicated no meaningful effect size, r = 0.041. For BB_{cone}, the ASD-H group (M = 0.050) was lower than the TD-H group (M = 0.216), U = 92.0, Z = -0.914, p = .361, and a small effect size, r = 0.167. For SOC_{cone}, the ASD-H group (M = 0.081) was lower than the TD-H group (M = 0.096), U = 102.0, Z = -0.326, p = .744, and no meaningful effect size was found, r = 0.060. For TEN_{cone}, the ASD-H group (M = 0.020) was lower than the TD-H group (M = 0.082), U = 97.5, Z = -0.752, p = .452, and a small effect size, r = 0.137.

Results indicated there were no statistically significant differences in TVD to the cone AOI between the ASD and TD groups in the highlighted condition. All p-values were greater than .01. Based on these findings, the null hypothesis could not be rejected. However, measures of effect size indicated small effect sizes for two of the four motor skill performances. A summary of results for the cone AOI are shown in Table 24 and graphically illustrated in Figure 21.

Table 24. *Highlighted ASD and TD Group Comparisons for TVD Cone*

Motor Skills	ASD-H (*n*=12)	TD-H (*n*=18)	*diff.*	*U* / *t*	*Z* / *df*	*p*	*ES* [b c]
BT_{cone}	0.116 (0.242)	0.214 (0.379)	-0.098	103.5	-0.227	.820	0.041[c]
BB_{cone}	0.050 (0.152)	0.216 (0.406)	-0.166	92.0	-0.914	.361	0.167[c]
SOC_{cone}	0.081 (0.129)	0.096 (0.197)	-0.015	102.0	-0.326	.744	0.060[c]
TEN_{cone}	0.020 (0.069)	0.082 (0.197)	-0.062	97.5	-0.752	.452	0.137[c]

Note. TVD measures are in seconds; Standard deviations are in parentheses; *diff.* = between group mean differences; Motor skills performances: BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; Groups: ASD-NH = ASD-non-highlight, TD-NH = TD-non-highlight, ASD-H = ASD-highlight, TD-H = TD-highlight. *Significant $p < .01$.
[a] = *p*-value computed by the independent samples *t*-test.
[b] = Hedge's *g* for an independent samples *t*-test (small=0.2, medium=0.5, large=0.8)
[c] = Cohen's for a Mann-Whitney *U* test (small=0.1, medium=0.3, large=0.5)

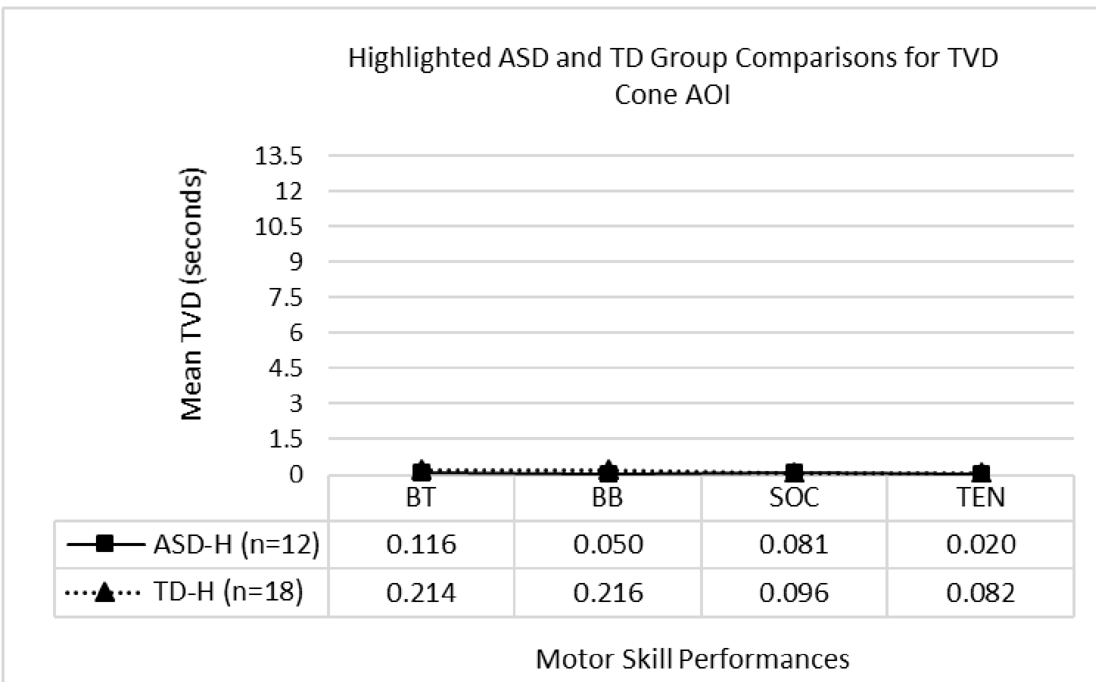

Figure 21. Highlighted ASD and TD Group Comparisons for TVD Cone.

Non-Highlighted and Highlighted ASD Group Comparisons for TVD Cone

With regard to the cone AOI, results indicated that the ASD-NH group (*n* = 14) had a higher group mean than the ASD-H (*n* = 12) across the four motor skills performances. The higher group means indicated longer durations (e.g., more time) spent visually attending to the cone AOIs.

Results of the Mann-Whitney *U* test indicated the following: For BT_{cone}, the ASD-NH group (*M* = 0.366) was higher than the ASD-H (*M* = 0.116), *U* = 61.5, *Z* = -1.287, *p* = .198, and Cohen's (1988) indicated a small effect size, *r* = 0.252. For BB_{cone}, the ASD-NH group (*M* = 0.337) was higher than the ASD-H (*M* = 0.050), *U* = 57.0, *Z* = -1.698, *p* = .089, and a medium effect size, *r* = 0.333. For SOC_{cone}, the ASD-NH group (*M* = 0.891) was higher than the ASD-H (*M* = 0.081), *U* = 54.0, *Z* = -1.680, *p* = .093, and a medium effect size, *r* = 0.329. For TEN_{cone}, the ASD-NH group (*M* = 0.275) was higher than the ASD-H (*M* = 0.020), *U* = 65.0, *Z* = -1.420, *p* = .156, and a small effect size, *r* = 0.278.

Results indicated there were no statistically significant differences in TVD to the cone AOI between the non-highlighted and highlighted ASD group. All *p*-values were greater than .01. Based on these findings, the null hypothesis could not be rejected. However, measures of effect size indicated small to medium effect sizes across the four motor skill performances. A summary of results for the cone AOI are shown in Table 25 and graphically illustrated in Figure 22.

Table 25. *Non-Highlighted and Highlighted ASD Group Comparisons for TVD Cone*

Motor Skills	ASD-NH (*n*=14)	ASD-H (*n*=12)	*diff.*	*U / t*	*Z / df*	*p*	*ES* [b c]
BT_{cone}	0.366 (0.527)	0.116 (0.242)	+0.250	61.5	-1.287	.198	0.252[c]
BB_{cone}	0.337 (0.484)	0.050 (0.152)	+0.287	57.0	-1.698	.089	0.333[c]
SOC_{cone}	0.891 (2.298)	0.081 (0.129)	+0.810	54.0	-1.680	.093	0.329[c]
TEN_{cone}	0.275 (0.494)	0.020 (0.069)	+0.255	65.0	-1.420	.156	0.278[c]

Note. TVD measures are in seconds; Standard deviations are in parentheses; *diff.* = between group mean differences; Motor skills performances: BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; Groups: ASD-NH = ASD-non-highlight, TD-NH = TD-non-highlight, ASD-H = ASD-highlight, TD-H = TD-highlight. *Significant $p < .01$.

[a] = *p*-value computed by the independent samples *t*-test.

[b] = Hedge's *g* for an independent samples *t*-test (small=0.2, medium=0.5, large=0.8)

[c] = Cohen's for a Mann-Whitney *U* test (small=0.1, medium=0.3, large=0.5)

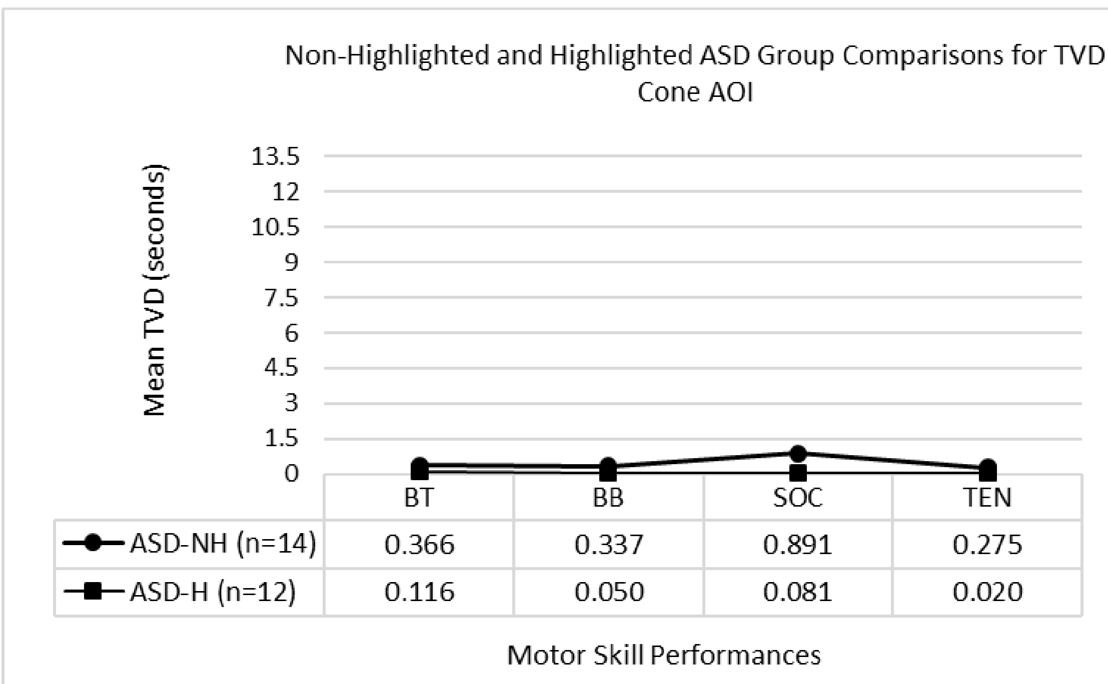

Figure 22. Non-Highlighted and Highlighted ASD Group Comparisons for TVD Cone.

Non-Highlighted and Highlighted TD Group Comparisons for TVD Cone

With regard to the cone AOI, results indicated that the TD-NH group (*n* = 22) had a higher group mean than the TD-H (*n* = 18) across the four motor skills performances. The higher group means indicated longer durations (e.g., less time) spent visually attending to the cone AOI.

Results of the Mann-Whitney *U* test indicated the following: For BT_{cone}, the TD-NH group (*M* = 0.251) was higher than the TD-H (*M* = 0.214), *U* = 193.5, *Z* = -0.147, *p* = .883, and Cohen's (1988) indicated no meaningful effect size, *r* = 0.023. For BB_{cone}, the TD-NH group (*M* = 0.452) was higher than the TD-H (*M* = 0.216), *U* = 191.5, *Z* = -0.218, *p* = .827, and no meaningful effect size was found, *r* = 0.034. For SOC_{cone}, the TD-NH group (*M* = 0.380) was higher than the TD-H (*M* = 0.096), *U* = 159.5, *Z* = -1.258, *p* = .209, and a small effect size, *r* = 0.199. For TEN_{cone}, the TD-NH group (*M* = 0.283) was higher than the TD-H (*M* = 0.082), *U* = 164.5, *Z* = -1.198, *p* = .231, and a small effect size, *r* = 0.189.

Results indicated there were no statistically significant differences in TVD to the cone AOI between the non-highlighted and highlighted TD group. All *p*-values were greater than .01. Based on these findings, the null hypothesis could not be rejected. However, measures of effect size indicated small effect sizes for two of the four motor skill performances. A summary of results for the cone AOI are shown in Table 26 and graphically illustrated in Figure 23.

Table 26. *Non-Highlighted and Highlighted TD Group Comparisons for TVD Cone*

Motor Skills	TD-NH (n=22)	TD-H (n=18)	*diff.*	U / t	Z / df	p	$ES^{b\ c}$
BT_{cone}	0.251 (0.634)	0.214 (0.379)	+0.037	193.5	-0.147	.883	0.023[c]
BB_{cone}	0.452 (1.290)	0.216 (0.406)	+0.236	191.5	-0.218	.827	0.034[c]
SOC_{cone}	0.380 (0.748)	0.096 (0.197)	+0.284	159.5	-1.258	.209	0.199[c]
TEN_{cone}	0.283 (0.520)	0.082 (0.197)	+0.201	164.5	-1.198	.231	0.189[c]

Note. TVD measures are in seconds; Standard deviations are in parentheses; *diff.* = between group mean differences; Motor skills performances: BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; Groups: ASD-NH = ASD-non-highlight, TD-NH = TD-non-highlight, ASD-H = ASD-highlight, TD-H = TD-highlight. *Significant $p < .01$.
[a] = p-value computed by the independent samples t-test.
[b] = Hedge's g for an independent samples t-test (small=0.2, medium=0.5, large=0.8)
[c] = Cohen's for a Mann-Whitney U test (small=0.1, medium=0.3, large=0.5)

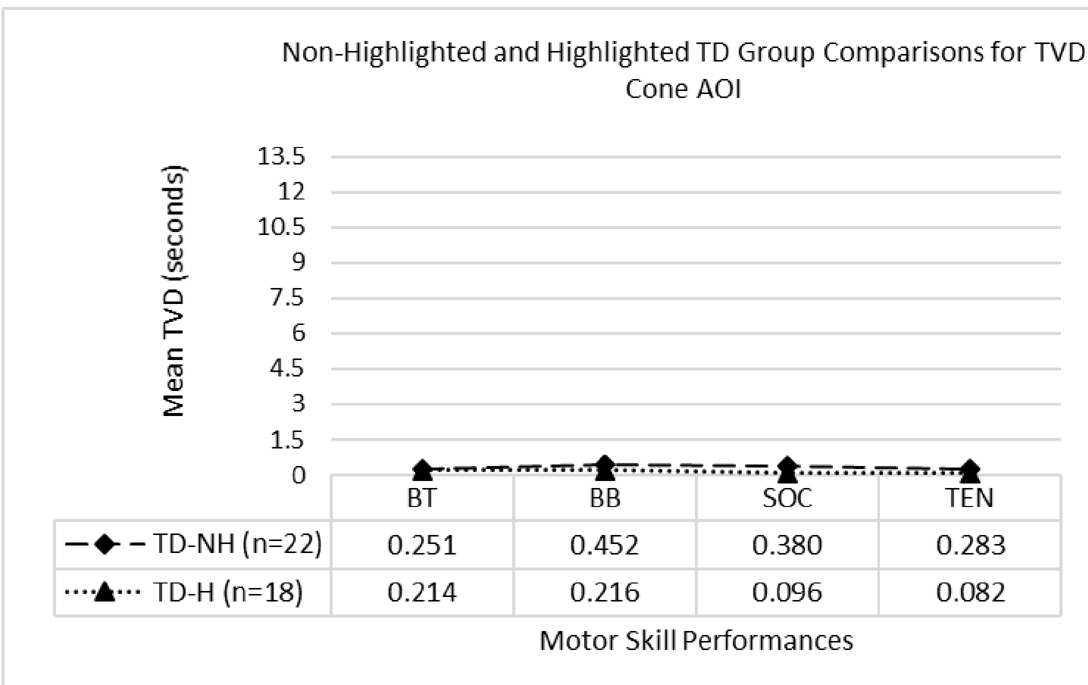

Figure 23. Non-Highlighted and Highlighted TD Group Comparisons for TVD Cone.

Summary of Results for Total Visit Duration (TVD) Head AOI

Total Visit Duration (TVD) is the measure of time in seconds that an individual visually attends to a specific area of the visual stimuli. For a summary of results for TVD to the head area of interest see Table 27.

Table 27. *Summary of Results for Total Visit Duration (TVD) Head AOI*

Motor Skills	ASD-NH (*n*=14)	TD-NH (*n*=22)	*diff.*	*U / t*	*Z / df*	*p*	*ES* [b c]
BT_{head}	1.529 (2.265)	2.215 (2.184)	-0.686	110.5	-1.415	.157	0.236[c]
BB_{head}	1.293 (2.411)	2.351 (2.602)	-1.058	91.5	-2.033	.042	0.339[c]
SOC_{head}	1.081 (2.357)	1.584 (1.338)	-0.503	79.5	-2.453	.014	0.409[c]
TEN_{head}	2.194 (2.865)	1.669 (1.280)	+0.495	145.0	-0.293	.770	0.002[c]
	ASD-H (*n*=12)	TD-H (*n*=18)					
BT_{head}	1.378 (1.181)	2.376 (1.825)	-0.998	-1.067	28	.106[a]	0.623[b]
BB_{head}	1.134 (1.159)	1.855 (1.674)	-0.721	83.5	-1.038	.299	0.190[c]
SOC_{head}	1.092 (1.295)	1.307 (1.567)	-0.215	96.5	-0.491	.623	0.090[c]
TEN_{head}	1.183 (1.177)	1.578 (1.261)	-0.395	-.861	28	.396[a]	0.321[b]
	ASD-NH (*n*=14)	ASD-H (*n*=12)					
BT_{head}	1.529 (2.265)	1.378 (1.181)	+0.151	66.0	-0.927	.354	0.182[c]
BB_{head}	1.293 (2.411)	1.134 (1.159)	+0.159	61.0	-1.185	.236	0.232[c]
SOC_{head}	1.081 (2.357)	1.092 (1.295)	-0.011	67.0	-0.934	.350	0.183[c]
TEN_{head}	2.194 (2.865)	1.183 (1.177)	+1.011	85.5	-0.180	.857	0.035[c]
	TD-NH (*n*=22)	TD-H (*n*=18)					
BT_{head}	2.215 (2.184)	2.376 (1.825)	-0.161	179.0	-0.517	.605	0.082[c]
BB_{head}	2.351 (2.602)	1.855 (1.674)	+0.496	190.0	-0.218	.828	0.034[c]
SOC_{head}	1.584 (1.338)	1.307 (1.567)	+0.277	163.5	-0.939	.347	0.148[c]
TEN_{head}	1.699 (1.280)	1.578 (1.261)	+0.121	.299	38	.767[a]	0.095[b]

Note. TVD measures are in seconds; Standard deviations are in parentheses; *diff.* = between group mean differences; Motor skills performances: BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; Groups: ASD-NH = ASD-non-highlight, TD-NH = TD-non-highlight, ASD-H = ASD-highlight, TD-H = TD-highlight. *Significant $p < .01$.

[a] = *p*-value computed by the independent samples *t*-test.

[b] = Hedge's *g* for an independent samples *t*-test (small=0.2, medium=0.5, large=0.8)

[c] = Cohen's for a Mann-Whitney *U* test (small=0.1, medium=0.3, large=0.5)

Non-Highlighted ASD and TD Group Comparisons for TVD Head

With regard to the head AOI, results indicated that the ASD-NH group (n = 14) had a lower group mean than the TD-NH group (n=22) on three of the four motor skills performances (i.e., BT_{head}, BB_{head} and SOC_{head}). The lower group means indicated shorter durations (e.g., less time) spent visually attending to the head AOIs.

Results of the Mann-Whitney U test indicated the following: For BT_{head}, the ASD-NH group (M = 1.529) was lower than the TD-NH group (M = 2.215), U = 110.5, Z = -1.415, p = .157, and Cohen's (1988) indicated a medium effect size, and a small effect size, r = 0.236. For BB_{head}, the ASD-NH group (M = 1.293) was lower than the TD-NH group (M = 2.351), U = 91.5, Z = -2.033, p = .042, and a medium effect size, r = 0.339. For SOC_{head}, the ASD-NH group (M = 1.081) was lower than the TD-NH group (M = 1.584), U = 79.5, Z = -2.453, p = .014, and a medium effect size, r = 0.409. For TEN_{head}, the ASD-NH group (M = 2.194) was higher than the TD-NH group (M = 1.669), U = 145.0, Z = -0.293, p = .770, and no meaningful effect size was found, r = 0.002.

Results indicated there were no statistically significant differences in TVD to the head AOI between the ASD and TD groups in the non-highlighted condition. All p-values were greater than .01. Based on these findings, the null hypothesis could not be rejected. However, measures of effect size indicated small to medium effect sizes for three of the four motor skill performances. A summary of results for the head AOI are shown in Table 28 and graphically illustrated in Figure 24.

Table 28. *Non-Highlighted ASD and TD Group Comparisons for TVD Head*

Motor Skills	ASD-NH (*n*=14)	TD-NH (*n*=22)	*diff.*	*U / t*	*Z / df*	*p*	*ES* [b c]
BT_{head}	1.529 (2.265)	2.215 (2.184)	-0.686	110.5	-1.415	.157	0.236[c]
BB_{head}	1.293 (2.411)	2.351 (2.602)	-1.058	91.5	-2.033	.042	0.339[c]
SOC_{head}	1.081 (2.357)	1.584 (1.338)	-0.503	79.5	-2.453	.014	0.409[c]
TEN_{head}	2.194 (2.865)	1.669 (1.280)	+0.495	145.0	-0.293	.770	0.002[c]

Note. TVD measures are in seconds; Standard deviations are in parentheses; *diff.* = between group mean differences; Motor skills performances: BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; Groups: ASD-NH = ASD-non-highlight, TD-NH = TD-non-highlight, ASD-H = ASD-highlight, TD-H = TD-highlight. *Significant $p < .01$.

[a] = *p*-value computed by the independent samples *t*-test.

[b] = Hedge's *g* for an independent samples *t*-test (small=0.2, medium=0.5, large=0.8)

[c] = Cohen's for a Mann-Whitney *U* test (small=0.1, medium=0.3, large=0.5)

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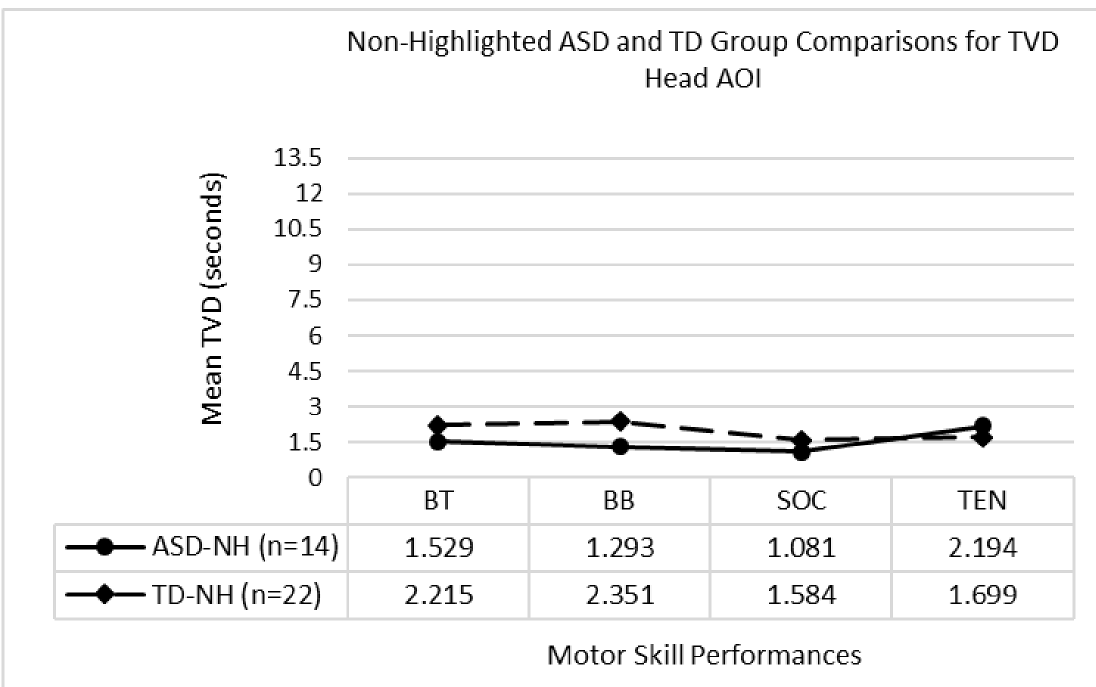

Figure 24. Non-Highlighted ASD and TD Group Comparisons for TVD Head.

Highlighted ASD and TD Group Comparisons for TVD Head

With regard to the head AOI, results indicated that the ASD-H group (*n* = 12) had a lower group mean than the TD-H group (*n* = 18) across the four motor skills performances. The lower group means indicated a shorter duration (e.g., less time) spent visually attending to the head AOI.

Results of an independent samples *t*-test indicated the following: For BT_{head}, the ASD-H group (*M* = 1.378) was lower than the TD-H group (*M* = 2.376), *t* (28) = -1.067, *p* = .106, and Hedge's *g* (Hedges & Olkin, 1985) indicated a medium effect size, *g* = 0.623. Results of the Mann-Whitney *U* test indicated the following: For BB_{head}, the ASD-H group (*M* = 1.134) was lower than the TD-H group (*M* = 1.855), *U* = 83.5, *Z* = -1.038, *p* = .299, and Cohen's (1988) indicated a small effect size, *r* = 0.190. For SOC_{head}, the ASD-H group (*M* = 1.092) was lower than the TD-H group (*M* = 1.307), *U* = 96.5, *Z* = -0.491, *p* = .623, and no meaningful effect size was found, *r* = 0.090. Results of an independent samples *t*-test indicated the following: For TEN_{head}, the ASD-H group (*M* = 1.183) was lower than the TD-H group (*M* = 1.578), *t* (28) = -.861, *p* = .396, and a small effect size, *g* = 0.321.

Results indicated there were no statistically significant differences in TVD to the head AOI between the ASD and TD groups in the highlighted condition. All *p*-values were greater than .01. Based on these findings, the null hypothesis could not be rejected. However, measures of effect size indicated small to medium effect sizes for three of the four motor skill performances. A summary of results for the head AOI are shown in Table 29 and graphically illustrated in Figure 25.

Table 29. *Highlighted ASD and TD Group Comparisons for TVD Head*

Motor Skills	ASD-H (*n*=12)	TD-H (*n*=18)	*diff.*	*U / t*	*Z / df*	*p*	*ES* [b c]
BT_{head}	1.378 (1.181)	2.376 (1.825)	-0.998	-1.067	28	.106[a]	0.623[b]
BB_{head}	1.134 (1.159)	1.855 (1.674)	-0.721	83.5	-1.038	.299	0.190[c]
SOC_{head}	1.092 (1.295)	1.307 (1.567)	-0.215	96.5	-0.491	.623	0.090[c]
TEN_{head}	1.183 (1.177)	1.578 (1.261)	-0.395	-.861	28	.396[a]	0.321[b]

Note. TFF measures are in seconds; Standard deviations are in parentheses; *diff.* = between group mean differences; Motor skills performances: BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; Groups: ASD-NH = ASD-non-highlight, TD-NH = TD-non-highlight, ASD-H = ASD-highlight, TD-H = TD-highlight. *Significant $p < .01$.

[a] = *p*-value computed by the independent samples *t*-test.

[b] = Hedge's *g* for an independent samples *t*-test (small=0.2, medium=0.5, large=0.8)

[c] = Cohen's for a Mann-Whitney *U* test (small=0.1, medium=0.3, large=0.5)

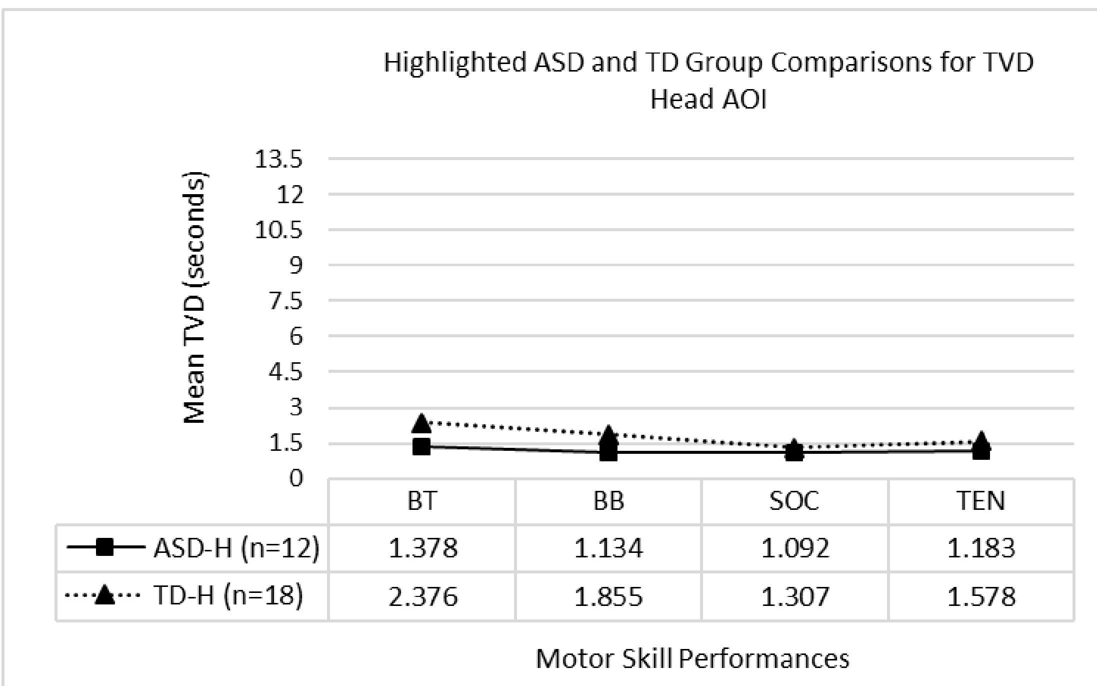

Figure 25. Highlighted ASD and TD Group Comparisons for TVD Head.

Non-Highlighted and Highlighted ASD Group Comparisons for TVD Head

With regard to the head AOI, results indicated that the ASD-NH group (*n* = 14) had a higher group mean than the ASD-H (*n* = 12) AOI on three of the four motor skills performances (i.e., BT_{head}, BB_{head}, and TEN_{head}). The higher group means indicated longer durations (e.g., more time) spent visually attending to the head AOI.

Results of the Mann-Whitney *U* test indicated the following: For BT_{head}, the ASD-NH group ($M = 1.529$) was higher than the ASD-H ($M = 1.378$), $U = 66.0$, $Z = -0.927$, $p = .354$, and Cohen's (1988) indicated a small effect size, $r = 0.182$. For BB_{head}, the ASD-NH group ($M = 1.293$) was higher than the ASD-H ($M = 1.134$), $U = 61.0$, $Z = -1.185$, $p = .236$, and a small effect size, $r = 0.232$. For SOC_{head}, the ASD-NH group ($M = 1.081$) was lower than the ASD-H ($M = 1.092$), $U = 67.0$, $Z = -0.934$, $p = .350$, and a small effect size, $r = 0.183$. For TEN_{head}, the ASD-NH group ($M = 2.194$) was higher than the ASD-H ($M = 1.183$), $U = 85.5$, $Z = -0.180$, $p = .857$, and no meaningful effect size was found, $r = 0.035$.

Results indicated there were no statistically significant differences in TVD to the head AOI between the non-highlighted and highlighted ASD group. All *p*-values were greater than .01. Based on these findings, the null hypothesis could not be rejected. However, measures of effect size indicated small effect sizes for three of the four motor skill performances. A summary of results for the head AOI are shown in Table 30 and graphically illustrated in Figure 26.

Table 30. *Non-Highlighted and Highlighted ASD Group Comparisons for TVD Head*

Motor Skills	ASD-NH (*n*=14)	ASD-H (*n*=12)	*diff.*	*U / t*	*Z / df*	*p*	*ES* [b c]
BT_{head}	1.529 (2.265)	1.378 (1.181)	+0.151	66.0	-0.927	.354	0.182[c]
BB_{head}	1.293 (2.411)	1.134 (1.159)	+0.159	61.0	-1.185	.236	0.232[c]
SOC_{head}	1.081 (2.357)	1.092 (1.295)	-0.011	67.0	-0.934	.350	0.183[c]
TEN_{head}	2.194 (2.865)	1.183 (1.177)	+1.011	85.5	-0.180	.857	0.035[c]

Note. TVD measures are in seconds; Standard deviations are in parentheses; *diff.* = between group mean differences; Motor skills performances: BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; Groups: ASD-NH = ASD-non-highlight, TD-NH = TD-non-highlight, ASD-H = ASD-highlight, TD-H = TD-highlight. *Significant $p < .01$.
[a] = *p*-value computed by the independent samples *t*-test.
[b] = Hedge's *g* for an independent samples *t*-test (small=0.2, medium=0.5, large=0.8)
[c] = Cohen's for a Mann-Whitney *U* test (small=0.1, medium=0.3, large=0.5)

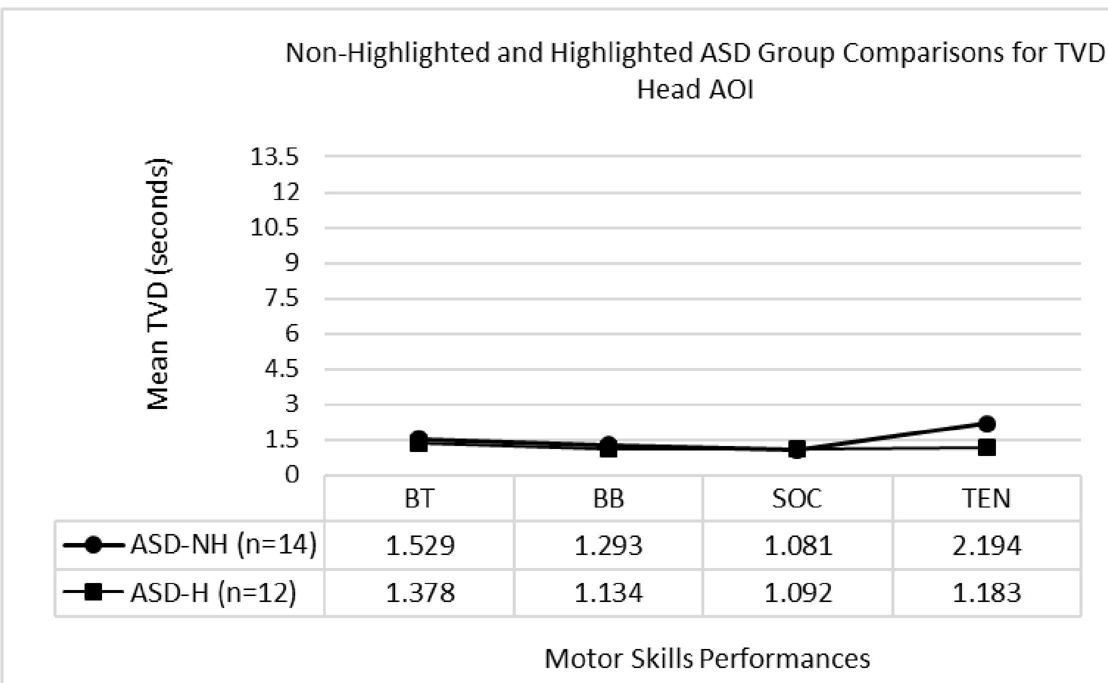

Figure 26. Non-Highlighted and Highlighted ASD Group Comparisons for TVD Head.

Non-Highlighted and Highlighted TD Group Comparisons for TVD Head

With regard to the head AOI, results indicated that the TD-NH group (*n* = 22) had a higher group mean than the TD-H (*n* = 18) on three of the four motor skills performances (i.e., BB_{head}, SOC_{head}, and $TEN_{head,}$). The higher group mean indicated a longer duration (e.g., more time) spent visually attending to the head AOI.

Results of the Mann-Whitney *U* test indicated the following: For BT_{head}, the TD-NH group (*M* = 2.215) was lower than the TD-H (*M* = 2.376), *U* = 179.0, *Z* = -0.517, *p* = .605, and Cohen's (1988) indicated no meaningful effect size was found, *r* = 0.082. For BB_{head}, the TD-NH group (*M* = 2.351) was higher than the TD-H (*M* = 1.855) *U* = 190.0, *Z* = -0.218, *p* = .828, and no meaningful effect size was found, *r* = 0.034. For SOC_{head}, the TD-NH group (*M* = 1.584) was higher than the TD-H (*M* = 1.307), *U* = 163.5, *Z* = -0.939, *p* = .347, and a small effect size, *r* = 0.148. Results of an independent samples *t*-test indicated the following: For TEN_{head}, the TD-NH group (*M* = 1.699) was higher than the TD-H (*M* = 1.578), *t* (38) = .299, *p* = .767, and Hedge's *g* (Hedges & Olkin, 1985), *g* = 0.095.

Results indicated there were no statistically significant differences in TVD to the head AOI between the non-highlighted and highlighted TD group. All *p*-values were greater than .01. Based on these findings, the null hypothesis could not be rejected. Measures of effect size indicated a small effect size for one of the four motor skill performances. A summary of results for the head AOI are shown in Table 31 and graphically illustrated in Figure 27.

Table 31. *Non-Highlighted and Highlighted TD Group Comparisons for TVD Head*

Motor Skills	TD-NH (n=22)	TD-H (n=18)	*diff.*	U / t	Z / df	p	$ES^{b\ c}$
BT_{head}	2.215 (2.184)	2.376 (1.825)	-0.161	179.0	-0.517	.605	0.082[c]
BB_{head}	2.351 (2.602)	1.855 (1.674)	+0.496	190.0	-0.218	.828	0.034[c]
SOC_{head}	1.584 (1.338)	1.307 (1.567)	+0.277	163.5	-0.939	.347	0.148[c]
TEN_{head}	1.699 (1.280)	1.578 (1.261)	+0.121	.299	38	.767[a]	0.095[b]

Note. TFF measures are in seconds; Standard deviations are in parentheses; *diff.* = between group mean differences; Motor skills performances: BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; Groups: ASD-NH = ASD-non-highlight, TD-NH = TD-non-highlight, ASD-H = ASD-highlight, TD-H = TD-highlight. *Significant $p < .01$.
[a] = p-value computed by the independent samples t-test.
[b] = Hedge's g for an independent samples t-test (small=0.2, medium=0.5, large=0.8)
[c] = Cohen's for a Mann-Whitney U test (small=0.1, medium=0.3, large=0.5)

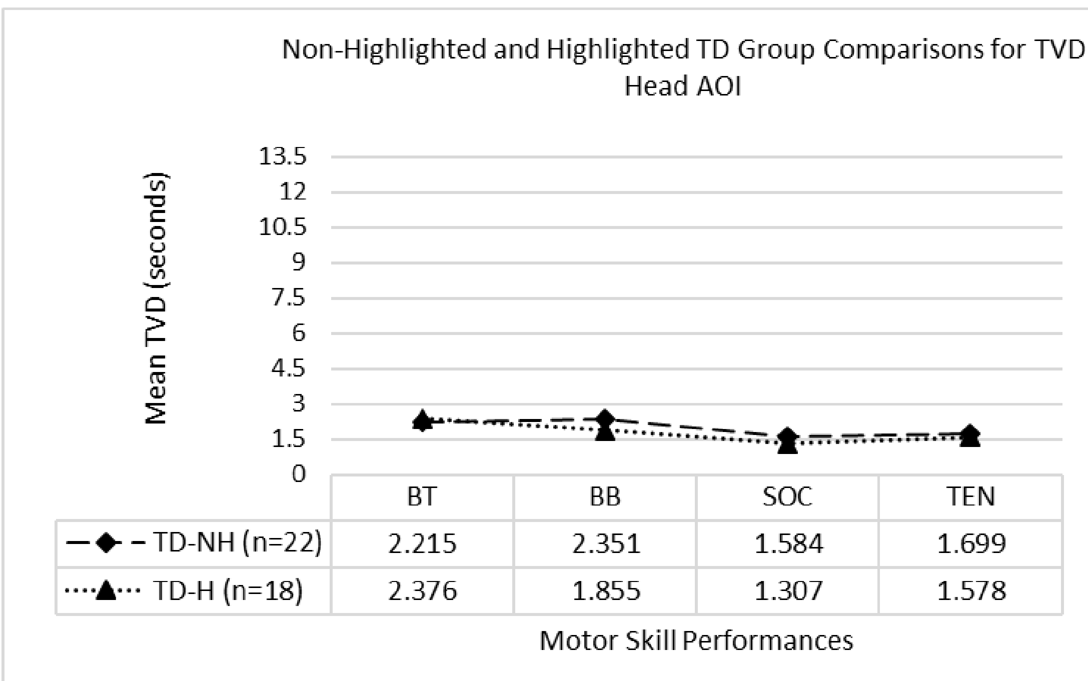

Figure 27. Non-Highlighted and Highlighted TD Group Comparisons for TVD Head.

Summary of Results for Visit Count (VC)

Visit Count (VC)

Visit Count (VC) measures the number visits and re-visits to an area of interest (AOI) (i.e., action, cone, and head). A visit ends when the eyes move outside the AOI (Tobii Studio, 2016). AOIs are defined regions of a display from which quantitative data are collected (Holmqvist et al., 2011). In this investigation, three AOIs (i.e., action, cone, and head) were built into each of the motor skill performance videos and were not visible to the participants. AOI results are presented separately (i.e., action, cone and head) to address the following research questions:

RQ 5: During the presentation of a motor skill performance, how does the group mean VC (number) of children with autism compare to typically developing children?

H_0: There are no differences in the group mean VC (number) of children with autism when compared to typically developing children.

RQ 6: During the presentation of a motor skill performance, how does the mean VC (number) of the non-highlighted condition compare to the highlighted condition?

H_0: There are no differences in the mean VC (number) between the non-highlighted and highlighted conditions.

Note. All mean group comparisons for Visit Count (VC) are summarized in Table 32. Written summaries, tables, and graphic illustrations for the following group comparisons: (a) ASD-NH and TD-NH, (b) ASD-H and TD-H, (c) ASD-NH and ASD-H, and (d) TD-NH and TD-H. See Appendix T for the preliminary analysis for VC.

Summary of Results for Visit Count (VC) Action AOI

Visit Count (VC) measures the number of visits and re-visits to an area of interest (AOI). A visit ends when the eyes move outside the AOI (Tobii Studio, 2016). For a summary of results for VC to the action area of interest see Table 32.

Table 32. *Summary of Results for Visit Count (VC) Action AOI*

Motor Skills	ASD-NH (*n*=14)	TD-NH (*n*=22)	*diff.*	*U / t*	*Z / df*	*p*	*ES* [b c]
BT_{action}	7.07 (4.46)	5.41 (2.11)	+1.66	110.0	-1.435	.151	0.239[c]
BB_{action}	5.00 (4.15)	4.27 (2.49)	+0.73	148.0	-0.196	.845	0.033[c]
SOC_{action}	5.79 (4.89)	6.36 (3.95)	-0.57	134.0	-0.654	.513	0.109[c]
TEN_{action}	5.57 (3.03)	3.91 (1.82)	+1.66	101.0	-1.736	.083	0.289[c]
	ASD-H (*n*=12)	TD-H (*n*=18)					
BT_{action}	7.42 (3.40)	6.72 (3.56)	+0.70	0.533	28	.598[a]	0.200[b]
BB_{action}	7.67 (4.56)	5.39 (2.66)	+2.28	76.5	-1.343	.179	0.245[c]
SOC_{action}	6.08 (4.46)	7.11 (3.51)	-1.03	-0.705	28	.487[a]	0.263[b]
TEN_{action}	5.25 (2.99)	4.28 (1.49)	+0.97	97.5	-0.450	.653	0.082[c]
	ASD-NH (*n*=14)	ASD-H (*n*=12)					
BT_{action}	7.07 (4.46)	7.42 (3.40)	-0.35	-0.219	24	.829[a]	0.087[b]
BB_{action}	5.00 (4.15)	7.67 (4.56)	-2.67	-1.561	24	.132[a]	0.615[b]
SOC_{action}	5.79 (4.89)	6.08 (4.46)	-0.29	-0.161	24	.873[a]	0.062[b]
TEN_{action}	5.57 (3.03)	5.25 (2.99)	+0.32	0.271	24	.788[a]	0.106[b]
	TD-NH (*n*=22)	TD-H (*n*=18)					
BT_{action}	5.41 (2.11)	6.72 (3.56)	-1.31	163.0	-0.959	.338	0.152[c]
BB_{action}	4.27 (2.49)	5.39 (2.66)	-1.12	150.0	-1.318	.188	0.208[c]
SOC_{action}	6.36 (3.95)	7.11 (3.51)	-0.75	-0.626	38	.535[a]	0.199[b]
TEN_{action}	3.91 (1.82)	4.28 (1.49)	-0.37	-0.690	38	.494[a]	0.220[b]

Note. VC measured in count; Standard deviations are in parentheses; *diff.* = between group mean differences; Motor skills performances: BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; Groups: ASD-NH = ASD-non-highlight, TD-NH = TD-non-highlight, ASD-H = ASD-highlight, TD-H = TD-highlight. *Significant $p < .01$.

[a] = *p*-value computed by the independent samples *t*-test.

[b] = Hedge's *g* for an independent samples *t*-test (small=0.2, medium=0.5, large=0.8)

[c] = Cohen's for a Mann-Whitney *U* test (small=0.1, medium=0.3, large=0.5)

Non-Highlighted ASD and TD Group Comparisons for VC Action

With regard to the action AOI, results indicated that the ASD-NH group (n = 14) had a higher group mean than the TD-NH group (n=22) on three of the four motor skills performances (i.e., BT_{action}, BB_{action}, and TEN_{action}). The higher group means indicated a greater number of visits to the action AOIs.

Results of the Mann-Whitney U test indicated the following: For BT_{action}, the ASD-NH group (M = 7.07) was higher than the TD-NH group (M = 5.41), U = 110.0, Z = -1.435, p = .151, and Cohen's (1988) indicated a small effect size, r = 0.239. For BB_{action}, the ASD-NH group (M = 5.00) was higher than the TD-NH group (M = 4.27), U = 148.0, Z = -0.196, p = .845, and no meaningful effect size was found, r = 0.033. For SOC_{action}, the ASD-NH group (M = 5.79) was lower than the TD-NH group (M = 6.36), U = 134.0, Z = -0.654, p = .513, and a small effect size, r = 0.109. For TEN_{action}, the ASD-NH group (M = 5.57) was higher than the TD-NH group (M = 3.91), U = 101.0, Z = -1.736, p = .083, and a small effect size, r = 0.289. Results indicated there were no statistically significant differences in VC to the action AOI between the ASD and TD groups in the non-highlighted condition. All p-values were greater than .01. Based on these findings, the null hypothesis could not be rejected. However, measures of effect size indicated small effect sizes for three of the four motor skill performances. A summary of results are shown in Table 33 and graphically illustrated in Figure 28.

Table 33. *Non-Highlighted ASD and TD Group Comparisons for VC Action*

Motor Skills	ASD-NH (*n*=14)	TD-NH (*n*=22)	*diff.*	*U / t*	*Z / df*	*p*	*ES* [b c]
BT_{action}	7.07 (4.46)	5.41 (2.11)	+1.66	110.0	-1.435	.151	0.239[c]
BB_{action}	5.00 (4.15)	4.27 (2.49)	+0.73	148.0	-0.196	.845	0.033[c]
SOC_{action}	5.79 (4.89)	6.36 (3.95)	-0.57	134.0	-0.654	.513	0.109[c]
TEN_{action}	5.57 (3.03)	3.91 (1.82)	+1.66	101.0	-1.736	.083	0.289[c]

Note. VC measured in count; Standard deviations are in parentheses; *diff.* = between group mean differences; Motor skills performances: BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; Groups: ASD-NH = ASD-non-highlight, TD-NH = TD-non-highlight, ASD-H = ASD-highlight, TD-H = TD-highlight. *Significant $p < .01$.

[a] = *p*-value computed by the independent samples *t*-test.

[b] = Hedge's *g* for an independent samples *t*-test (small=0.2, medium=0.5, large=0.8)

[c] = Cohen's for a Mann-Whitney *U* test (small=0.1, medium=0.3, large=0.5)

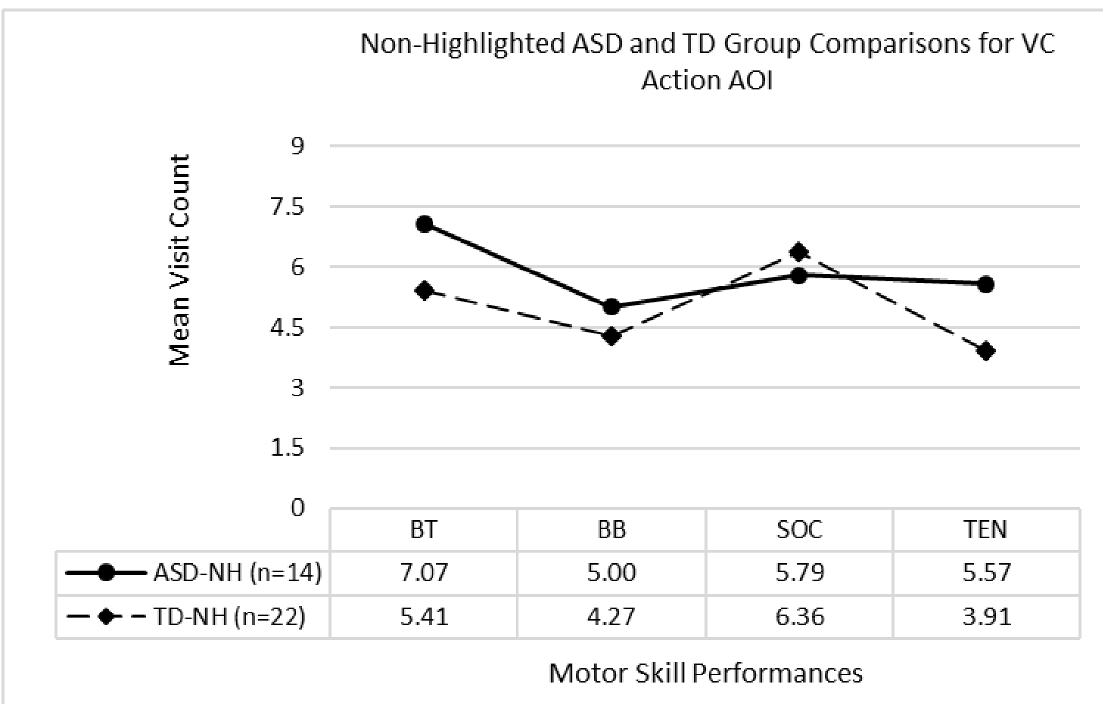

Figure 28. Non-Highlighted ASD and TD Group Comparisons for VC Action.

Highlighted ASD and TD Group Comparisons for VC Action

With regard to the action AOI, results indicated that the ASD-H group (n = 12) had a higher group mean than the TD-H group (n = 18) on three of the four motor skills performances (i.e., $BT_{action,}$ BB_{action}, and TEN_{action}). The higher group means indicated a greater number of visits to the action AOIs.

Results of an independent samples t-test indicated the following: For BT_{action}, the ASD-H group (M = 7.42) was higher than the TD-H group (M = 6.72), t (28) = .533, p = .598, and Hedge's g (Hedges & Olkin, 1985) indicated a small effect size, g = 0.200. Results of the Mann-Whitney U test indicated the following: For BB_{action}, the ASD-H group (M = 7.67) was higher than the TD-H group (M = 5.39), U = 76.5, Z = -1.343, p = .179, and Cohen's (1988) indicated a small effect size, r = 0.245 Results of an independent samples t-test indicated the following: For SOC_{action}, the ASD-H group (M = 6.08) was lower than the TD-H group (M = 7.11), t (28) = -0.705, p = .487, and a small effect size, g = 0.263. Results of the Mann-Whitney U test indicated the following: For TEN_{action}, the ASD-H group (M = 5.25) was higher than the TD-H group (M = 4.28), U = 97.5, Z = -0.450, p = .653, and no meaningful effect size was found, r = 0.082.

Results indicated there were no statistically significant differences in VC to the action AOI between the ASD and TD groups in the highlighted condition. All p-values were greater than .01. Based on these findings, the null hypothesis could not be rejected. However, measures of effect size indicated small effect sizes for three of the four motor skill performances. Results of the mean group comparisons for the action AOI are shown in Table 34 and graphically illustrated in Figure 29.

Table 34. *Highlighted ASD and TD Group Comparisons for VC Action*

Motor Skills	ASD-H (*n*=12)	TD-H (*n*=18)	*diff.*	*U / t*	*Z / df*	*p*	*ES* [b c]
BT_{action}	7.42 (3.40)	6.72 (3.56)	+0.70	0.533	28	.598[a]	0.200[b]
BB_{action}	7.67 (4.56)	5.39 (2.66)	+2.28	76.5	-1.343	.179	0.245[c]
SOC_{action}	6.08 (4.46)	7.11 (3.51)	-1.03	-0.705	28	.487[a]	0.263[b]
TEN_{action}	5.25 (2.99)	4.28 (1.49)	+0.97	97.5	-0.450	.653	0.082[c]

Note. VC measured in count; Standard deviations are in parentheses; *diff.* = between group mean differences; Motor skills performances: BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; Groups: ASD-NH = ASD-non-highlight, TD-NH = TD-non-highlight, ASD-H = ASD-highlight, TD-H = TD-highlight. *Significant $p < .01$.
[a] = *p*-value computed by the independent samples *t*-test.
[b] = Hedge's *g* for an independent samples *t*-test (small=0.2, medium=0.5, large=0.8)
[c] = Cohen's for a Mann-Whitney *U* test (small=0.1, medium=0.3, large=0.5)

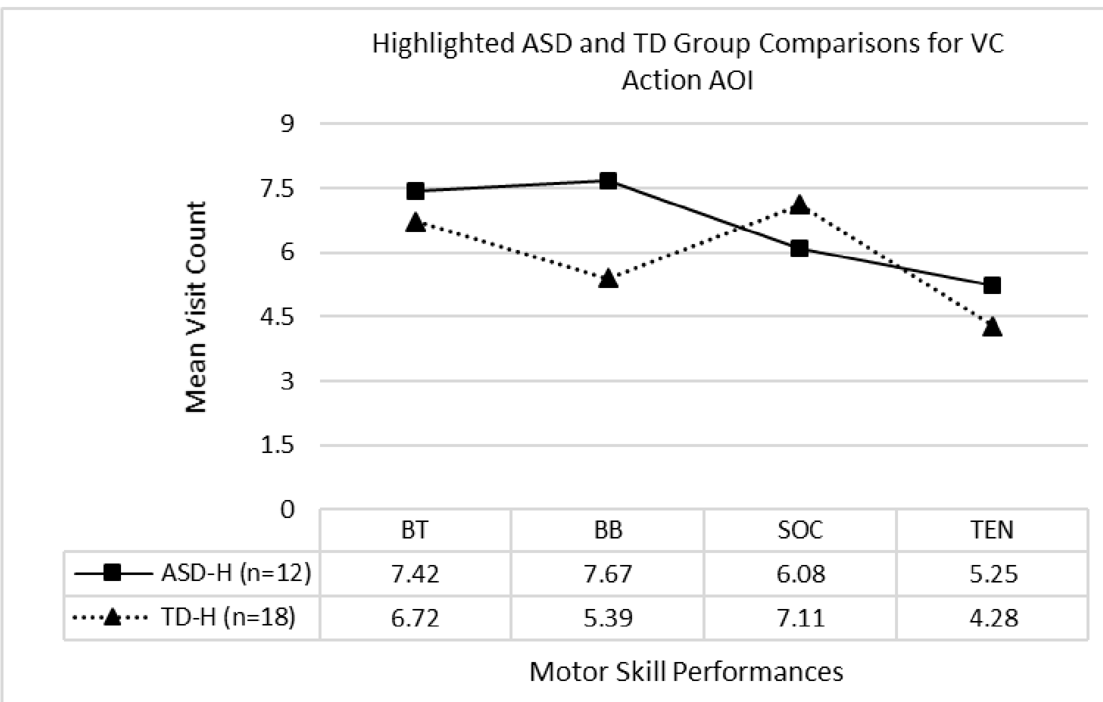

Figure 29. Highlighted ASD and TD Group Comparisons for VC Action.

Non-Highlighted and Highlighted ASD Group Comparisons for VC Action

With regard to the action AOI, results indicated that the ASD-NH group (n = 14) had a lower group mean than the ASD-H group (n = 12) on three of the four motor skills performances (i.e., BT_{action}, BB_{action}, and SOC_{action}). The lower group means indicated fewer visits to the action AOIs.

Results of an independents samples t-test indicated the following:

For BT_{action}, the ASD-NH group (M = 7.07) was lower than the ASD-H group (M = 7.42), t (24) = -0.219, p = .829, and Hedge's g (Hedges & Olkin, 1985) indicated no meaningful effect size was found, g = 0.087.

For BB_{action}, the ASD-NH group (M = 5.00) was lower than the ASD-H group (M = 7.67), t (24) = -1.561, p = .132, and a medium effect size, g = 0.615.

For SOC_{action}, the ASD-NH group (M = 5.79) was lower than the ASD-H group (M = 6.08), t (24) = -0.161, p = .873, and no meaningful effect size was found, g = 0.062.

For TEN_{action}, the ASD-NH group (M = 5.57) was higher than the ASD-H group (M = 5.25), t (24) = 0.271, p = .788, and no meaningful effect size was found, g = 0.106.

Results indicated there were no statistically significant differences in VC to the action AOI between the non-highlighted and highlighted ASD groups. All p-values were greater than .01. Based on these findings, the null hypothesis could not be rejected. Measures of effect size indicated a medium effect size for one of the four motor skill performances. A summary of results are shown in Table 35 and graphically illustrated in Figure 30.

Table 35. *Non-Highlighted and Highlighted ASD Group Comparisons for VC Action*

Motor Skills	ASD-NH (*n*=14)	ASD-H (*n*=12)	*diff.*	*U / t*	*Z / df*	*p*	*ES* [b c]
BT_{action}	7.07 (4.46)	7.42 (3.40)	-0.35	-0.219	24	.829[a]	0.087[b]
BB_{action}	5.00 (4.15)	7.67 (4.56)	-2.67	-1.561	24	.132[a]	0.615[b]
SOC_{action}	5.79 (4.89)	6.08 (4.46)	-0.29	-0.161	24	.873[a]	0.062[b]
TEN_{action}	5.57 (3.03)	5.25 (2.99)	+0.32	0.271	24	.788[a]	0.106[b]

Note. VC measured in count; Standard deviations are in parentheses; *diff.* = between group mean differences; Motor skills performances: BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; Groups: ASD-NH = ASD-non-highlight, TD-NH = TD-non-highlight, ASD-H = ASD-highlight, TD-H = TD-highlight. *Significant $p < .01$.

[a] = *p*-value computed by the independent samples *t*-test.

[b] = Hedge's *g* for an independent samples *t*-test (small=0.2, medium=0.5, large=0.8)

[c] = Cohen's for a Mann-Whitney *U* test (small=0.1, medium=0.3, large=0.5)

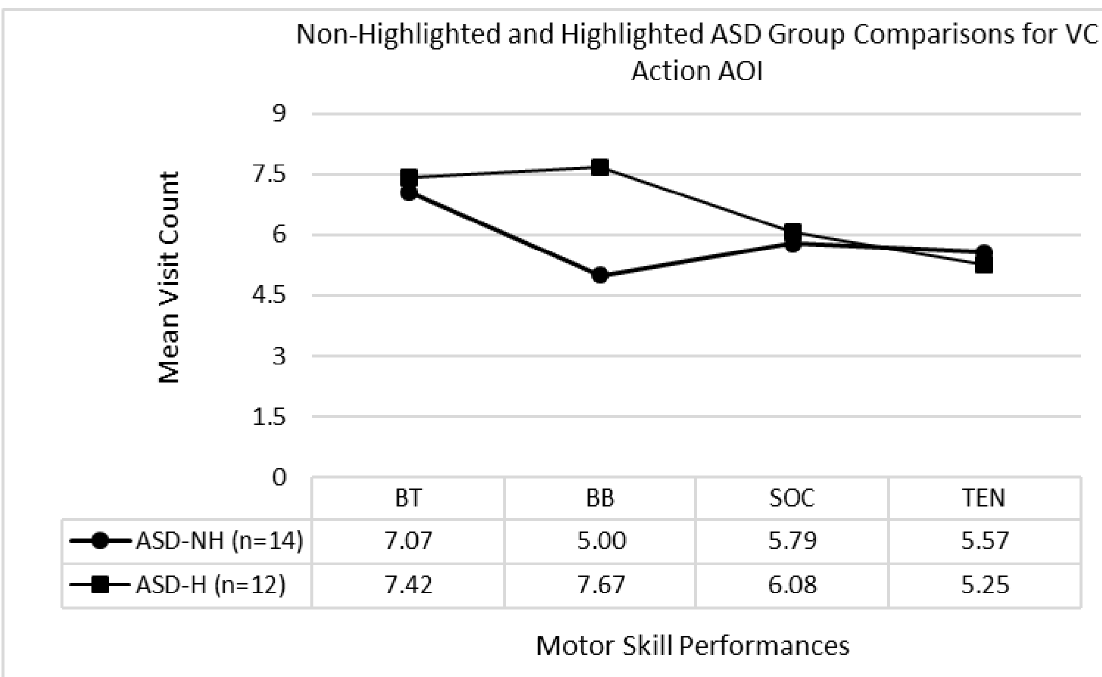

Figure 30. Non-Highlighted and Highlighted ASD Group Comparisons for VC Action.

Non-Highlighted and Highlighted TD Group Comparisons for VC Action

With regard to the action AOI, results indicated that the TD-H group (*n* = 18) had a lower group mean than the TD-NH group (*n* = 22) on all four motor skills performances. The lower group means indicated fewer visits to the action AOI.

Results of the Mann-Whitney *U* test indicated the following: For BT_{action}, the TD-NH group (*M* = 5.41) was lower than the TD-H group (*M* = 6.72), *U* = 163.0, *Z* = -0.959, *p* = .338, and Cohen's (1988) indicated a small effect size, *r* = 0.152. For BB_{action}, the TD-NH group (*M* = 4.27) was lower than the TD-H group (*M* = 5.39), *U* = 150.0, *Z* = -1.318, *p* = .188, and a small effect size, *r* = 0.208. Results of an independent samples *t*-test indicated the following: For SOC_{action}, the TD-NH group (*M* = 6.36) was lower than the TD-H group (*M* = 7.11), *t* (38) = -0.626, *p* = .535, and Hedge's *g* (Hedges & Olkin, 1985) indicated no meaningful effect size was found, *g* = 0.199. For TEN_{action}, the TD-NH group (*M* = 3.91) was lower than the TD-H group (*M* = 4.28), *t* (38) = -0.690, *p* = .494, and a small effect size, *g* = 0.220.

Results indicated there were no statistically significant differences in VC to the action AOI between the non-highlighted and highlighted TD group. All *p*-values were greater than .01. Based on these findings, the null hypothesis could not be rejected. However, measures of effect size indicated small effect sizes for three of the four motor skill performances. A summary of results are shown in Table 36 and graphically illustrated in Figure 31.

Table 36. *Non-Highlighted and Highlighted TD Group Comparisons for VC Action*

Motor Skills	TD-NH (*n*=22)	TD-H (*n*=18)	*diff.*	*U / t*	*Z / df*	*p*	*ES* [b c]
BT_{action}	5.41 (2.11)	6.72 (3.56)	-1.31	163.0	-0.959	.338	0.152[c]
BB_{action}	4.27 (2.49)	5.39 (2.66)	-1.12	150.0	-1.318	.188	0.208[c]
SOC_{action}	6.36 (3.95)	7.11 (3.51)	-0.75	-0.626	38	.535[a]	0.199[b]
TEN_{action}	3.91 (1.82)	4.28 (1.49)	-0.37	-0.690	38	.494[a]	0.220[b]

Note. VC measured in count; Standard deviations are in parentheses; *diff.* = between group mean differences; Motor skills performances: BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; Groups: ASD-NH = ASD-non-highlight, TD-NH = TD-non-highlight, ASD-H = ASD-highlight, TD-H = TD-highlight. *Significant $p < .01$.

[a] = *p*-value computed by the independent samples *t*-test.

[b] = Hedge's *g* for an independent samples *t*-test (small=0.2, medium=0.5, large=0.8)

[c] = Cohen's for a Mann-Whitney *U* test (small=0.1, medium=0.3, large=0.5)

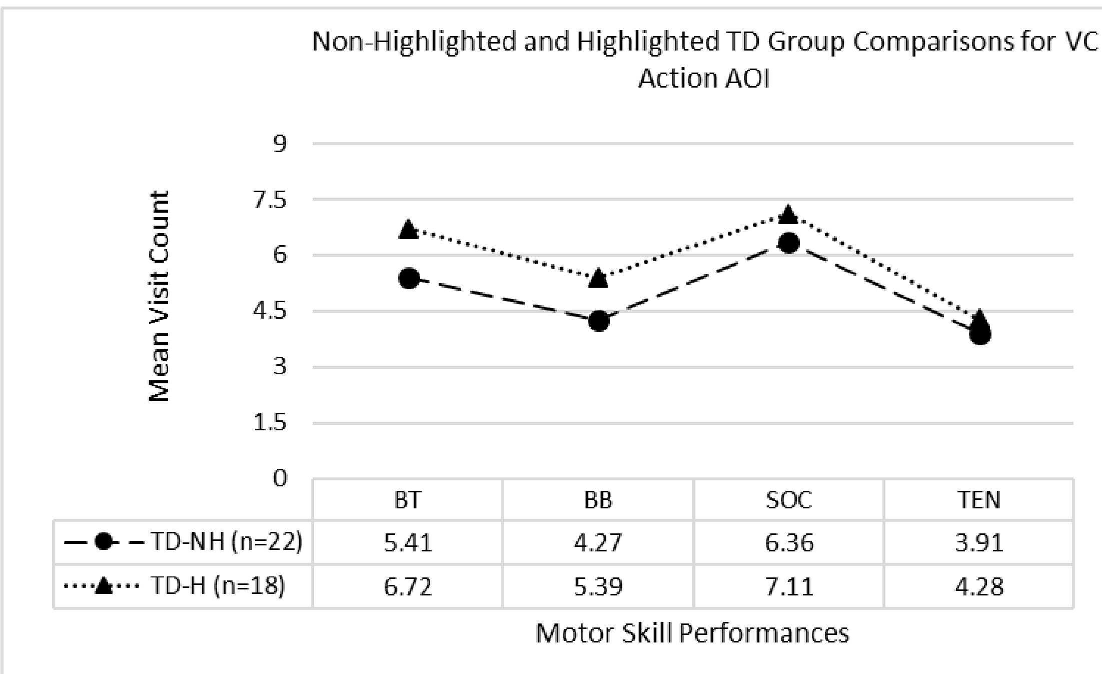

Figure 31. Non-Highlighted and Highlighted TD Group Comparisons for VC Action.

Summary of Results for Visit Count (VC) Cone AOI

Visit Count (VC) measures the number visits and re-visits to an area of interest. A visit ends when the eyes move outside the AOI (Tobii Studio, 2016). For a summary of results for VC to the cone area of interest see Table 37.

Table 37. *Summary of Results for Visit Count (VC) Cone AOI*

Motor Skills	ASD-NH (*n*=14)	TD-NH (*n*=22)	*diff.*	*U / t*	*Z / df*	*p*	*ES* [b c]
BT_{cone}	0.93 (1.14)	0.41 (0.67)	+0.52	117.0	-1.377	.168	0.230[c]
BB_{cone}	0.79 (1.25)	0.59 (1.10)	+0.20	138.0	-0.608	.543	0.101[c]
SOC_{cone}	1.71 (3.20)	0.59 (0.96)	+1.12	122.0	-1.149	.250	0.192[c]
TEN_{cone}	0.79 (1.37)	0.50 (0.80)	+0.29	149.0	-0.200	.842	0.033[c]
	ASD-H (*n*=12)	TD-H (*n*=18)					
BT_{cone}	0.67 (1.15)	0.50 (0.86)	+0.17	105.0	-0.152	.879	0.028[c]
BB_{cone}	0.17 (0.39)	0.56 (0.92)	-0.39	87.0	-1.146	.252	0.209[c]
SOC_{cone}	0.33 (0.49)	0.22 (0.43)	+0.11	96.0	-0.663	.507	0.121[c]
TEN_{cone}	0.08 (0.29)	0.17 (0.38)	-0.09	99.0	-0.647	.518	0.118[c]
	ASD-NH (*n*=14)	ASD-H (*n*=12)					
BT_{cone}	0.93 (1.14)	0.67 (1.15)	+0.26	60.0	-1.523	.128	0.299[c]
BB_{cone}	0.79 (1.25)	0.17 (0.39)	+0.62	71.0	-0.749	.454	0.147[c]
SOC_{cone}	1.71 (3.20)	0.33 (0.49)	+1.38	58.0	-1.492	.136	0.293[c]
TEN_{cone}	0.79 (1.37)	0.08 (0.29)	+0.71	65.0	-1.421	.155	0.279[c]
	TD-NH (*n*=22)	TD-H (*n*=18)					
BT_{cone}	0.41 (0.67)	0.50 (0.86)	-0.09	193.0	-0.165	.869	0.026[c]
BB_{cone}	0.59 (1.10)	0.56 (0.92)	+0.03	195.5	-0.082	.935	0.013[c]
SOC_{cone}	0.59 (0.96)	0.22 (0.43)	+0.37	157.0	-1.360	.174	0.215[c]
TEN_{cone}	0.50 (0.80)	0.17 (0.38)	+0.33	162.0	-1.292	.196	0.204[c]

Note. VC measured in count; Standard deviations are in parentheses; *diff.* = between group mean differences; Motor skills performances: BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; Groups: ASD-NH = ASD-non-highlight, TD-NH = TD-non-highlight, ASD-H = ASD-highlight, TD-H = TD-highlight. *Significant $p < .01$.

[a] = p-value computed by the independent samples t-test.

[b] = Hedge's g for an independent samples t-test (small=0.2, medium=0.5, large=0.8)

[c] = Cohen's for a Mann-Whitney U test (small=0.1, medium=0.3, large=0.5)

Non-Highlighted ASD and TD Group Comparisons for VC Cone

With regard to the cone AOI, results indicated that the ASD-NH group (n = 14) had a higher group mean than the TD-NH group (n = 22) across the four motor skills performances. The higher group means indicated a greater number of visits to the cone AOI.

Results of the Mann-Whitney U test indicated the following: For BT_{cone}, the ASD-NH group (M = 0.93) was higher than the TD-NH group (M = 0.41), U = 117.0, Z = -1.377, p = .168, and Cohen's (1988) indicated a small effect size, and a small effect size, r = 0.230. For BB_{cone}, the ASD-NH group (M = 0.79) was higher than the TD-NH group (M = 0.59), U = 138.0, Z = -0.608, p = .543, and a small effect size, r = 0.101. For SOC_{cone}, the ASD-NH group (M = 1.71) was higher than the TD-NH group (M = 0.59), U = 122.0, Z = -1.149, p = .250, and a small effect size, r = 0.192. For TEN_{cone}, the ASD-NH group (M = 0.79) was higher than the TD-NH group (M = 0.50), U = 149.0, Z = -0.200, p = .842, and no meaningful effect size was found, r = 0.033.

Results indicated there were no statistically significant differences in VC to the cone AOI between the ASD and TD groups in the non-highlighted condition. All p-values were greater than .01. Based on these findings, the null hypothesis could not be rejected. However, measures of effect size indicated small effect sizes for three of the four motor skill performances. A summary of results are shown in Table 38 and graphically illustrated in Figure 32.

Table 38. *Non-Highlighted ASD and TD Group Comparisons for VC Cone*

Motor Skills	ASD-NH (*n*=14)	TD-NH (*n*=22)	*diff.*	*U / t*	*Z / df*	*p*	*ES* [b c]
BT_{cone}	0.93 (1.14)	0.41 (0.67)	+0.52	117.0	-1.377	.168	0.230[c]
BB_{cone}	0.79 (1.25)	0.59 (1.10)	+0.20	138.0	-0.608	.543	0.101[c]
SOC_{cone}	1.71 (3.20)	0.59 (0.96)	+1.12	122.0	-1.149	.250	0.192[c]
TEN_{cone}	0.79 (1.37)	0.50 (0.80)	+0.29	149.0	-0.200	.842	0.033[c]

Note. VC measured in count; Standard deviations are in parentheses; *diff.* = between group mean differences; Motor skills performances: BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; Groups: ASD-NH = ASD-non-highlight, TD-NH = TD-non-highlight, ASD-H = ASD-highlight, TD-H = TD-highlight. *Significant $p < .01$.

[a] = p-value computed by the independent samples t-test.

[b] = Hedge's g for an independent samples t-test (small=0.2, medium=0.5, large=0.8)

[c] = Cohen's for a Mann-Whitney U test (small=0.1, medium=0.3, large=0.5)

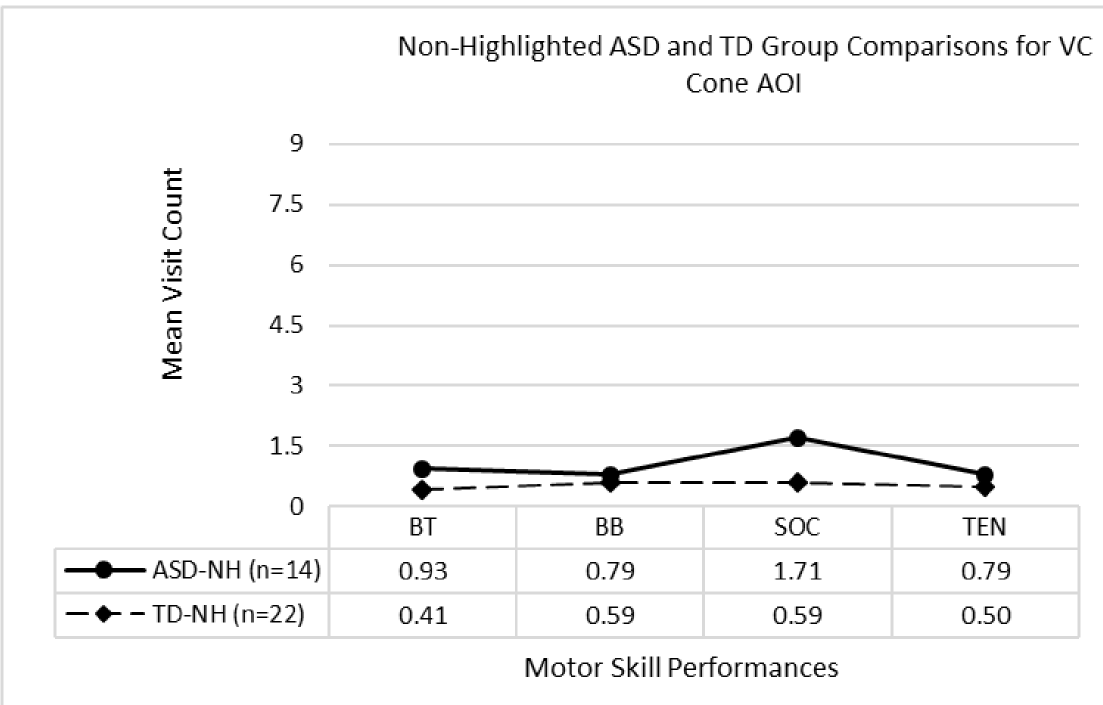

Figure 32. Non-Highlighted ASD and TD Group Comparisons for VC Cone.

Highlighted ASD and TD Group Comparisons for VC Cone

With regard to the cone AOI, results indicated that the ASD-H group (n = 12) had a higher group mean than the TD-H group (n = 18) on two of the four motor skills performances (i.e., BT_{cone} and SOC_{cone}). The higher group means indicated a greater number of visits to the cone AOI.

Results of the Mann-Whitney U test indicated the following: For BT_{cone}, the ASD-H group (M = 0.67) was higher than the TD-H group (M = 0.50), U = 105.0, Z = -0.152, p = .879, and Cohen's (1988) indicated no meaningful effect size was found, r = 0.028. For BB_{cone}, the ASD-H group (M = 0.17) was lower than the TD-H group (M = 0.56), U = 87.0, Z = -1.146, p = .252, and a small effect size, r = 0.209. For SOC_{cone}, the ASD-H group (M = 0.33) was higher than the TD-H group (M = 0.22), U = 96.0, Z = -0.663, p = .507, and a small effect size, r = 0.121. For TEN_{cone}, the ASD-H group (M = 0.08) was lower than the TD-H group (M = 0.17), U = 99.0, Z = -0.647, p = .518, and a small effect size, r = 0.118.

Results indicated there were no statistically significant differences in VC to the cone AOI between the ASD and TD groups in the highlighted condition. All p-values were greater than .01. Based on these findings, the null hypothesis could not be rejected. However, measures of effect size indicated small effect sizes for three of the four motor skill performances. A summary of results are shown in Table 39 and graphically illustrated in Figure 33.

Table 39. *Highlighted ASD and TD Group Comparisons for VC Cone*

Motor Skills	ASD-H (*n*=12)	TD-H (*n*=18)	*diff.*	*U / t*	*Z / df*	*p*	*ES* [b c]
BT_{cone}	0.67 (1.15)	0.50 (0.86)	+0.17	105.0	-0.152	.879	0.028[c]
BB_{cone}	0.17 (0.39)	0.56 (0.92)	-0.39	87.0	-1.146	.252	0.209[c]
SOC_{cone}	0.33 (0.49)	0.22 (0.43)	+0.11	96.0	-0.663	.507	0.121[c]
TEN_{cone}	0.08 (0.29)	0.17 (0.38)	-0.09	99.0	-0.647	.518	0.118[c]

Note. VC measured in count; Standard deviations are in parentheses; *diff.* = between group mean differences; Motor skills performances: BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; Groups: ASD-NH = ASD-non-highlight, TD-NH = TD-non-highlight, ASD-H = ASD-highlight, TD-H = TD-highlight. *Significant $p < .01$.

[a] = *p*-value computed by the independent samples *t*-test.

[b] = Hedge's *g* for an independent samples *t*-test (small=0.2, medium=0.5, large=0.8)

[c] = Cohen's for a Mann-Whitney *U* test (small=0.1, medium=0.3, large=0.5)

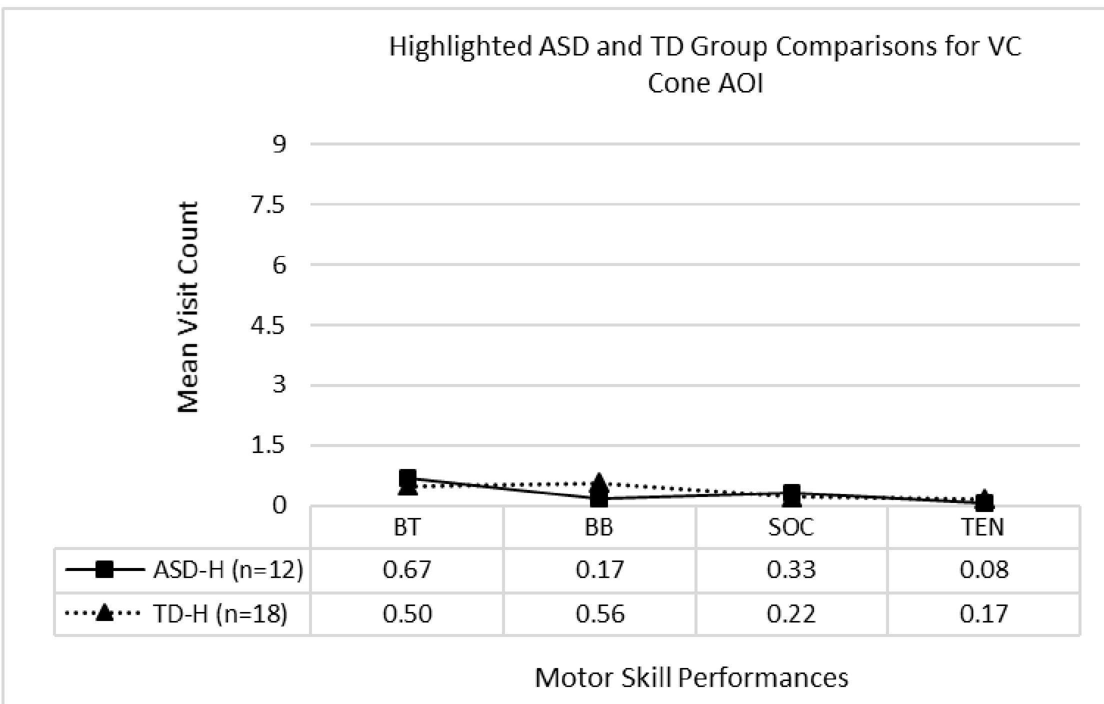

Figure 33. Highlighted ASD and TD Group Comparisons for VC Cone.

Non-Highlighted and Highlighted ASD Group Comparisons for VC Cone

With regard to the cone AOI, results indicated that the ASD-NH group (n = 14) had a higher group mean than the AOI ASD-H group (n = 12) across the four motor skills performances. The higher group means indicated a greater number of visits to the cone AOI.

Results of the Mann-Whitney U test indicated the following: For BT_{cone}, the ASD-NH group (M = 0.93) was higher than the ASD-H group (M = 0.67), U = 60.0, Z = -1.523, p = .128, and Cohen's (1988) indicated a small effect size, r = 0.299. For BB_{cone}, the ASD-NH group (M = 0.79) was higher than the ASD-H group (M = 0.17), U = 71.0, Z = -0.749, p = .454, and a small effect size, r = 0.147. For SOC_{cone}, the ASD-NH group (M = 1.71) was higher than the ASD-H group (M = 0.33), U = 58.0, Z = -1.492, p = .136, and a small effect size, r = 0.293. For TEN_{cone}, the ASD-NH group (M = 0.79) was higher than the ASD-H group (M = 0.08), U = 65.0, Z = -1.421, p = .155, and a small effect size, r = 0.279.

Results indicated there were no statistically significant differences in VC to the cone AOI between the non-highlighted and highlighted ASD group. All p-values were greater than .01. Based on these findings, the null hypothesis could not be rejected. However, measures of effect size indicated small effect sizes across the four motor skill performances. A summary of results are shown in Table 40 and graphically illustrated in Figure 34.

Table 40. *Non-Highlighted and Highlighted ASD Group Comparisons for VC Cone*

Motor Skills	ASD-NH (*n*=14)	ASD-H (*n*=12)	*diff.*	*U / t*	*Z / df*	*p*	*ES* [b c]
BT_{cone}	0.93 (1.14)	0.67 (1.15)	+0.26	60.0	-1.523	.128	0.299[c]
BB_{cone}	0.79 (1.25)	0.17 (0.39)	+0.62	71.0	-0.749	.454	0.147[c]
SOC_{cone}	1.71 (3.20)	0.33 (0.49)	+1.38	58.0	-1.492	.136	0.293[c]
TEN_{cone}	0.79 (1.37)	0.08 (0.29)	+0.71	65.0	-1.421	.155	0.279[c]

Note. VC measured in count; Standard deviations are in parentheses; *diff.* = between group mean differences; Motor skills performances: BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; Groups: ASD-NH = ASD-non-highlight, TD-NH = TD-non-highlight, ASD-H = ASD-highlight, TD-H = TD-highlight. *Significant $p < .01$.
[a] = *p*-value computed by the independent samples *t*-test.
[b] = Hedge's *g* for an independent samples *t*-test (small=0.2, medium=0.5, large=0.8)
[c] = Cohen's for a Mann-Whitney *U* test (small=0.1, medium=0.3, large=0.5)

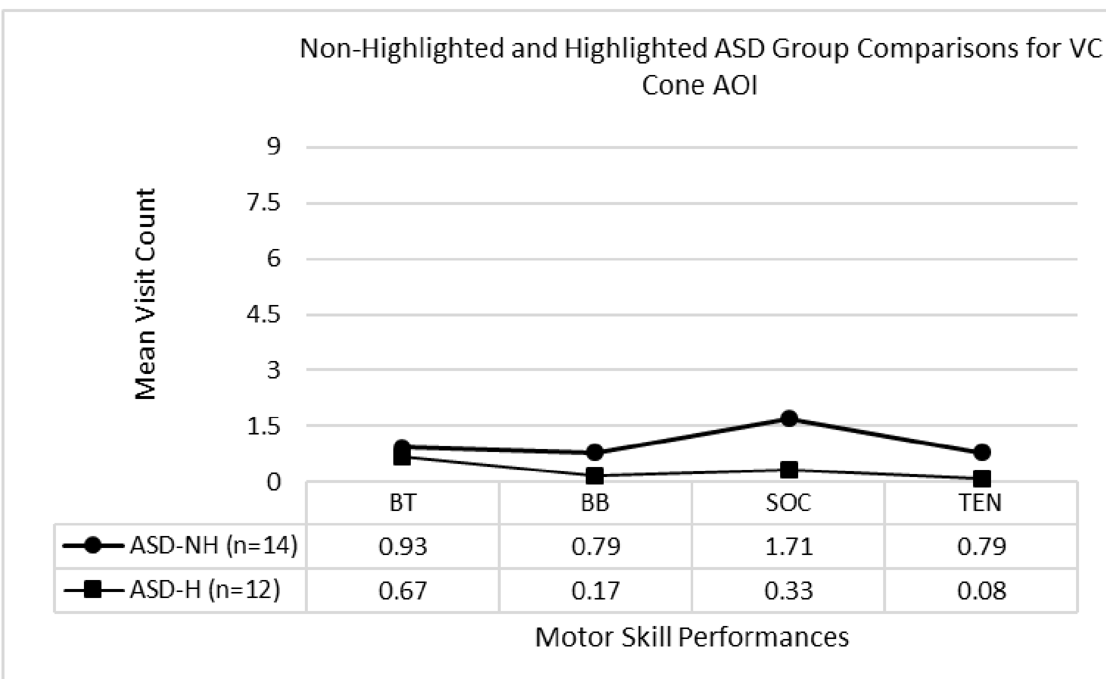

Figure 34. Non-Highlighted and Highlighted ASD Group Comparisons for VC Cone.

Non-Highlighted and Highlighted TD Group Comparisons for VC Cone

With regard to cone AOI, results indicated that the TD-NH group (*n* = 22) had a higher group mean than the TD-H group (*n* = 18) on three of the four motor skills performances (i.e., BB_{cone}, SOC_{cone}, and TEN_{cone}). The higher group means indicated a greater number of visits to the cone AOI.

Results of the Mann-Whitney *U* test indicated the following: For BT_{cone}, the TD-NH group (*M* = 0.41) was lower than the TD-H group (*M* = 0.50), *U* = 193.0, *Z* = -0.165, *p* = .869, and Cohen's (1988) indicated no meaningful effect size, *r* = 0.026. For BB_{cone}, the TD-NH group (*M* = 0.59) was higher than the TD-H group (*M* = 0.56), *U* = 195.5, *Z* = -0.082, *p* = .935, and no meaningful effect size was found, *r* = 0.013. For SOC_{cone}, the TD-NH group (*M* = 0.59), was higher than the TD-H group (*M* = 0.22), *U* = 157.0, *Z* = -1.360, *p* = .174, and a small effect size, *r* = 0.215. For TEN_{cone}, the TD-NH group (*M* = 0.50) was higher than the TD-H group (*M* = 0.17), *U* = 162.0, *Z* = -1.292, *p* = .196, and a small effect size, *r* = 0.204.

Results indicated there were no statistically significant differences in VC to the cone AOI between the non-highlighted and highlighted TD group. All *p*-values were greater than .01. Based on these findings, the null hypothesis could not be rejected. However, measures of effect size indicated small effect sizes for two of the four motor skill performances. A summary of results are shown in Table 41 and graphically illustrated in Figure 35.

Table 41. *Non-Highlighted and Highlighted TD Group Comparisons for VC Cone*

Motor Skills	TD-NH (*n*=22)	TD-H (*n*=18)	*diff.*	*U / t*	*Z / df*	*p*	*ES* [b c]
BT_{cone}	0.41 (0.67)	0.50 (0.86)	-0.09	193.0	-0.165	.869	0.026[c]
BB_{cone}	0.59 (1.10)	0.56 (0.92)	+0.03	195.5	-0.082	.935	0.013[c]
SOC_{cone}	0.59 (0.96)	0.22 (0.43)	+0.37	157.0	-1.360	.174	0.215[c]
TEN_{cone}	0.50 (0.80)	0.17 (0.38)	+0.33	162.0	-1.292	.196	0.204[c]

Note. VC measured in count; Standard deviations are in parentheses; *diff.* = between group mean differences; Motor skills performances: BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; Groups: ASD-NH = ASD-non-highlight, TD-NH = TD-non-highlight, ASD-H = ASD-highlight, TD-H = TD-highlight. *Significant $p < .01$.

[a] = *p*-value computed by the independent samples *t*-test.

[b] = Hedge's *g* for an independent samples *t*-test (small=0.2, medium=0.5, large=0.8)

[c] = Cohen's for a Mann-Whitney *U* test (small=0.1, medium=0.3, large=0.5)

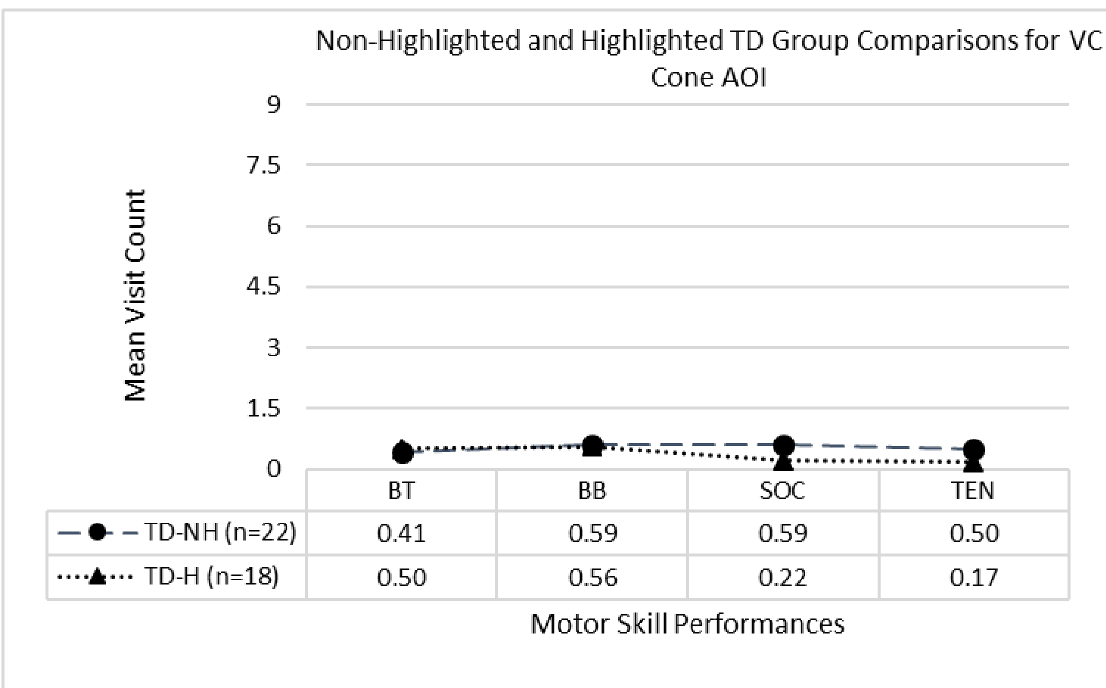

Figure 35. Non-Highlighted and Highlighted TD Group Comparisons for VC Cone.

Summary of Results for Visit Count (VC) Head AOI

Visit Count (VC) measures the number of visits and re-visits to an area of interest (AOI). A visit ends when the eyes move outside the AOI (Tobii Studio, 2016). For a summary of results for VC to the head area of interest see Table 42.

Table 42. *Summary of Results for Visit Count Head AOI*

Motor Skills	ASD-NH (n=14)	TD-NH (n=22)	*diff.*	U / t	Z / df	p	$ES^{b\ c}$
BT_{head}	3.21 (3.66)	2.73 (1.98)	+0.48	149.0	-0.165	.869	0.028[c]
BB_{head}	2.07 (2.23)	2.86 (2.40)	-0.79	123.5	-1.006	.314	0.168[c]
SOC_{head}	1.36 (2.31)	2.68 (2.10)	-1.32	84.5	-2.304	.021	0.384[c]
TEN_{head}	3.29 (3.38)	2.73 (2.05)	+0.56	148.0	-0.197	.844	0.033[c]
	ASD-H (n=12)	TD-H (n=18)					
BT_{head}	3.42 (2.11)	3.39 (2.35)	+0.03	.033	28	.974[a]	0.013[b]
BB_{head}	2.92 (2.27)	2.72 (1.74)	+0.20	.265	28	.793[a]	0.102[b]
SOC_{head}	1.67 (2.15)	1.89 (1.60)	-0.22	89.5	-0.804	.421	0.147[c]
TEN_{head}	1.83 (1.19)	2.00 (1.50)	-0.17	-.323	28	.749[a]	0.123[b]
	ASD-NH (n=14)	ASD-H (n=12)					
BT_{head}	3.21 (3.66)	3.42 (2.11)	-0.21	67.5	-0.859	.391	0.143[c]
BB_{head}	2.07 (2.23)	2.92 (2.27)	-0.85	61.5	-1.179	.238	0.197[c]
SOC_{head}	1.36 (2.31)	1.67 (2.15)	-0.31	72.0	-0.662	.508	0.110[c]
TEN_{head}	3.29 (3.38)	1.83 (1.19)	+1.46	73.5	-0.554	.580	0.092[c]
	TD-NH (n=22)	TD-H (n=18)					
BT_{head}	2.73 (1.98)	3.39 (2.35)	-0.66	168.5	-0.811	.417	0.128[c]
BB_{head}	2.86 (2.40)	2.72 (1.74)	+0.14	192.5	-0.152	.879	0.024[c]
SOC_{head}	2.68 (2.10)	1.89 (1.60)	+0.79	157.0	-1.135	.256	0.179[c]
TEN_{head}	2.73 (2.05)	2.00 (1.50)	+0.73	162.0	-0.996	.319	0.157[c]

Note. VC measured in count; Standard deviations are in parentheses; *diff.* = between group mean differences; Motor skills performances: BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; Groups: ASD-NH = ASD-non-highlight, TD-NH = TD-non-highlight, ASD-H = ASD-highlight, TD-H = TD-highlight. *Significant $p < .01$.

[a] = p-value computed by the independent samples t-test.

[b] = Hedge's g for an independent samples t-test (small=0.2, medium=0.5, large=0.8)

[c] = Cohen's for a Mann-Whitney U test (small=0.1, medium=0.3, large=0.5)

Non-Highlighted ASD and TD Group Comparisons for VC Head

With regard to the head AOI, results indicated that the ASD-NH group (n = 14) had a higher group mean than the TD-NH group (n = 22) on two of the four motor skills performances (i.e., BT_{head} and SOC_{head}). The higher group means indicated a greater number of visits to the head AOI.

Results of the Mann-Whitney U test indicated the following: For BT_{head}, the ASD-NH group (M = 3.21) was higher than the TD-NH group (M = 2.73), U = 149.0, Z = -0.165, p = .869, and Cohen's (1988) indicated no meaningful effect size, r = 0.028. For BB_{head}, the ASD-NH group (M = 2.07) was lower than the TD-NH group (M = 2.86), U = 123.5, Z = -1.006, p = .314, and a small effect size, r = 0.168. For SOC_{head}, the ASD-NH group (M = 1.36) was lower than the TD-NH group (M = 2.68), U = 84.5, Z = -2.304, p = .021, and a medium effect size, r = 0.384. For TEN_{head}, the ASD-NH group (M = 3.29) was higher than the TD-NH group (M = 2.73), U = 148.0, Z = -0.197, p = .844, and no meaningful effect size was found, r = 0.033.

Results indicated there were no statistically significant differences in VC to the head AOI between the ASD and TD groups in the non-highlighted condition. All p-values were greater than .01. Based on these findings, the null hypothesis could not be rejected. Measures of effect size indicated a small effect size for one of the four motor skill performances. A summary of are shown in Table 43 and graphically illustrated in Figure 36.

Table 43. *Non-Highlighted ASD and TD Group Comparisons for VC Head*

Motor Skills	ASD-NH (*n*=14)	TD-NH (*n*=22)	*diff.*	*U / t*	*Z / df*	*p*	*ES* [b c]
BT_{head}	3.21 (3.66)	2.73 (1.98)	+0.48	149.0	-0.165	.869	0.028[c]
BB_{head}	2.07 (2.23)	2.86 (2.40)	-0.79	123.5	-1.006	.314	0.168[c]
SOC_{head}	1.36 (2.31)	2.68 (2.10)	-1.32	84.5	-2.304	.021	0.384[c]
TEN_{head}	3.29 (3.38)	2.73 (2.05)	+0.56	148.0	-0.197	.844	0.033[c]

Note. VC measured in count; Standard deviations are in parentheses; *diff.* = between group mean differences; Motor skills performances: BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; Groups: ASD-NH = ASD-non-highlight, TD-NH = TD-non-highlight, ASD-H = ASD-highlight, TD-H = TD-highlight. *Significant $p < .01$.

[a] = *p*-value computed by the independent samples *t*-test.

[b] = Hedge's *g* for an independent samples *t*-test (small=0.2, medium=0.5, large=0.8)

[c] = Cohen's for a Mann-Whitney *U* test (small=0.1, medium=0.3, large=0.5)

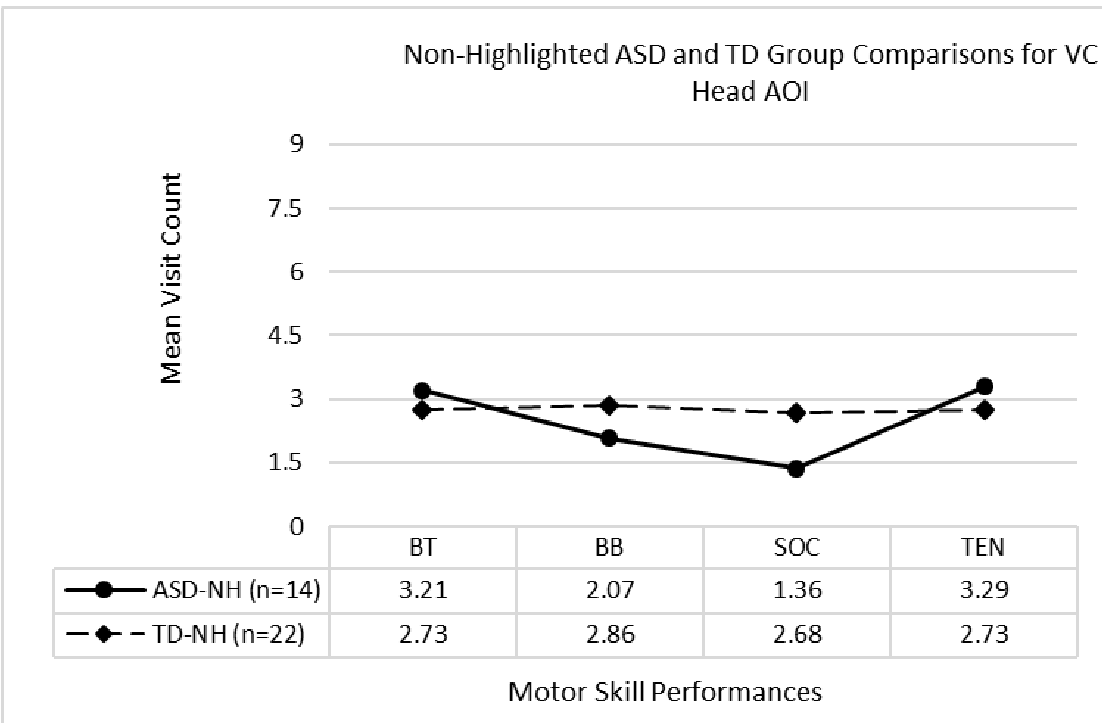

Figure 36. Non-Highlighted ASD and TD Group Comparisons for VC Head.

Highlighted ASD and TD Group Comparisons for VC Head

With regard to the head AOI, results indicated that the ASD-H group (*n* = 12) had a higher group mean than the TD-H group (*n* = 18) on two of the four motor skills performances (i.e., BT_{head} and BB_{head}). The higher group means indicated a greater number of visits to the head AOI.

Results of an independent samples *t*-test indicated the following: For BT_{head}, the ASD-H group (M = 3.42) was higher than the TD-H group (M = 3.39), t (28) = .033, p = .974, and Hedge's *g* (Hedges & Olkin, 1985) indicated no meaningful effect size was found, g = 0.013. For BB_{head}, the ASD-H group (M = 2.92) was higher than the TD-H group (M = 2.72), t (28) =.265, p = .793, and no meaningful effect size was found, g = 0.102. Results of the Mann-Whitney *U* test indicated the following: For SOC_{head}, the ASD-H group (M = 1.67) was lower than the TD-H group (M = 1.89), U = 89.5, Z = -0.804, p = .421, and Cohen's (1988) indicated a small effect size, r = 0.147. Results of an independent samples *t*-test indicated the following: For TEN_{head}, the ASD-H group (M = 1.83) was lower than the TD-H group (M = 2.00), t (28) = -.323, p = .749, and no meaningful effect size was found, g = 0.123.

Results indicated there were no statistically significant differences in VC to the head AOI between the ASD and TD groups in the highlighted condition. All *p*-values were greater than .01. Based on these findings, the null hypothesis could not be rejected. Measures of effect size indicated a small effect size for one of the four motor skill performances. A summary of results are shown in Table 44 and graphically illustrated in Figure 37.

Table 44. *Highlighted ASD and TD Group Comparisons for VC Head*

Motor Skills	ASD-H (*n*=12)	TD-H (*n*=18)	*diff.*	*U / t*	*Z / df*	*p*	*ES* [b c]
BT_{head}	3.42 (2.11)	3.39 (2.35)	+0.03	.033	28	.974[a]	0.013[b]
BB_{head}	2.92 (2.27)	2.72 (1.74)	+0.20	.265	28	.793[a]	0.102[b]
SOC_{head}	1.67 (2.15)	1.89 (1.60)	-0.22	89.5	-0.804	.421	0.147[c]
TEN_{head}	1.83 (1.19)	2.00 (1.50)	-0.17	-.323	28	.749[a]	0.123[b]

Note. VC measured in count; Standard deviations are in parentheses; *diff.* = between group mean differences; Motor skills performances: BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; Groups: ASD-NH = ASD-non-highlight, TD-NH = TD-non-highlight, ASD-H = ASD-highlight, TD-H = TD-highlight. *Significant $p < .01$.

[a] = *p*-value computed by the independent samples *t*-test.

[b] = Hedge's *g* for an independent samples *t*-test (small=0.2, medium=0.5, large=0.8)

[c] = Cohen's for a Mann-Whitney *U* test (small=0.1, medium=0.3, large=0.5)

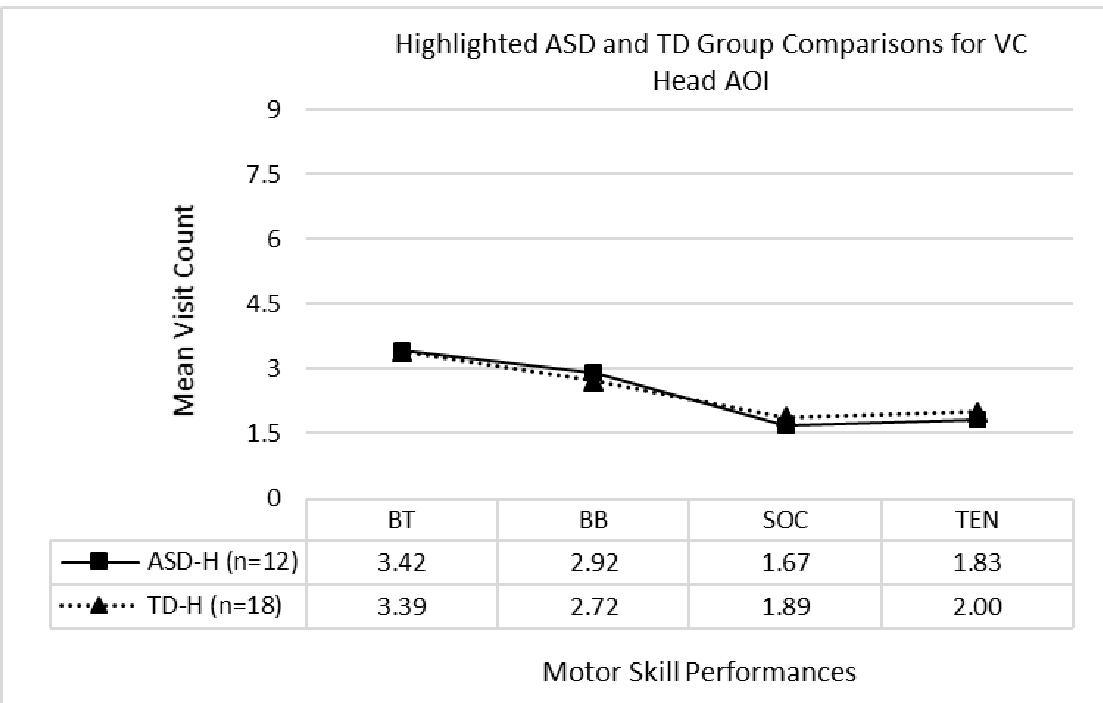

Figure 37. Highlighted ASD and TD Group Comparisons for VC Head.

Non-Highlighted and Highlighted ASD Group Comparisons for VC Head

With regard to the head AOI, results indicated that the ASD-NH group (n = 14) had a lower group mean than the ASD-H group (n = 12) on three of the four motor skills performances (i.e., BB_{head}, BT_{head}, and SOC_{head}). The lower group means indicated fewer visits to the head AOI.

Results of the Mann-Whitney U test indicated the following: For BT_{head}, the ASD-NH group (M = 3.21) was lower than the ASD-H group (M = 3.42) U = 67.5, Z = -0.859, p = .391, and Cohen's (1988) indicated a small effect size, r = 0.143. For BB_{head}, the ASD-NH group (M = 2.07) was lower than the ASD-H group (M = 2.92) U = 61.5, Z = -1.179, p = .238, and a small effect size, r = 0.197. For SOC_{head}, the ASD-NH group (M = 1.36) was lower than the ASD-H group (M = 1.67), U = 72.0, Z = -0.662, p = .508, and a small effect size, r = 0.110. For TEN_{head}, the ASD-NH group (M = 3.29) was higher than the ASD-H group (M = 1.83) U = 73.5, Z = -0.554, p = .580, and no meaningful effect size was found, r = 0.092.

Results indicated there were no statistically significant differences in VC to the head AOI between the non-highlighted and highlighted ASD group. All p-values were greater than .01. Based on these findings, the null hypothesis could not be rejected. However, measures of effect size indicated small effect sizes for three of the four motor skill performances. A summary of results are shown in Table 45 and graphically illustrated in Figure 38.

Table 45. *Non-Highlighted and Highlighted ASD Group Comparisons for VC Head*

Motor Skills	ASD-NH (n=14)	ASD-H (n=12)	*diff.*	U / t	Z / df	p	$ES^{b\ c}$
BT_{head}	3.21 (3.66)	3.42 (2.11)	-0.21	67.5	-0.859	.391	0.143[c]
BB_{head}	2.07 (2.23)	2.92 (2.27)	-0.85	61.5	-1.179	.238	0.197[c]
SOC_{head}	1.36 (2.31)	1.67 (2.15)	-0.31	72.0	-0.662	.508	0.110[c]
TEN_{head}	3.29 (3.38)	1.83 (1.19)	+1.46	73.5	-0.554	.580	0.092[c]

Note. VC measured in count; Standard deviations are in parentheses; *diff.* = between group mean differences; Motor skills performances: BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; Groups: ASD-NH = ASD-non-highlight, TD-NH = TD-non-highlight, ASD-H = ASD-highlight, TD-H = TD-highlight. *Significant $p < .01$.

[a] = p-value computed by the independent samples t-test.

[b] = Hedge's g for an independent samples t-test (small=0.2, medium=0.5, large=0.8)

[c] = Cohen's for a Mann-Whitney U test (small=0.1, medium=0.3, large=0.5)

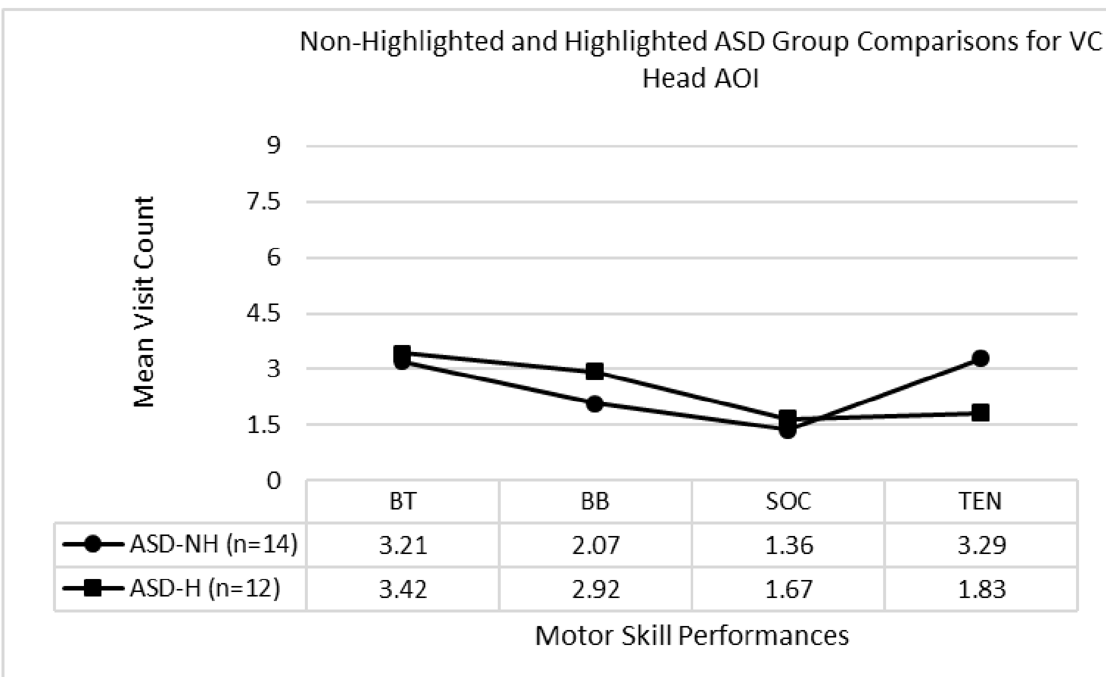

Figure 38. Non-Highlighted and Highlighted ASD Group Comparisons for VC Head.

Non-Highlighted and Highlighted TD Group Comparisons for VC Head

With regard to the head AOI, results indicated that the TD-NH group (*n* = 22) had a higher group mean than the TD-H group (*n* = 18) on three of the four motor skills performances (i.e., BB_{head}, SOC_{head}, and TEN_{head}). The higher group means indicated a greater number of visits to the head AOI.

Results of the Mann-Whitney *U* test indicated the following: For BT_{head}, the TD-NH group (M = 2.73) was lower than the TD-H group (M = 3.39), U = 168.5, Z = -0.811, p = .417, and Cohen's (1988) indicated a small effect size, r = 0.128. For BB_{head}, the TD-NH group (M = 2.86) was higher than the TD-H group (M = 2.72), U = 192.5, Z = -0.152, p = .879, and no meaningful effect size was found, r = 0.024. For SOC_{head}, the TD-NH group (M = 2.68) was higher than the TD-H group (M = 1.89), U = 157.0, Z = -1.135, p = .256, and a small effect size, r = 0.179. For TEN_{head}, the TD-NH group (M = 2.73) was higher than the TD-H group (M = 2.00), U = 162.0, Z = -0.996, p = .319, and a small effect size, r = 0.157.

Results indicated there were no statistically significant differences in VC to the head AOI between the non-highlighted and highlighted TD group. All *p*-values were greater than .01. Based on these findings, the null hypothesis could not be rejected. However, measures of effect size indicated a small effect size for three of the four motor skill performances. A summary of results are shown in Table 46 and graphically illustrated in Figure 39.

Table 46. *Non-Highlighted and Highlighted TD Group Comparisons for VC Head*

Motor Skills	TD-NH (*n*=22)	TD-H (*n*=18)	*diff.*	*U / t*	*Z / df*	*p*	*ES* [b c]
BT_{head}	2.73 (1.98)	3.39 (2.35)	-0.66	168.5	-0.811	.417	0.128[c]
BB_{head}	2.86 (2.40)	2.72 (1.74)	+0.14	192.5	-0.152	.879	0.024[c]
SOC_{head}	2.68 (2.10)	1.89 (1.60)	+0.79	157.0	-1.135	.256	0.179[c]
TEN_{head}	2.73 (2.05)	2.00 (1.50)	+0.73	162.0	-0.996	.319	0.157[c]

Note. VC measured in count; Standard deviations are in parentheses; *diff.* = between group mean differences; Motor skills performances: BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; Groups: ASD-NH = ASD-non-highlight, TD-NH = TD-non-highlight, ASD-H = ASD-highlight, TD-H = TD-highlight. *Significant $p < .01$.

[a] = *p*-value computed by the independent samples *t*-test.

[b] = Hedge's *g* for an independent samples *t*-test (small=0.2, medium=0.5, large=0.8)

[c] = Cohen's effect size for a Mann-Whitney *U* test (small=0.1, medium=0.3, large=0.5)

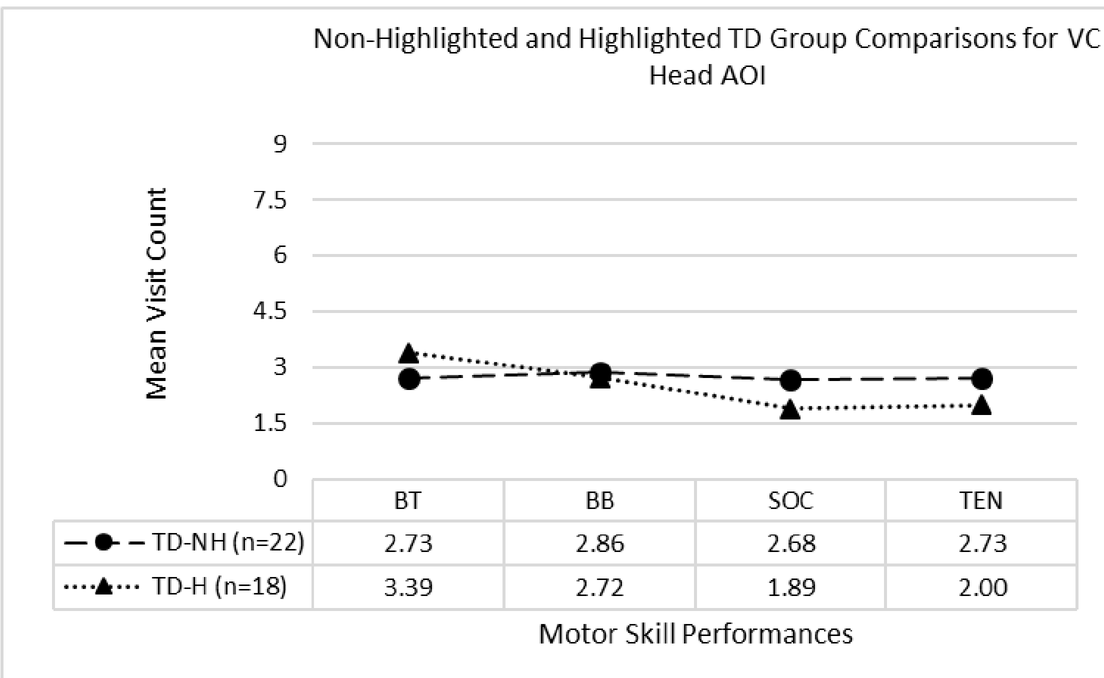

Figure 39. Non-Highlighted and Highlighted TD Group Comparisons for VC Head.

CHAPTER V: DISCUSSION

In 1943, both, Leo Kanner and Hans Asperger reported an array of motor deficits and delays (i.e., posture control, gait patterns, gross motor performances) in children with autism (Asperger & Frith, 1991; Kanner, 1943). Today, researchers continue to examine the motor deficits of this population (Downey & Rapport, 2012; Fournier et al., 2010; Paquet et al., 2016; Van Damme et al., 2015). Based on these findings, it is necessary to identify effective interventions and instructional strategies to support the motor development of children with autism. According to SHAPE America, ". . . motor competency is essential for participation in physical activity and for health-enhancing fitness" (America, S. H. A. P. E., Couturier et al., 2014, p. 6). Therefore, it is necessary for researchers to explore evidence-based practices to support the motor development of children with autism. Evidence-based practices are interventions shown to be effective and have sufficient empirical support (Wong et al., 2014).

One evidence-based practice shown to be effective in teaching children with autism is video modeling (Ayres & Langone, 2005; Bellini & Akullian, 2007; D'Ateno et al., 2003; McCoy & Hermansen, 2007). Deeply rooted in the works of Albert Bandura's Social Cognitive Theory (1986, 1977), numerous studies have shown video modeling to be an effective practice in teaching behavioral functioning, social communication skills, and functional skills (Bellini & Akullian, 2007). However, very few studies have examined the effects of video modeling in teaching motor skills to children with autism

(Gies, 2012; Gruber, 2008; Kourassanis et al., 2014; Trocki-Ables, 2014; Yanardag et al., 2013).

As researchers extend the literature on the effects of video modeling, there has been a growing interest in the visual attention patterns of children with autism. Using eye-tracking technology, researchers have identified an array of atypical visual attention patterns amongst this population. For example, researchers have shown children with autism to have reduced eye gaze towards faces (Sasson & Touchstone, 2014), a stronger preference towards moving geometric shapes than social images (Pierce et al., 2015), limited exploration of images, and longer periods of fixation (Sasson et al., 2008). What's more, studies have shown that children with autism attend less to biological motion (Annaz, Campbell, Coleman, Milne, & Swettenham, 2012; Klin et al., 2009), and more to background objects than typically developing children (Shic et al., 2011).

The purpose of this study was to examine and compare the visual attention patterns of children with autism to typically developing children as they observed video-modeled demonstrations of four motor skill performances. Quantitative data were collected on the eye-tracking metrics: (a) time to first fixation, (b) total visit duration, and (c) visit count. In addition, the current study examined the effects of attentional highlighting to the action area of the video-modeled performances. The findings of this investigation could lead to more innovative ideas in the design, creation, and presentation of video-modeled motor skill performances to children with autism.

This chapter is organized into the following sections: (a) discussion of the results including pertinent literature, (b) limitations of the study, (c) future research, and (d) conclusion.

Discussion of the Results including Pertinent Literature

Time to First Fixation

Time to First Fixation (TFF) is the measure of time in seconds from the onset of a visual stimulus to the participant's first fixation to an area of interest (AOI) (Tobii Studio, 2016). AOIs are defined regions from which quantitative data are collected (Holmqvist et al., 2011). In this investigation, three AOIs (i.e., action, cone, and head) were built into each motor skill performance videos and were not visible to the participants (see Figure 40). Quantitative data from the AOIs were collected and analyzed to address the following research questions:

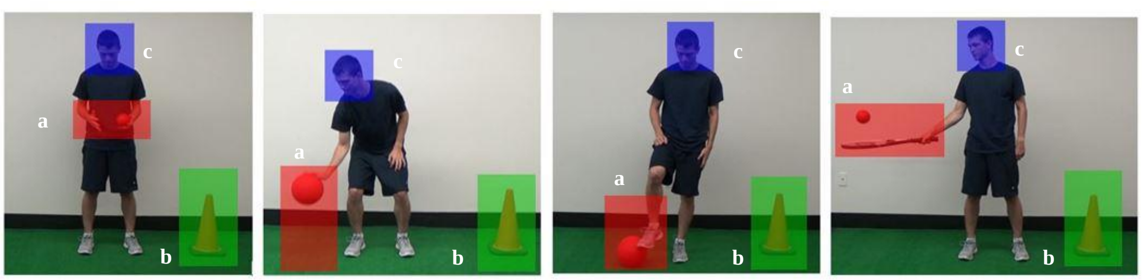

Figure 40. Illustrations of the three areas of interest (AOIs) (a) action, (b) cone, and (c) head.

RQ 1: During the presentation of a motor skill performance, how does the mean time to first fixation (TFF) of children with autism compare to typically developing children?

With regard to Research Question 1, the results of this study indicated there were no statistically significant differences in the group means for TFF between the ASD and TD groups in the non-highlighted and highlighted conditions. Therefore, the null hypothesis, no difference between the groups for TFF could not be rejected.

ASD-NH and TD-NH Groups

First, the ASD-NH and TD-NH groups were compared in the non-highlighted condition. To further examine the differences between the group means for TFF, measures of effect size were calculated. Small to medium effect sizes were found. For Ball Toss, a medium effect size (r = 0.354), ASD-NH group = 1.466; TD-NH group = 0.069; for Basketball, a medium effect size (r = 0.330), ASD-NH group = 1.334; TD-NH group = 0.306; and for Soccer, a small effect size (r = 0.265), ASD-NH group = 1.753; TD-NH group = 0.369. Higher group means indicate slower times to the first fixation. Results of this study showed children with autism to have slower times to the first fixation across the four motor skill performances in the non-highlighted condition. This finding suggests future research to examine instructional strategies to support children with autism to quickly identify and attend to the relevant cues of a motor skill performance.

ASD-H and TD-H Groups

Next, the ASD-H and TD-H group were compared on the highlighted condition. To further examine the differences between the group means for TFF, measures of effect size were calculated. Medium effect sizes were found for Ball Toss, a medium effect size (*r* = 0.424), ASD-H group = 0.365; TD-H group = 0.123; and for Tennis, a medium effect size (*r* = 0.325), ASD-H group = 0.495; TD-H group = 0.354. Higher group means indicate slower times to the first fixation. Results of this study showed children with autism to have slower times to the first fixation across the four motor skill performances in the non-highlighted condition. This finding suggests for future research to examine instructional strategies that support children with autism in directing their attention to the relevant cues of motor skill performances.

With regard to TFF, the results of the current study show children with autism to take longer to attend to the first fixation compared to typically developing children in both the non-highlighted and highlighted conditions. This finding is supported in the literature, as studies have shown atypical saccade latencies with this population. Saccades are rapid eye movements that transition from one fixation to another (Bojko, 2013). Using eye-tracking technology, Elison et al. (2013) examined the oculomotor functioning and visual orientation of 7-month old infants. The researchers measured the saccade reaction time of infants at high-risk and at low-risk for autism. Results showed infants, who later displayed symptoms of autism had greater saccade latencies at 7-months. Similarly, Schmitt, Cook, Sweeney, and Mosconi (2014) examined the saccade movements of individuals with autism. From this investigation, researchers found individuals with autism to have reduced accuracy, prolonged duration, reduce peak velocity, and saccades that took longer to accelerate to peak velocity.

Based on the findings of the current study and previous literature, it is suggested that future research explore the design, creation, and presentation of video-modeled motor skill performances where the skills are highlighted. As studies have shown children with autism to exhibit atypical oculomotor functioning (e.g., saccade latencies) (Elison et al., 2013; Johnson et al., 2016; Schmitt et al., 2014) some children with autism may have difficulty in attending and accurately identifying relevant cues of a video-modeled motor skill performance. Therefore, some children with autism may need additional time to attend to, and accurately identify the relevant cues of motor skill performances. It is also suggested that future research examine the effects of slow motion on the presentation of video-modeled motor skill performances.

RQ 2: During the presentation of a motor skill performance, how does the mean time to first fixation (TFF) of the non-highlighted condition compare to the highlighted condition for both the ASD and TD groups?

With regard to Research Question 2, findings from this investigation indicated there were no statistically significant differences in the group means for TFF by condition (i.e., non-highlighted and highlighted). Therefore, the null hypothesis, no difference between the groups for TFF could not be rejected.

ASD-NH and ASD-H Groups

First, the ASD-NH and ASD-H groups were compared by condition. To further examine the differences between the group means for TFF, measures of effect size were calculated. Small effect sizes were found for Basketball, (*r* = 0.192), ASD-NH group = 1.334; ASD-H group = 0.488; for Soccer, (*r* = 0.160), ASD-NH group = 1.753; ASD-H group = 0.903; and for Tennis, (*r* = 0.187), ASD-NH group = 1.025; ASD-H group = 0.495. Higher group means indicate slower times to the first fixation. Results of this study showed children with autism had slower times to the first fixation across the four motor skill performances in the non-highlighted condition. This finding suggests attentional highlighting supports children with autism in making quicker fixations to an AOI.

TD-NH and TD-H Groups

Next, the TD-NH and TD-H groups were compared by condition. To further examine the differences between the group means for TFF, measures of effect size were calculated. Small effect sizes were found for Ball Toss (*r* = 0.103), TD-NH group = 0.069; TD-H group = 0.123; and for Basketball (*r* = 0.127), TD-NH group = 0.306; TD-H group = 0.404. Higher group means indicate slower times to the first fixation. Results of this study showed typically developing children in the non-highlighted condition had faster times to the first fixation for three of the four motor skill performances. This finding suggests attentional highlighting to have less of an effect on time to first fixation for typically developing children.

It is possible that some participants felt the motor skill performances were too basic. Participants with prior knowledge and experience in sport and physical activity may have become bored or disinterested in the modeled performances. The current study did not control for previous experience with sport or physical activity. Therefore, it is suggested for future research to collect data on the participants' experience with sport and physical activity.

Another possible reason the attentional highlight had less of an effect on the TD group may have been that it was a symbolic cue (i.e., a yellow arrow). According to Hermens and Walker (2016), social cues (i.e., eye gaze and pointing gestures) result in quicker fixations, and longer fixated durations than symbolic cues (i.e., arrows). This finding suggests the type of attentional highlighting (i.e., cueing) used in a video modeled performance could produce different outcomes. Nevertheless, Bandura (1986) asserted that for people to learn through observation, they must attend to, and accurately identify the relevant cues of a modeled event (Bandura, 1986).

Results of this investigation should be interpreted with caution. While additional research is needed, findings from this investigation could aid in the development and design of video-modeled motor skill performances that would accommodate all learners.

Figure 41. An illustration of the highlighted video condition.

Total Visit Duration

Total Visit Duration (TVD) is the measure of time (seconds) that an individual visually attends to a specific area of the visual stimuli. Specific areas of interest are commonly referred to as areas of interest or AOIs (Bergstrom & Schall, 2014). AOIs are defined regions of a display from which quantitative data are collected (Holmqvist et al., 2011). In this investigation, three AOIs (i.e., action, cone, and head) were built into each of the motor skill performance videos and were not visible to the participants. Quantitative data from the AOIs were collected and analyzed to address the following research questions:

RQ 3: During the presentation of a motor skill performance, how does the mean total visit duration (TVD) of children with autism compare to typically developing children?

With regard to Research Question 3, results of this investigation indicated there were no statistically significant differences in the group means for TVD between the ASD-NH and TD-H groups; and the ASD-H and TD-H groups across the three AOIs. Therefore, the null hypothesis, no difference between the groups for TVD could not be rejected. However, to further examine the differences between the group means for TVD, measures of effect size were calculated for each AOI (i.e., action, cone, and head).

ASD-NH and TD-NH Groups

First, the ASD-NH and TD-NH groups were compared on TVD to the Action AOI in the non-highlighted condition. To further examine the differences between the group means for TVD, measures of effect size were calculated. Small to medium effect sizes were found. For Ball Toss, a medium effect size (r = 0.384), ASD-NH = 6.881; TD-NH = 10.616; for Basketball, a small effect size (r = 0.276), ASD-NH = 6.156; TD-NH = 9.012; Soccer, a small effect size (r = 0.298), ASD-NH = 5.417; TD-NH = 8.154;

and for Tennis, a medium effect size (r = 0.460), ASD-NH = 6.744; TD-NH = 10.880. Higher group means indicate longer fixations to the action of a motor skill performance. Results of this study showed children with autism attend less to the action of a motor skill performance than typically developing children across the four motor skill performance in the non-highlighted condition. This finding suggests future research to examine instructional strategies to increase attention to the action of motor skill performances. According to Bandura (1986) “The more often and the longer children attend to a models’ behavior, the higher their level of observational learning” (p. 53).

Previous research has shown children with autism to attend less to the action of a motor performance. For example, using eye-tracking technology, studies have shown children with autism to have decreased attention to biological motion compared to typically developing children (Annaz et al., 2012; Klin et al., 2009). A lack of attention to the action of motor skill performances could impede learning. Therefore, the development of instructional strategies to increase attention to the action area of a motor skill performance may support the motor development of children with autism.

Next, the ASD-NH and TD-NH groups were compared on TVD to the Cone AOI in the non-highlighted condition. To further examine the differences between the group means for TVD, measures of effect size were calculated. Small effect sizes were found for Ball Toss (r = 0.194), ASD-NH group = 0.366; TD-NH = 0.251; for Basketball (r = 0.107), ASD-NH group = 0.337; TD-NH = 0.452; and for Soccer, (r = 0.161), ASD-NH group = 0.891; TD-NH = 0.380. Higher group means indicate longer fixations to the cone. Results of this study showed children with autism to have longer fixations to the cone than typically developing children for two of the four motor skill performances in the non-highlighted condition. This finding suggests children with autism to have similar visual attention patterns to typically developing children, with regard to visual attention to background objects in non-highlighted settings.

This finding does not align with previous research that found children with autism to focus on background objects. For example, Shic et al. (2011) found young children with autism to attend less to the activities of others and focused more on background objects (e.g., toys) compared to young children with typical development. A possible reason for the difference in results between the current study and previous research could be the age of the participants. The current study examined participants' ages 8-12 years and Shic et al. (2011) examined toddlers' age 20-months. In a study of 91 participants ages 2-18 years, Elison, Sasson, Turner-Brown, Dichter, and Bodfish (2012) examined the effects of age on the visual attention patterns of children and adolescents with and without autism. Results of the study indicated ". . . a sharp increase in visual exploration with age and a decrease in perseverative and detailed-focused attention for both groups." (Elison et al., 2012, p. 842). Based on the current finding and previous research, background objects may capture the attention of younger children, but have less of an effect on older children and adolescents. Therefore, background objects in a video-modeled motor skill performance may vary (i.e., more or less objects in the background) depending on the age of the learner.

Lastly, the ASD-NH and TD-NH groups were compared on TVD to the Head AOI in the non-highlighted condition. To further examine the differences between the group means for TVD, measures of effect size were calculated. Small to medium effect sizes were found. For Ball Toss, a small effect size (r = 0.236), ASD-NH group = 1.529; TD-NH = 2.215; for Basketball, a medium effect size (r = 0.339), ASD-NH group = 1.293; TD-NH = 2.351; and for Soccer, a medium effect size (r = 0.409), ASD-NH group = 1.081; TD-NH = 1.584. Higher group means indicate longer fixations to the head of the model. Results of this study showed children with autism attended less to the head of the model for three of the four motor skill performances in the non-highlighted condition. Measures of effect size indicate small to medium effect sizes for three of the four motor skill performances. This finding suggests children with autism look less at the head of the model compared to typically developing children in a non-highlighted setting.

This finding aligns with previous research that showed children with autism to look less at the heads and faces of people (Shic et al., 2011). However, using eye-tracking technology, Wagner et al. (2013) examined the face processing of adolescents with and without autism. Participants scanned faces as they appeared on the screen. The study concluded that adolescents with and without autism have similar scanning patterns of faces. In the current study, results showed that children with autism looked less at the head than typically developing children in the non-highlighted condition. While the results of this study should be interpreted with caution, it is suggested for future research to examine the eye-gaze of the video model. It is plausible that the model's eye-gaze patterns could have an effect on the learner's visual attention. Eye-gaze patterns could be either direct (i.e., looking at the camera) or adverted (i.e., looking away from the camera). Such findings could aid in the development and design of video-modeled motor skill performance videos.

ASD-H and TD-H Groups

Findings from this investigation indicated there were no statistically significant differences in the group means for TVD between the ASD-H and TD-H groups across the three AOIs. Therefore, the null hypothesis, no difference between the groups for TVD could not be rejected.

First, the ASD-H and TD-H groups were compared on TVD to the Action AOI in the highlighted condition. To further examine the differences between the group means for TVD, measures of effect size were calculated. Small effect sizes were found for Ball Toss (g = 0.379), ASD-H group = 8.583; TD-H = 9.954; for Soccer (r = 0.294), ASD-H group = 7.028; TD-H = 9.898; and for Tennis (r = 0.124), ASD-H group = 10.034; TD-H = 11.529. Higher group means indicate longer fixations to the action of a motor skill performance. Results of this study show children with autism to have shorter fixations to the action of a motor skill performance than typically developing children in a highlighted condition.

This finding suggests future research to examine instructional strategies to increase attention to the action of motor skill performances for children with autism. This finding supports previous research that has shown children with autism to attend less to the action of a motor skill performance. Using eye-tracking technology, studies have shown children with autism to have decreased attention to biological motion compared to typically developing children (Annaz et al., 2012; Klin et al., 2009). While there is limited research that examines the effects of attentional highlighting motor skill performances for children with autism, it is suggested for future research to examine the effects of attentional highlighting on the visual attention of motor skill performances.

Next, the ASD-H and TD-H groups were compared on TVD to the Cone AOI in the highlighted condition. To further examine the differences between the group means for TVD, measures of effect size were calculated. Small effect sizes were found for Basketball (r = 0.167), ASD-H group = 0.050; TD-H = 0.216; and for Tennis (r = 0.137), ASD-H group = 0.020; TD-H = 0.082. Higher group means indicate longer fixations to the cone. Results of this study show children with autism to have shorter fixations to the cone than typically developing children in a highlighted condition. This finding shows children with autism to fixate less on background objects (i.e., cones) during the presentation of motor skill performances in a highlighted condition.

While the cone, in the current study, did not appear to distract children with autism, studies have shown children with autism to have stimulus over-selectivity (e.g., difficulty in responding to multiple cues in the environment) (Charlop-Christy et al., 2000; Lovaas et al., 1971). Therefore, multiple cues and cluttered backgrounds could make it difficult for young children to visually attend to video-modeled performances. According to Bandura (1986), young children often have limited ability to attend to multiple cues, identify relevant cues, and maintain attention, which can impede learning and hinder the performance of a modeled event. Therefore, it is suggested for future research to examine the setting of video-modeled performances. Background objects (i.e., cones, balls, scoreboards) may impede the learning of motor skill performances of young children with autism.

Lastly, the ASD-H and TD-H groups were compared on TVD to the Head AOI in the highlighted condition. To further examine the differences between the group means for TVD, measures of effect size were calculated. Small to medium effect sizes were found. For Ball Toss, a medium effect size (g = 0.623), ASD-H group = 1.378; TD-H = 2.376; for Basketball, a small effect size (r = 0.190), ASD-H group = 1.134; TD-H = 1.855; and for Tennis, a small effect size (g = 0.321), ASD-H group = 1.183; TD-H = 1.578.

Higher group means indicate longer fixations to the head. Results of this study show children with autism to have shorter fixations to the head of the model than typically developing children in a highlighted condition. This finding aligns with previous research that has shown children with autism to attend less to the faces of others (Sasson & Touchstone, 2014; Vivanti et al., 2008).

While the results of the current study should be interpreted with caution, it is suggested for future research to examine the eye-gaze patterns of the video model. It is possible that the eye-gaze patterns of the model could disrupt attention and impede learning. Motor skill performances that focus on the head or upper body may result in decreased attention to the modeled performance. It is further suggested for future research to examine the eye-gaze patterns of the video model. Such findings could aid in the development and design of video-modeled motor skill performances.

RQ 4: During the presentation of a motor skill performance, how does the mean total visit duration (TVD) of the non-highlighted condition compare to the highlighted condition for both the ASD and TD groups?

With regard to Research Question 4, findings from this investigation indicated there were no statistically significant differences in the group means for TVD between the ASD-NH and ASD-H groups; and the TD-NH and TD-H groups across the three AOIs. Therefore, the null hypothesis, no difference between the groups for TVD could not be rejected. However, to further examine the differences between the group means for TVD, measures of effect size were calculated for each AOI (i.e., action, cone, and head).

ASD-NH and ASD-H Group

First, the ASD-NH and ASD-H groups were compared on TVD to the Action AOI. To further examine the differences between the group means for TVD by condition, measures of effect size were calculated. Small to medium effect sizes were found. For Ball Toss, a small effect size (g = 0.372), ASD-NH group = 6.881; ASD-H = 8.583; for Basketball, a small effect size (r = 0.222), ASD-NH group = 6.156; ASD-H = 8.108; for Soccer, a small effect size (g = 0.331), ASD-NH group = 5.417; ASD-H = 7.028; and for Tennis, a medium effect size (r = 0.353), ASD-NH group = 6.744; ASD-H = 10.034. Higher group means indicate longer fixations to the action of the motor skill performance. Results of this study show children with autism in the non-highlighted condition look less to the action of a motor skill performance than children with autism in the highlighted condition. This finding suggests attentional highlighting supports children with autism in maintaining attention to the action of a motor skill performance.

This finding aligns with previous research that has shown attentional highlighting to increase attention to relevant information to improve learning (Imhof et al., 2013; de Koning et al., 2009; Kriz and Hegarty, 2007). Based on the findings of the current study, it appears attentional highlighting help the ASD-H group. However, these findings should be interpreted cautiously, as future research is needed. Difficulties in gaining and holding attention can often impede learning and hinder the performance of a modeled event (Bandura, 1986). Therefore, it is necessary to examine various types of attentional highlighting. For example, Hermens and Walker (2016) found social cues (i.e., eye gaze and pointing gestures) to result in quicker fixations and longer fixated durations than symbolic cues (i.e., arrows).

Next, the ASD-NH and ASD-H groups were compared on TVD to the Cone AOI. To further examine the differences between the group means for TVD by condition, measures of effect size were calculated. Small to medium effect sizes were found. For

Ball Toss, a small effect size (r = 0.252), ASD-NH group = 0.366; ASD-H = 0.116; for Basketball, a medium effect size (r = 0.333), ASD-NH group = 0.337; ASD-H = 0.050; for Soccer, a medium effect size (r = 0.329), ASD-NH group = 0.891; ASD-H = 0.081, and for Tennis, a small effect size (r = 0.278), ASD-NH group = 0.275; ASD-H = 0.020. Higher group means indicate longer fixations to the cone. Results of this study show children with autism to have longer fixations to the cone in the non-highlighted condition than children with autism in the highlighted condition. This finding suggests attentional highlighting to the action of a motor skill performance may decrease visual attention to background objects (i.e., cones) for children with autism. It is further suggested for future research to examine the effects of attentional highlighting on motor skill performances, as other areas of the learning environment may need to be observed (e.g., shooting a basketball towards the basket).

Lastly, the ASD-NH and ASD-H groups were compared on TVD to the Head AOI. To further examine the differences between the group means for TVD by condition, measures of effect size were calculated. Small effect sizes were found for Ball Toss (r = 0.182), ASD-NH group = 1.529; ASD-H = 1.378; for Basketball (r = 0.232), ASD-NH group = 1.293; ASD-H = 1.134; and for Soccer (r = 0.183), ASD-NH group = 1.081; ASD-H = 1.092. Higher group means indicate longer fixations to the head of the model. Results of this study show children with autism to have longer fixations to the head of the model in the non-highlighted condition than children with autism in the highlighted condition for three of the four motor skill performances. This finding suggests attentional highlighting to the action of a motor skill performance may decrease visual attention to the head of the model for children with autism. It is further suggested for future research to examine the effects of attentional highlighting on the eye-gaze patterns of children with autism. Studies have shown children with autism to have eye avoidance (e.g., the act of looking away to elude the discomfort of making eye contact with another person) (Tanaka & Sung, 2016).

TD-NH Group and TD-H Group

Findings from this investigation indicated there were no statistically significant differences in the group means for TVD between the TD-NH and TD-H groups across the three AOIs. Therefore, the null hypothesis, no difference between the groups for TVD could not be rejected.

First, the TD-NH and TD-H groups were compared on TVD to the Action AOI. To further examine the differences between the group means for TVD by condition, measures of effect size were calculated. Small to large effect sizes were found. For Ball Toss, a small effect size (g = 0.209), TD-NH group = 10.616; TD-H = 9.954; and for Soccer, a medium effect size (g = 0.541), TD-NH group = 8.154; TD-H = 9.898.

Higher group means indicate longer fixations to the action of a motor skill performance. Results of this study showed typically developing children in the non-highlighted condition had longer fixations to the action of the motor skill performance for Ball Toss and Tennis. This finding suggests attentional highlighting has less of an effect on typically developing children than children with autism. It is worthy to note that there was a medium effect size for Soccer (i.e., g = 0.541). It is possible that prior knowledge and experience with soccer may have played a role in this outcome. It is suggested for future research to collect data on the participants' previous experience with sport and physical activity.

Next, the TD-NH and TD-H groups were compared on TVD to the Cone AOI. To further examine the differences between the group means for TVD by condition, measures of effect size were calculated. Small effect sizes were found for Soccer (r =

0.199), TD-NH group = 0.380; TD-H = 0.096; and for Tennis (*r* = 0.189), TD-NH group = 0.283; TD-H = 0.082. Higher group means indicate longer fixations to the cone. Results of this study show typically developing children in a non-highlighted condition had longer fixations to the cone than typically developing children in the highlighted condition. This finding suggests attentional highlighting may decrease visual attention to background objects (i.e., cone) during the presentation of a motor skill performance for typically developing children.

Lastly, the TD-NH and TD-H groups were compared on TVD to the Head AOI. To further examine the differences between the group means for TVD by condition, measures of effect size were calculated. Small effect sizes were found for Soccer (*r* = 0.148), TD-NH group = 1.584; TD-H = 1.307. Higher group means indicate longer fixations to the head of the model. Results of this study show typically developing children in a non-highlighted condition had longer fixations to the head of the model for three of the four motor skill performances. This finding suggests attentional highlighting may decrease visual attention to the head of the model during the presentation of a motor skill performance for typically developing children.

Visit Count

Visit Count (VC) measures the number of visits and re-visits to an area of interest (AOI). A visit ends when the eyes move outside the AOI (Tobii Studio, 2016). AOIs are defined regions of a display from which quantitative data are collected (Holmqvist et al., 2011). In this investigation, three AOIs (i.e., action, cone, and head) were built into each of the motor skill performance videos and were not visible to the participants.

Quantitative data from the AOIs were collected and analyzed to address the following research questions:

RQ 5: During the presentation of a motor skill performance, how does the mean visit count (VC) of children with autism compare to typically developing children? :

With regard to Research Question 5, findings from this investigation indicated there were no statistically significant differences in the group means for VC between the ASD-NH and TD-NH group and the ASD-H and TD-H group for VC across the three AOIs. Therefore, the null hypothesis, no difference between the groups for VC could not be rejected.

ASD-NH and TD-NH Groups

First, the ASD-NH and TD-NH groups were compared on VC to the Action AOI. To further examine the differences between the group means for VC, measures of effect size were calculated. Results indicated small effects sizes between the groups for Ball Toss (r = 0.239), ASD-NH = 7.07; TD-NH = 5.41; for Soccer (r = 0.109), ASD-NH = 5.79; TD-NH = 6.36; and for Tennis (r = 0.289), ASD-NH = 5.57; TD-NH = 3.91. Higher group means indicate more visit counts to the action of the motor skill performance. Results of this study showed children with autism had more visits to the action of a motor skill performance than typically developing children for three of the four motor skill performances in the non-highlighted condition. This finding is inconclusive, as previous research has shown children with autism to have ocular motor deficits (i.e., saccade latencies). It is plausible that in tracking the action of the motor skill performance, the eye-gaze may have exited the Action AOI, then re-entered (i.e., re-visits). This may explain the higher visit count for children with autism. Caution is suggested for the interpretation of this finding, as future research is needed. It is suggested for future research to examine the effects of attentional highlighting on visit count for children with autism.

Next, the ASD-NH and TD-NH groups were compared on VC to the Cone AOI. To further examine the differences between the group means for VC, measures of effect size were calculated. Results indicated small effects sizes between the groups for Ball Toss (r = 0.230), ASD-NH = 0.93; TD-NH = 0.41; Basketball (r = 0.101), ASD-NH = 0.79; TD-NH = 0.59; and for Soccer (r = 0.192), ASD-NH = 1.71; TD-NH = 0.59. Higher group means indicate more visits to the cone. Results of this study showed children with autism had more visits to the cone during a motor skill performance than typically developing children in the non-highlighted condition. This finding shows children with autism looked to the cone, more often than typically developing children in a non-highlighted condition. This finding is inconclusive, as future research on visit count is needed.

Lastly, the ASD-NH and TD-NH groups were compared on VC to the Head AOI. To further examine the differences between the group means for VC, measures of effect size were calculated. Results indicated small to medium effects sizes. For Basketball, a small effect size (r = 0.168), ASD-NH = 2.07; TD-NH = 2.86; and for Soccer, a medium effects size (r = 0.384), ASD-NH = 1.36; TD-NH = 2.68. Higher group means indicate more visit counts to the head of the model. Results of this study showed children with autism to have more visits to the head of the model than typically developing children for two of the four motor skill performances in the non-highlighted condition.

This finding suggests children with autism are similar to typically developing children with regard to the number of visits to the head of the model in a non-highlighted condition. This finding opposes previous research that shows children with autism look less to the head and faces of people (Shic et al., 2011). It is suggested for future research to examine the effects of attentional highlighting on the visit counts of children with autism.

ASD-H and TD-H Groups

First, the ASD-H and TD-H groups were compared on VC to the Action AOI. To further examine the differences between the group means for VC, measures of effect size were calculated. Small effects sizes were found for Ball Toss (g = 0.200), ASD-H = 7.42; TD-H = 6.72; for Basketball (r = 0.245), ASD-H = 7.67; TD-H = 5.39; and for Soccer (g = 2.63), ASD-H = 6.08; TD-H = 7.11. Higher group means indicate more visit counts to the action of a motor skill performance. Results of this study showed children with autism had more visits to the action of a motor skill performance than typically developing children in the highlighted condition for three of the four motor skill performances. This finding is inconclusive, as previous research has shown children with autism to have ocular motor deficits (i.e., saccade latencies). It is plausible that in tracking the action of the motor skill performance, the eye-gaze may have exited the Action AOI, then re-entered (e.g., increasing the visit count). This may explain the higher visit count for children with autism. Caution is suggested for the interpretation of this finding, as future research is needed. It is suggested for future research to examine the effects of attentional highlighting on visit count for children with autism.

Next, the ASD-H and the TD-H groups were compared on VC to the Cone AOI. To further examine the differences between the group means for VC, measures of effect size were calculated. Results indicated small effects sizes between the groups for Basketball (r = 0.209), ASD-H = 0.17; TD-H = 0.56; Soccer (r = 0.121), ASD-H = 0.33; TD-H = 0.22; and for Tennis (r = 0.118), ASD-H = 0.08; TD-H = 0.17. Higher group means indicate more visit counts to the cone. Results of this study showed children with autism had more visits to the cone than typically developing children for two of the four motor skill performances in the non-highlighted condition. This finding suggests children with autism are similar to typically developing children with regard to the number of visits to the cone in a highlighted condition. It is suggested for future research to examine the effects of attentional highlighting on visit count for children with autism.

Lastly, the ASD-H and TD-H groups were compared on VC to the Head AOI. To further examine the differences between the group means for VC, measures of effect size were calculated. Small effect sizes were found for Soccer (r = 0.147), ASD-H = 1.67; TD-H = 1.89. Higher group means indicate more visit counts to the head of the model. Results of this study showed children with autism had more visits to the head of the model than typically developing children for two of the four motor skill performances in the highlighted condition. This finding suggests children with autism are similar to typically developing children with regard to the number of visits to the head of the model in a highlighted condition. This finding opposes previous research that shows children with autism look less to the head and faces of people (Shic et al., 2011). It is suggested for future research to examine the effects of attentional highlighting on visit count of children with autism.

RQ 6: During the presentation of a motor skill performance, how does the mean VC of the non-highlighted condition compare to the highlighted condition for both the ASD and TD groups?

With regard to Research Question 6, findings from this investigation indicated there were no statistically significant differences in the group means for VC between the groups by condition across the three AOIs. Therefore, the null hypothesis, no difference between the groups for VC could not be rejected.

ASD-NH and ASD-H Groups

First, the ASD-NH and ASD-H groups were compared on VC to the Action AOI. To further examine the differences between the group means for VC, measures of effect size were calculated. Results indicated a medium effects size between the groups for Basketball, (g = 0.615), ASD-NH = 5.00; ASD-H = 7.67. Higher group means indicate more visit counts to the head of the model. Results of this study showed children with autism in the non-highlighted condition had fewer visits to the action of a motor skill performance than children with autism in the highlighted condition for three of the four motor skill performances.

This finding is inconclusive, as previous research has shown children with autism to have ocular motor deficits (i.e., saccade latencies). However, it is possible in that tracking the basketball, the eye-gaze may have exited the Action AOI, then re-entered (e.g., increasing the visit count). This may explain the higher visit count for children with autism. Caution is suggested for the interpretation of this finding, as future research is needed.

Next, the ASD-NH and ASD-H groups were compared on VC to the Cone AOI. To further examine the differences between the group means for VC, measures of effect size were calculated. Small effects sizes were found for Ball Toss (r = 0.299), ASD-NH = 0.93; ASD-H = 0.67; Basketball (r = 0.147), ASD-NH = 0.79; ASD-H = 0.17; Soccer (r = 0.293), ASD-NH = 1.71; ASD-H = 0.33; and for Tennis (r = 0.279), ASD-NH = 0.79; ASD-H = 0.08. Higher group means indicate more visit counts to the cone. Results of this study showed children with autism in the non-highlighted condition had more visits to the cone than children with autism in the highlighted condition across the four motor skill performances. This finding is inconclusive. However, it is possible that attentional highlighting the action of a motor skill performance may hold the visual attention of children with autism for a longer duration; therefore, decreasing the number of visits to the cone. It is suggested for future research to use eye-tracking technology to examine the effects of attentional highlighting on visit count for children with autism.

Lastly, the ASD-NH and the ASD-H groups were compared on VC to the Head AOI. To further examine the differences between the group means for VC, measures of effect size were calculated. Small effect sizes were found for Ball Toss (r = 0.143), ASD-NH = 3.21; ASD-H = 3.42; Basketball (r = 0.197), ASD-NH = 2.07; ASD-H = 2.92; and for Soccer (r = 0.110), ASD-NH = 1.36; ASD-H = 1.67. Higher group means indicate more visit counts to the head of the model. Results of this study showed children with autism in the non-highlighted condition had fewer visits to the head than children with autism in the highlighted condition for three of the four motor skill performances. This finding is inconclusive. It is suggested for future research to use eye-tracking technology to examine the effects of attentional highlighting on visit count for children with autism.

TD-NH and TD-H Groups

First, the TD-NH and TD-H groups were compared on VC to the Action AOI. To further examine the differences between the group means for VC, measures of effect size were calculated. Small effect sizes were found for Ball Toss (r = 0.152), TD-NH = 5.41; TD-H = 6.72; for Basketball (r = 0.208), TD-NH = 4.27; TD-H = 5.39; and for Tennis (g = 0.220), TD-NH = 3.91; TD-H = 4.28. Higher group means indicate more visit counts to the action of a modeled performance. Results of this study showed typically developing children in the non-highlighted condition had fewer visits to the action of a motor skill performance than typically developing children in the highlighted condition across the four motor skill performances. This finding is inconclusive. It is suggested for future research to use eye-tracking technology to examine the effects of attentional highlighting on visit count for children with and without autism.

Next, the TD-NH and the TD-H groups were compared on VC to the Cone AOI. To further examine the differences between the group means for VC, measures of effect size were calculated. Small effect sizes were found for Soccer (r = 0.215), TD-NH = 0.59; TD-H = 0.22; and for Tennis (r = 0.204), TD-NH = 0.50; TD-H = 0.17. Higher group means indicate more visit counts to the cone. Results of this study showed typically developing children in the non-highlighted condition had more visits to the cone than typically developing children in the highlighted condition for three of the four motor skill performances. This finding is inconclusive. It is suggested for future research to use eye-tracking technology to examine the effects of attentional highlighting on visit count for children.

Lastly, the TD-NH and TD-H groups were compared on VC to the Head AOI. To further examine the differences between the group means for VC, measures of effect size were calculated. Small effects sizes were found for Ball Toss (r = 0.128), TD-NH = 2.73; TD-H = 3.39; for Soccer (r = 0.179), TD-NH = 2.68; TD-H = 1.89; and for Tennis (r = 0.157), TD-NH = 2.73; TD-H = 2.00. Higher group means indicate more visit counts to the head of the model. Results of this study showed typically developing children in the non-highlighted condition had more visits to the head than typically developing children in the highlighted condition for three of the four motor skill performances. This finding is inconclusive. It is suggested for future research to use eye-tracking technology to examine the effects of attentional highlighting on visit count for children.

The purpose of visit count (VC) eye-tracking metrics was to compare and contrast the visual attention patterns of children with autism to typically developing children on scanning the environment of the video-modeled presentation. According to Bandura (1986), “Learning is largely an informational-processing activity in which information about the structure of the behavior and about environmental events is transformed into symbolic representations that serve as guides for action” (Bandura, 1986, p. 51). While data were collected and analyzed, this particular eye-tracking metrics did not appear to be a good fit for this particular study. In review of the results obtained from this metrics, it would be an interesting measure for research related to attention deficit disorder (ADD) or attention deficit / hyperactivity disorder (ADHD).

Summary of Major Findings

This study indicated five key findings. One, with regard to time to first fixation, results indicated that children with autism took longer to attend the visual stimuli. This finding appeared in both the non-highlighted and highlighted conditions and across all four motor skill performances. Two, results indicated that children with autism visually attended to the AOIs for a shorter duration than typically developing children. This finding occurred in both the non-highlighted and highlighted conditions and across the four motor skill performances. Three, with regard to attentional highlighting, children with autism in the highlighted condition had faster times to first fixation than children with autism in the non-highlighted condition. Four, attentional highlighting increased total visit duration to the Action AOIs for children with autism. Five, an overall finding showed that both children with autism and typically developing children to have similar patterns of visual attention to the AOIs (e.g., both the ASD and TD groups attended to the Action AOI for the longest period of time, followed by the Head AOI, and then the Cone AOI). These findings are to be interpreted with caution, as future research is needed.

Limitations of the Study

This study has limitations that necessitate caution in the interpretation and generalization of the findings. First, the study used a modest sample size (*n* = 35).

Replicating the study on a larger scale would increase the statistical power and precision of the experiment. Second, due to the heterogeneity of autism, there were varying levels of severity, language ability, and adaptive behavior skills amongst the participants diagnosed. For example, results of the Social Communication Questionnaire (SCQ) ranged from 2-33 for the ASD group and 0-15 for the TD group. Lower scores on the SCQ indicated greater proficiency in social communication skills. For this reason, the results of this investigation cannot be generalized across all individuals with autism.

Third, this investigation did not control for attention deficit disorder (ADD) or attention deficit / hyperactivity disorder (ADHD). Though it was reported in nearly one-third of the participants, both with and without an autism diagnosis. Fourth, this study did not control for the time of day in which the data were collected. Appointments were dependent upon the availability of the participants. Subsequently, most appointments were scheduled afterschool when the participant may have been tired, hungry, or in need of medicine. Fifth, this study did not collect data on the participants' prior sport knowledge and experience, as this may have been a factor in the data collected for TVD for the TD group in the highlighted condition.

Lastly, a limitation of this investigation was that the researcher was new to eye-tracking technology. While the technology was user-friendly and easy to implement during data collection, there was a learning curve in the design and creation of the video presentations. While eye-tracking technology offers an array of research opportunities, it is further suggested for researchers new to the technology to focus their research to specific motor skill performances using one or two eye-tracking metrics.

Future Research

Bandura's theoretical framework of observational learning provides researchers a systematic approach to understanding how people learn through modeled events. Bandura (1986) asserted that for observational learning to occur the four subprocesses must coincide: (a) attention, (b) retention, (c) production, and (d) motivation. Attention, the first subprocess of observational learning was the primary focus of the current study. Bandura (1986) proclaimed that for people to learn through observation, they must attend to, and accurately identify the relevant cues of a modeled activity. Using eye-tracking technology, the aim of this study was to examine the visual attention patterns of children with autism as they observed video-modeled demonstrations of motor skill performances. Suggested research:

1. In the current study, data were collected on social communication and adaptive behavior. It is suggested for future research to examine possible links between the visual attention patterns of children with autism and other measures (i.e., social communication, adaptive behavior, autism severity, IQ and age).
2. In the current study, a yellow attentional highlight arrow was used to draw attention to the action AOI. It is suggested for future research to examine other forms of attentional highlighting (i.e., color, shape, size, motion, audio, location, and timing of appearance).
3. In the current study, only continuous motor skill performances were presented to the participants. Therefore, it is suggested for future research to examine discrete

motor skill performances (i.e., kicking, striking, and throwing) to determine if there are any differences in visual attention to those skills.

4. In the current study, the model used adverted eye-gaze (e.g., he did not look at the camera). It is suggested for future research to examine the effect of direct eye-gaze on visual attention.
5. In the current study, the model wore plain clothing and the room had a sparse décor. It is suggested for future research to examine model types, settings, background distractors, audio, slow motion, zoom, and other variables as they relate to the other three subprocesses of observational learning (i.e., retention, production, and motivation).
6. As eye-tracking technology continues to grow in popularity, it is suggested for future research to examine the four subprocesses of observational learning. While the current study did not find significant differences in attention, there may be underlying concerns in one or more of the other subprocesses of observational learning (i.e., retention, production, and motivation). A systematic exploration of the subprocesses of observational learning is suggested for future research.

Conclusion

A growing body of literature has shown motor impairments to have far-reaching implications on the overall development of children with autism (Downey & Rapport, 2012; Fournier et al., 2010; Leonard & Hill, 2014). Therefore, it is necessary to explore evidence-based practices and interventions to support the motor development of children with autism.

Video modeling is an evidence-based practice shown to be effective in teaching children with autism (Ayres & Langone, 2005; Bellini & Akullian, 2007; D'Ateno et al., 2003; McCoy & Hermansen, 2007). However, very few studies have examined the effects of video modeling motor skill performances to children with autism. What's more, studies have shown this population to have atypical patterns of visual attention.

The purpose of this study was to examine the visual attention patterns of children with autism as they observed video-modeled demonstrations of motor skill performances. Using eye-tracking technology, quantitative data were collected on three eye-tracking metrics: (a) time to first fixation, (b) total visit duration, and (c) visit count. In addition, the study examined the effects of attentional highlighting motor skill performances.

Understanding the visual attention patterns of children with autism could lead to more innovative ideas in the design, creation, and presentation of video-modeled demonstrations of motor skill performances. It is hoped that this study will provide a foundation for future research to support the motor development of children with autism, so they can live a healthy and physically active lifestyle.

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APPENDICES

Appendix A. USM Institutional Review Board (IRB) Approval Form

THE UNIVERSITY OF
SOUTHERN MISSISSIPPI

INSTITUTIONAL REVIEW BOARD
118 College Drive #5147 | Hattiesburg, MS 39406-0001
Phone: 601.266.5997 | Fax: 601.266.4377 | www.usm.edu/research/institutional.review.board

NOTICE OF COMMITTEE ACTION

The project has been reviewed by The University of Southern Mississippi Institutional Review Board in accordance with Federal Drug Administration regulations (21 CFR 26, 111), Department of Health and Human Services (45 CFR Part 46), and university guidelines to ensure adherence to the following criteria:

- The risks to subjects are minimized.
- The risks to subjects are reasonable in relation to the anticipated benefits.
- The selection of subjects is equitable.
- Informed consent is adequate and appropriately documented.
- Where appropriate, the research plan makes adequate provisions for monitoring the data collected to ensure the safety of the subjects.
- Where appropriate, there are adequate provisions to protect the privacy of subjects and to maintain the confidentiality of all data.
- Appropriate additional safeguards have been included to protect vulnerable subjects.
- Any unanticipated, serious, or continuing problems encountered regarding risks to subjects must be reported immediately, but not later than 10 days following the event. This should be reported to the IRB Office via the "Adverse Effect Report Form".
- If approved, the maximum period of approval is limited to twelve months. Projects that exceed this period must submit an application for renewal or continuation.

PROTOCOL NUMBER: 16112202
PROJECT TITLE: Video Modeling Motor Skill Performances: An Eye-Tracking Analysis of Children with Autism Spectrum Disorder
PROJECT TYPE: New Project
RESEARCHER(S): Joann Judge
COLLEGE/DIVISION: College of Health
DEPARTMENT: School of Kinesiology
FUNDING AGENCY/SPONSOR: N/A
IRB COMMITTEE ACTION: Expedited Review Approval
PERIOD OF APPROVAL: 12/06/2016 to 12/05/2017
Lawrence A. Hosman, Ph.D.
Institutional Review Board

Appendix B. UVA IRB Authorization Agreement (IAA)

IRB Authorization Agreement

This agreement authorizes **University of Virginia IRB for the Social and Behavioral Sciences (IRB-SBS)** to rely on **University of Southern Mississippi** for the review of the research noted below.

University of Southern Mississippi (Institution A)
OHRP Federal Wide Assurance (FWA) #: 0002393
University of Virginia (Institution B)
OHRP Federal Wide Assurance (FWA) #: 00006183

Protocol IRB Number from Reviewing IRB: 16112202
Title of Study: Video Modeling Motor Skill Performances: An Eye-Tracking Analysis of Children with Autism Spectrum Disorder
Principal Investigator at UVa: Joann Judge (In role of Ph.D. graduate student, Curry School of Education, UVA)
Principal Investigator at Institution B: Joann Judge (In role of Assistant Professor, School of Kinesiology, USM)

The following terms are agreed upon by all parties and attested to by signature below:
Responsibilities of Reviewing IRB: University of Southern Mississippi (Institution A)

1. Maintain an FWA with OHRP and maintain IRB registration with OHRP, as applicable.
2. Conduct initial review and continuing oversight in compliance with applicable federal regulations and state and local requirements to meet the human subject protection requirements of the FWA of Institution B.
3. Maintain membership of the IRB(s) that meets applicable federal regulations and human subject protection requirements of the FWA.
4. Make available to Institution B, the IRB policies and procedures.
5. Conduct reviews of initial, continuing, and amendment submissions; unanticipated problem reports; and any other documentation submitted by the Principal Investigator.
6. Maintain and upon request or provided through the principal investigator, make accessible to Institution B the IRB application, protocol reviews, letters to Principal Investigators, approvals and disapprovals, and approved informed consent documents
7. Investigate and manage any event that appears to rise to the level of an unanticipated problem involving risks to subjects or others and/or serious or continuing noncompliance.
8. Notify Institution B promptly if a determination of serious or continuing noncompliance is found, and the corrective actions deemed necessary by the IRB. The IRB may request that Institution B conduct its own investigation and report back to the IRB.
9. If the IRB determines that an event must be reported to oversight entities, such as ORHP, it will notify Institution B in advance and provide the opportunity for Institution B to review and comment on the report before it is sent. In addition, the IRB will notify institution B of any correspondence it receives regarding this study from OHRP and /or other regulatory agency.
10. Notify Institution B promptly if it decides to suspend, disapprove, or terminate a study covered by this agreement.
11. Notify Institution B of any lapses of approval.
12. Maintain a post approval monitoring program to ensure compliance with IRB approved protocols and adherence to regulatory requirements.

Appendix C. USM IRB Parent Consent Form

Office *of* Research Integrity

INSTITUTIONAL REVIEW BOARD

PARENTAL CONSENT FORM

PARENTAL CONSENT PROCEDURES

This document must be completed by the Principal Investigator and signed by the parent or guardian of each potential research participant.

- The Project Information and Research Description sections of this form should be completed by the Principal Investigator before submitting this form for IRB approval.
- Signed copies of the long form consent should be provided to a parent or guardian of every participant.

Last Edited May 22nd, 2014

Today's date:

PROJECT INFORMATION

Project Title: Video Modeling Motor Skill Performance: An Eye-Tracking Analysis of Children with Autism Spectrum Disorder		
Principal Investigator: Joann P. Judge	Phone: 601-266-5867	Email: joann.judge@usm.edu
College: College of Health	Department: Kinesiology	

RESEARCH DESCRIPTION

1. **Purpose:**

The purpose of this study is to examine the visual attention patterns of children with autism as they observe video modeled demonstrations of motor skill performances.

2. **Description of Study:**

This research project would require one, 30-minute visit to the University of South Mississippi in Hattiesburg, MS. During that time, you will be asked to complete a participant demographic form, an assessment item, and a questionnaire. In addition to completing the forms, your child will be asked to watch a two-minute video of motor skill performances using eye-tracking technology. A $15 gift certificate will be awarded to the participant for taking part in the study.

3. **Benefits:**

Findings from this investigation will extend the literature on video modeling and aid in the development and design of future video demonstrations of fundamental motor skills to support children with autism.

A potential benefit the participant may gain from this study would be an increase understanding of various motor skill performances.

4. **Risks:**

While potential risks to the participant in this study are minimal. The following methods will be employed to mitagate any potential risks, incoveniences, or discomforts: (A) The PI is trained in working with children with autism. If any signs of stress are observed in the children, the PI will ask them if they would like to take a short break. If signs of stress persist or increase, the PI will terminate the session; (B) Parent / guardian will be present in the lab during data collection.

Appendix D. USM IRB Minor Assent Form

ORI | Office *of* Research Integrity

INSTITUTIONAL REVIEW BOARD

MINOR ASSENT FORM

MINOR ASSENT PROCEDURES

This document must be completed by the Principle Investigator and signed by each assenting minor.

- The Project Information and Research Description sections of this form should be completed by the Principal Investigator before submitting this form for IRB approval.
- Parental consent must be obtained before soliciting the assent of any minor participating in the study.
- Signed copies of the IRB approved assent form should be provided to a parent or guardian of every assenting minor.

Last Edited May 22nd, 2014

Today's date:

PROJECT INFORMATION

Project Title: Video Modeling Motor Skill Performances: An Eye-Tracking Analysis of Children with Autism Spectrum Disorder

Principal Investigator: Joann P. Judge	Phone: 601-266-5867	Email: joann.judge@usm.edu
College: College of Health	Department: Kinesiology	

RESEARCH DESCRIPTION

1. Why am I being asked to participate?

Hello (name of participate). The reason you are participating in this study is so we help can help students learn the skills needed to play sports and to live a healthy and physically active lifestyle.

2. What will I have to do?

Now (name of participant), all you have to do is sit in front of a computer monitor and watch a 2-minute video of a person demonstrating different sport skills. It is important that you sit up straight, keep your eyes forward, and try to keep your head still.

3. What do I get if I agree to participate?

Once the video ends, you will be given a $15 gift card.

4. Can anything bad happen if I participate?

Now remember (name of participant), nothing bad can happen to you as you watch the video. The video is only 2-minutes long and your (parent / guardian) will be with you the whole time. If you have any questions or need a break, just let me know!

5. Who will get to see information about me?

Also remember that no one is going to see the your information. I will give you a special code, so no one will know your name, where you live, or where you go to school.

Appendix E. Parent / Guardian Letter of Consent

THE UNIVERSITY OF
SOUTHERN MISSISSIPPI

Parent / Guardian Letter of Consent

Dear Parent / Guardian,

My name is Joann P. Judge and I am an instructor in the School of Kinesiology at the University of Southern Mississippi. At this time, I am in the dissertation phase of my doctoral degree in Kinesiology and Adapted Physical Education at the University of Virginia. I am very interested in studying the effects of video modeling on the motor skill acquisition of children with autism spectrum disorder.

I would like to invite you and your child to take part in my research project titled **Video Modeling Motor Skill Performances: An Eye-Tracking Analysis of Children with Autism Spectrum Disorder**. Using remote eye-tracking technology, this study will examine the visual attention patterns of children as they observe video modeled demonstrations of motor skill performances.

This study seeks to recruit 20 participants with autism and 20 participants without autism. All participants must be male and between 8-12 years of age. Findings from this investigation will extend the literature on video modeling and aid in the development of video modeling as an instructional strategy in teaching fundamental motor skills to children with autism spectrum disorder.

This research project would require **one, 30-minute visit** to the University of Southern Mississippi in Hattiesburg, MS. During the visit, the parent / guardian will be asked to sign a letter of consent, provide demographic information, and complete two parent / guardian questionnaires. The research participant (child) will be asked to sign a letter of assent and watch a two-minute video of motor skill performances using eye-tracking technology. A $15-gift certificate will be awarded to the research participant for taking part in the study.

NOTE: This research project has been approved by the Institutional Review Board. Participation is completely voluntary and the parent / guardian and child are free to withdraw from the study at any time. Information obtained from this study will be coded, secured, and kept strictly confidential. The child's name, location, school, community-based program, or other identity information will not be used in any report; and there are minimal risks to the child.

If you have any questions or concerns about the study, please contact me or my advisor at:

Joann P. Judge, Instructor
School of Kinesiology
University of Southern Mississippi
Hattiesburg, MS 39406
Telephone: 601-266-xxxx

Luke E. Kelly, Ph.D. (UVA Student Advisor)
Department of Kinesiology / Curry School of Education
University of Virginia
Charlottesville, VA 22904
Telephone: 434-924-xxxx

If you and your child are interested in participating in this study, please complete page 2.

Parent / Guardian Signed Consent:

As the parent / guardian of ____, I hereby
name of research participant
give permission for my child to participate in the research study titled **Video Modeling Motor Skill Performances: An Eye-Tracking Analysis of Children with Autism Spectrum Disorder**. I understand my child's participation in this research project is completely voluntary and they are free to withdraw from the study at any time.

SECTION A: PARENT / GUARDIAN CONTACT INFORMATION

Parent / Guardian Name: ____

Relationship to Research Participant: __________________________________

Address: ____

City: ________________________ State: ________ Zip Code: ________

Telephone Number: ____

Email Address: ____

SECTION B: PARENT / GUARDIAN SIGNED CONSENT

Research Participant's Name: ______________________________________

Research Participant's Date of Birth: __________________________________

Parent / Guardian (print name): ____________________________________

Parent / Guardian (signature): _____________________________________

Date Signed: ________________

SECTION C: TO BE COMPLETED BY THE PRINCIPAL INVESTIGATOR

Date of Visit to USM: ____________________

Date of Form Completion: __________________

Date of Eye-Tracking Data Collection: ____________

J. P. Judge Page 2 of 2 USM #16112202

Appendix F. Research Participant Demographic Information Form

UNIVERSITY OF SOUTHERN MISSISSIPPI
RESEARCH PARTICIPANT DEMOGRAPHIC INFORMATION FORM

Project Title: *Video modeling motor skill performances: An eye-tracking analysis of children with autism spectrum disorder*
Principal Investigator: Joann P. Judge, University of Southern Mississippi / School of Kinesiology

	Year	Month	Day
Test Date :			
Birth Date:			
Test Age:			

Diagnosis:

	Yes	No
Autism Spectrum Disorder		
ADD / ADHD		
Other________________		

Race / Ethnicity:

American Indian	
Alaskan Native	
Asian / Pacific Islander	
Black / African American	
Hispanic / Latino	
White / Caucasian	
Multiple Ethnicity	
Other:	

Corrective Eyewear:

	Yes	No
Glasses		
Contact Lenses		
Other________________		

Gender:

Male	X
Female	

Vineland-3 Assessment:

Domain	Raw Score	Standard Score	Percentile Rank
Communication (COM)			
Daily Living Skills (DLS)			
Socialization (SOC)			
Sum of Domain Standard Scores:			
Adaptive Behavior Composite (ABC)			
Motor Skills (MOT) *(age 8:0 - 9:11)			

Social Communication Questionnaire (SCQ):

Items	1-19	20-40	Total Score

Inclusion Criteria:
(check all that apply)

	Yes	No
Male 8-12 years.		
Understands verbal instructions.		
Has visual acuity of a computer monitor at a 20".		
Attains a successful 5-point eye-tracker calibration reading.		
Maintains proper body positioning during eye-tracking analysis.		
Attends to video presentation for 2 minutes.		

J. P. Judge　　Page 1 of 2　　USM #16112202

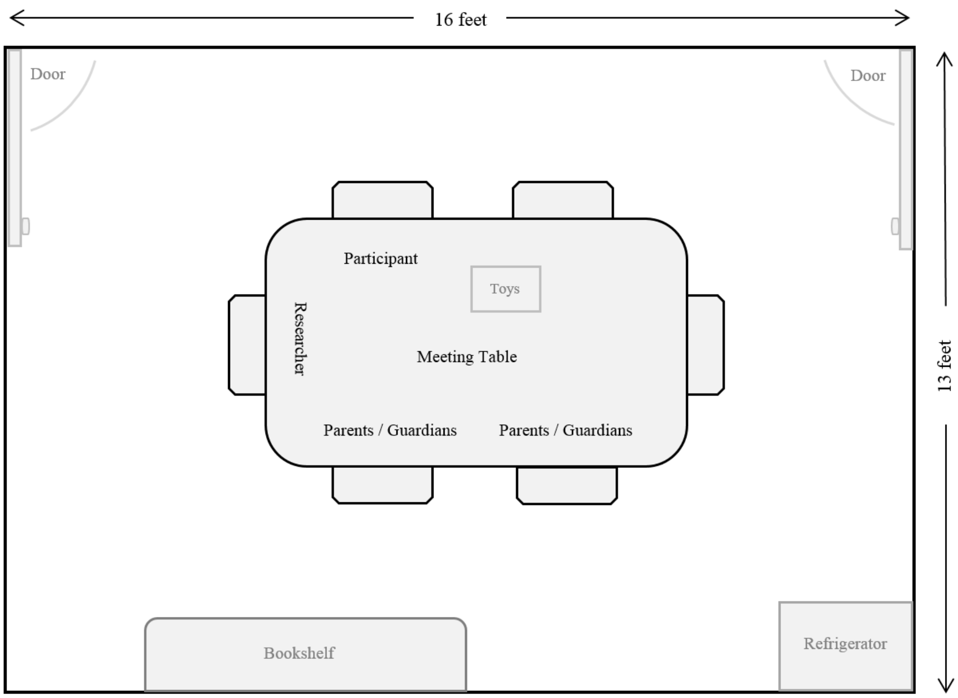
EYE-TRACKING DATA COLLECTION

#	Date	Time	Age	W_{gaze}	G_{sample}

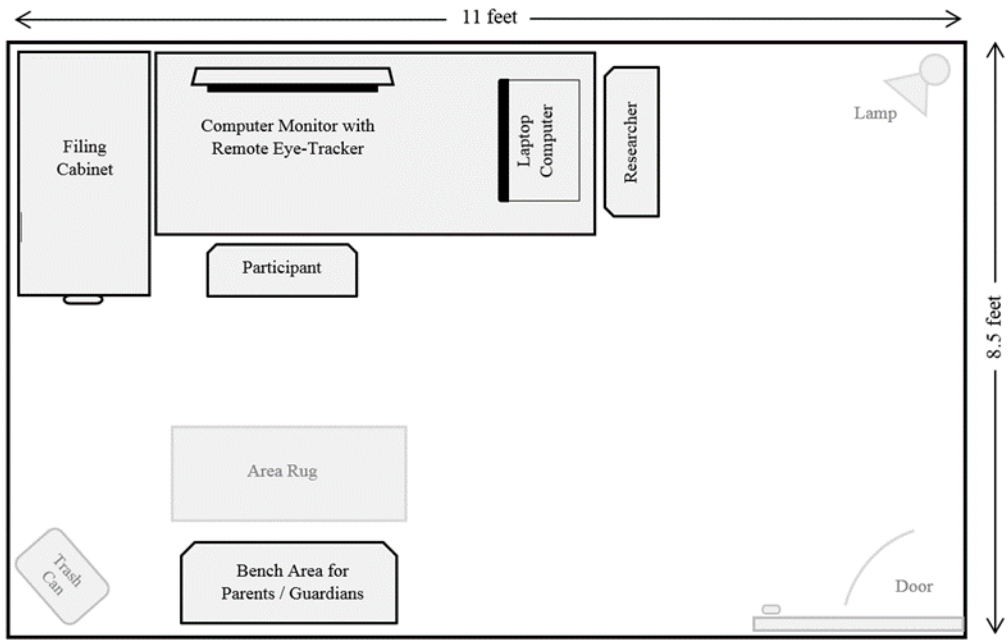
Time to First Fixation The time from the start of the stimulus display until the test participant fixates on the AOI for the first time (seconds).	**Action Region**	**Face Region**	**Cone Region**
N (count)			
Mean (seconds)			
Sum (seconds)			
Stdev (seconds)			
Visit Duration Duration of each individual visit within an AOI (seconds).	**Action Region**	**Face Region**	**Cone Region**
N (count)			
Mean (seconds)			
Sum (seconds)			
Stdev (seconds)			
Total Visit Duration Duration of all visits within an AOI (seconds).	**Action Region**	**Face Region**	**Cone Region**
N (count)			
Mean (seconds)			
Sum (seconds)			
Stdev (seconds)			
Visit Count Number of visits with in an AOI (count).	**Action Region**	**Face Region**	**Cone Region**
N (count)			
Mean (count)			
Sum (count)			
Stdev (count)			

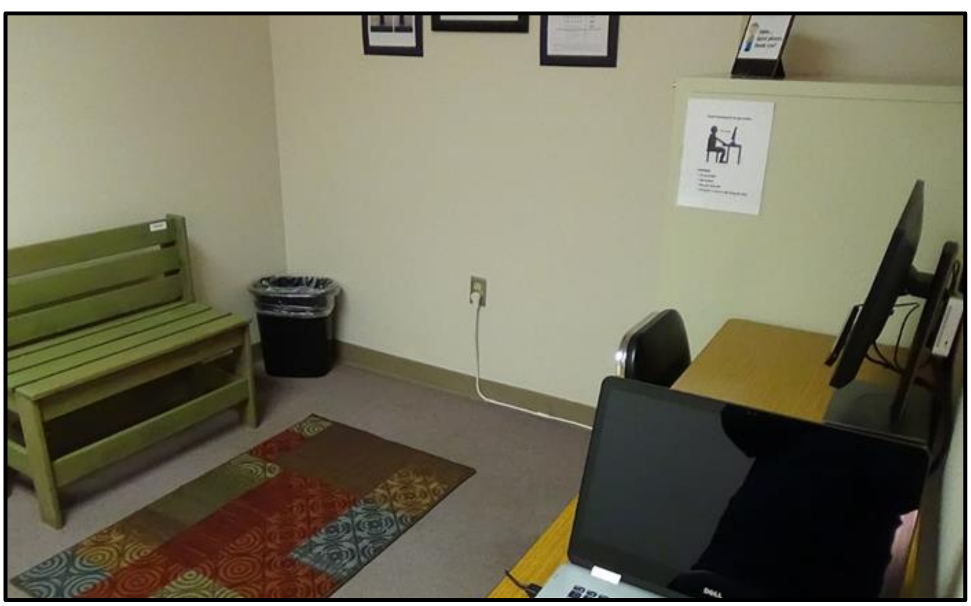
J. P. Judge | Page 2 of 2 | USM #16112202

Appendix G. Layout of the Meeting Room

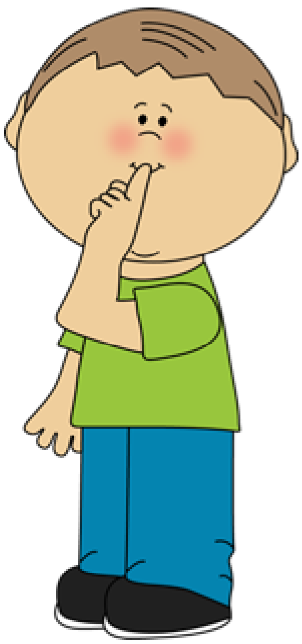

16 feet
13 feet
Door
Door
Participant
Toys
Researcher
Meeting Table
Parents / Guardians
Parents / Guardians
Bookshelf
Refrigerator

Appendix H. Layout of the Eye-Tracking Lab


11 feet
8.5 feet
Filing
Cabinet
Computer Monitor with
Remote Eye-Tracker
Laptop
Computer
Researcher
Lamp
Participant
Area Rug
Trash
Can
Bench Area for
Parents / Guardians
Door



Appendix I. Visual Support to Remain Quiet during Eye-Tracking



Shhh…

Quiet please, eye-tracking lab in use.

Thank you!

Appendix J. Visual Support for Proper Positioning during Eye-Tracking

Proper Positioning for the Eye-Tracker!

REMEMBER:

- ✓ sit up straight
- ✓ eyes forward
- ✓ keep your head still
- ✓ and try not to move or talk during the video.

Appendix K. Illustrations of the Eye-Tracking Calibration Simulator

Front View

Side View

Back View

(Created by the Principal Investigator on January 5, 2017)

Appendix L. Permission Form to Recruit from an Educational Setting

THE UNIVERSITY OF SOUTHERN MISSISSIPPI

Permission to Recruit Research Participants from an Educational Setting

Dear Administrator,

My name is Joann P. Judge and I am an instructor in the School of Kinesiology at the University of Southern Mississippi. At this time, I am in the dissertation phase of my doctoral degree in Kinesiology and Adapted Physical Education at the University of Virginia. I am very interested in studying the effects of video modeling on the motor skill acquisition of children with autism spectrum disorder.

I would like to request permission to advertise my research project titled **Video Modeling Motor Skill Performances: An Eye-Tracking Analysis of Children with Autism Spectrum Disorder** at your school. Using remote eye-tracking technology, this study will examine the visual attention patterns of children as they observe video modeled demonstrations of motor skill performances.

This study seeks to recruit 20 participants with autism and 20 participants without autism. All participants must be male and between 8-12 years of age. Findings from this investigation will extend the literature on video modeling and aid in the development of video modeling as an instructional strategy in teaching fundamental motor skills to children with autism spectrum disorder.

This research project would require **one, 30-minute visit** to the University of Southern Mississippi in Hattiesburg, MS. During the visit, the parent / guardian will be asked to sign a letter of consent, provide demographic information, and complete two parent / guardian questionnaires. The research participant (child) will be asked to sign a letter of assent and watch a two-minute video of motor skill performances using eye-tracking technology. A $15-gift certificate will be awarded to the research participant for taking part in the study.

NOTE: This research project has been approved by the Institutional Review Board. Participation is completely voluntary and the parent /guardian and child are free to withdraw from the study at any time. Information obtained from this study will be coded, secured, and kept strictly confidential. The child's name, location, school, community-based program, or other identity information will not be used in any report; and there are minimal risks to the child.

If you have any questions or concerns about the study, please contact me or my advisor at:

Joann P. Judge, Instructor
School of Kinesiology
University of Southern Mississippi
Hattiesburg, MS 39406
Telephone: 601-266-xxxx

Luke E. Kelly, Ph.D. (UVA Student Advisor)
Department of Kinesiology / Curry School of Education
University of Virginia
Charlottesville, VA 22904
Telephone: 434-924-xxxx

If you are interested in advertising this research project, please complete page 2.

Signed Consent to Recruit Research Participants from an Educational Setting

As the Administrator of the ____,
Name of the educational setting

I, ______________________________, hereby give Joann P. Judge, the principal
Name of the Administrator

investigator, permission to advertise her research project titled **Video Modeling Motor Skill Performances: An Eye-Tracking Analysis of Children with Autism Spectrum Disorder** at the school identified above. I understand this agreement is only intended to advertise for research participants and neither I nor this educational setting are directly involved in this study.

SECTION A: ADMINISTRATOR CONTACT INFORMATION

Name of the Educational Setting: ______________________________

Address: ______________________________

City: ____________________ State: __________ Zip Code: __________

Name of Administrator: ______________________________

Telephone Number: ______________________________

Email Address: ______________________________

Administrator (print name): ______________________________

Administrator (signature): ______________________________

Date Signed: ______________

Appendix M. Permission Form to Recruit from a Community-Based Setting

THE UNIVERSITY OF
SOUTHERN MISSISSIPPI.

Permission to Advertise for Research Participants from a Community-Based Setting

Dear Program Director,

My name is Joann P. Judge and I am an instructor in the School of Kinesiology at the University of Southern Mississippi. At this time, I am in the dissertation phase of my doctoral degree in Kinesiology and Adapted Physical Education at the University of Virginia. I am very interested in studying the effects of video modeling on the motor skill acquisition of children with autism spectrum disorder.

I would like to request permission to advertise my research project titled **Video Modeling Motor Skill Performances: An Eye-Tracking Analysis of Children with Autism Spectrum Disorder** at your establishment. Using remote eye-tracking technology, this study will examine the visual attention patterns of children as they observe video modeled demonstrations of motor skill performances.

This study seeks to recruit 20 participants with autism and 20 participants without autism. All participants must be male and between 8-12 years of age. Findings from this investigation will extend the literature on video modeling and aid in the development of video modeling as an instructional strategy in teaching fundamental motor skills to children with autism spectrum disorder.

This research project would require **one, 30-minute visit** to the University of Southern Mississippi in Hattiesburg, MS. During the visit, the parent / guardian will be asked to sign a letter of consent, provide demographic information, and complete two parent / guardian questionnaires. The research participant (child) will be asked to sign a letter of assent and watch a two-minute video of motor skill performances using eye-tracking technology. A $15-gift certificate will be awarded to the research participant for taking part in the study.

NOTE: This research project has been approved by the Institutional Review Board. Participation is completely voluntary and the parent / guardian and child are free to withdraw from the study at any time. Information obtained from this study will be coded, secured, and kept strictly confidential. The child's name, location, school, community-based program, or other identity information will not be used in any report; and there are minimal risks to the child.

If you have any questions or concerns about the study, please contact me or my advisor at:

Joann P. Judge, Instructor
School of Kinesiology
University of Southern Mississippi
Hattiesburg, MS 39406
Telephone: 601-266-xxxx

Luke E. Kelly, Ph.D. (UVA Student Advisor)
Department of Kinesiology / Curry School of Education
University of Virginia
Charlottesville, VA 22904
Telephone: 434-924-xxxx

If you are interested in advertising this research project, please complete page 2.

Signed Consent to Advertise for Research Participants from a Community-Based Setting

As the program director of the ____,
Name of the community-based program

I, ______________________________, hereby give Joann P. Judge, the principal
Name of the Program Director

investigation, permission to advertise her research project titled **Video Modeling Motor Skill Performances: An Eye-Tracking Analysis of Children with Autism Spectrum Disorder** at the community-based setting identified above. I understand this agreement is only intended to advertise for research participants and neither I nor this community-based program are directly involved in this study.

SECTION A: PROGRAM DIRECTOR CONTACT INFORMATION

Name of the Community-Based Program: ________________________________

Address: ____

City: ______________________ State: __________ Zip Code: __________

Name of the Program Director: ________________________________

Telephone Number: ____

Email Address: ____

Program Director (print name): ________________________________

Program Director (signature): ________________________________

Date Signed: ________________

Appendix N. Research Participants Needed Flyer

Research Participants Needed

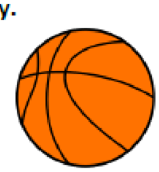
Video Modeling Motor Skill Performances: An Eye-Tracking Analysis of Children with Autism Spectrum Disorder

This study seeks to recruit **20** male participants **with** autism spectrum disorder and **20** male participants **without** autism spectrum disorder.

All participants must be male and between 8-12 years of age.

This research project would require **one, 30-minute visit** to the School of Kinesiology at The University of Southern Mississippi in Hattiesburg, MS. During that time, the parent / guardian will be asked to complete a participant demographic form and two questionnaires. In addition to completing the forms, the child participant will be asked to watch a two-minute video of motor skill performances using eye-tracking technology.

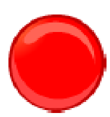
A $15 gift certificate will be awarded for participation in the study.

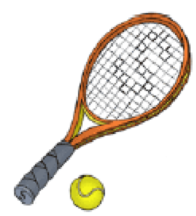


This study will be conducted by

Joann P. Judge, Instructor
College of Health / School of Kinesiology

The University of Southern Mississippi
Hattiesburg, Mississippi





For more information please contact:
Joann P. Judge, Principal Investigator
Phone: 601-266-5867
Email: joann.judge@usm.edu
IRB #16112202

RESEARCH STUDY #16112202
Contact: Joann P. Judge
601.266.5867
joann.judge@usm.edu

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joann.judge@usm.edu

RESEARCH STUDY #16112202
Contact: Joann P. Judge
601.266.5867
joann.judge@usm.edu

Appendix O. Overview of Data Collection Procedures

Overview of the Data Collection Procedure:

1. Parent / caregiver and the participant will be greeted at the front of the building.

2. After a brief introduction, the group will be escorted to the second floor and a tour of the meeting room and eye-tracking lab will be provided.

3. The meeting room will be setup prior to the arrial. All forms, documents, and writing utensils will be readily available. A small basket of play items (i.e., story books, coloring books, puzzles, toy cars, crayons, color pencils, and markers) will be place on the table within reach of the participant.

4. The eye-tracking lab will also be setup prior to arrival. Seating arrangements for both the meeting room and eye-tracking lab will be identified prior to data collection (i.e., parent / caregiver, participant, and the principal investigator).

5. Data collection will begin in the meeting room. Upon entry, the participant will be given permission to explore the basket of play items as the principal investigator provides the parent /caregiver an overview of the study and assistance with the completion of forms and the Social Communication Questionnaire (SCQ).

6. Once all the forms and the SCQ are completed, the principal investigator will escort the participant and the parent / caregiver to the eye-tracking lab.

7. Once the eye-tracking data are collected, the principal investigator will escort the participant and the parent / caregiver back to the meeting room. The participant will be provided the basket of play items while the parent / caregiver completes the Vineland Adaptive Behavior Scale-3 (VABS-3).

8. Once all the forms are complete, the principal investigator will acknowledge the parent's / caregiver's support, award the participant a $15 gift card, and escort the group to the main entrance of the building. *Estimated time of the visit was thirty minutes.

Appendix P. Research Participants Coded Data Collection Form

UNIVERSITY OF SOUTHERN MISSISSIPPI
RESEARCH PARTICIPANTS CODED DATA COLLECTION FORM

Project Title: *Video modeling motor skill performances: An eye-tracking analysis of children with autism spectrum disorder*
Principal Investigator: Joann P. Judge, University of Southern Mississippi / School of Kinesiology

#	Group A				Date of Visit
01.	A	G1	A	01	
02.	A	G2	B	02	
03.	A	G1	C	03	
04.	A	G2	D	04	
05.	A	G1	A	05	
06.	A	G2	B	06	
07.	A	G1	C	07	
08.	A	G2	D	08	
09.	A	G1	A	09	
10.	A	G2	B	10	
11.	A	G1	C	11	
12.	A	G2	D	12	
13.	A	G1	A	13	
14.	A	G2	B	14	
15.	A	G1	C	15	
16.	A	G2	D	16	
17.	A	G1	A	17	
18.	A	G2	B	18	
19.	A	G1	C	19	
20.	A	G2	D	20	

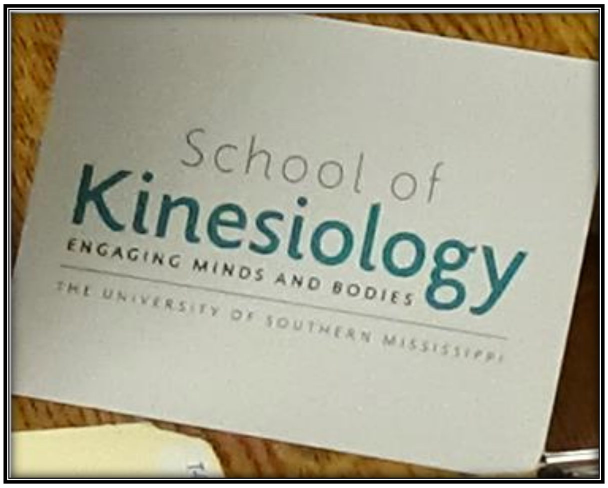
#	Group T				Date of Visit
21.	T	G1	A	01	
22.	T	G2	B	02	
23.	T	G1	C	03	
24.	T	G2	D	04	
25.	T	G1	A	05	
26.	T	G2	B	06	
27.	T	G1	C	07	
28.	T	G2	D	08	
29.	T	G1	A	09	
30.	T	G2	B	10	
31.	T	G1	C	11	
32.	T	G2	D	12	
33.	T	G1	A	13	
34.	T	G2	B	14	
35.	T	G1	C	15	
36.	T	G2	D	16	
37.	T	G1	A	17	
38.	T	G2	B	18	
39.	T	G1	C	19	
40.	T	G2	D	20	

Key Code

#	Group	Condition	Video Sequence	Participant Number	Date of Visit
No.	A-ASD T-TD	G1 - non-highlight G2 - highlight	A - basketball, soccer, tennis, ball toss; soccer, basketball, ball toss, tennis B - tennis, ball toss, basketball, soccer; ball toss, tennis, soccer, basketball C - soccer, tennis, ball toss, basketball; tennis, soccer, basketball, ball toss D - ball toss, basketball, soccer, tennis; basketball, ball toss, tennis, soccer	Participant #	1/1/17

Appendix Q. Research Participant Thank You Card

Research Participant Thank You Card



Cover (above) inside message (below)

Dear Research Participant,

Thank you very much for your participation in my research project. Your support is greatly appreciated!

Sincerely,
Joann P. Judge
Joann.judge@usm.edu
University of Southern Mississippi

Inside Message

* $15 Gift Certificate and Contact Card were also enclosed.

Appendix R. Preliminary Data Analysis for Time to First Fixation (TFF)

Step 1. Videos analyzed in the order as presented to the participant.

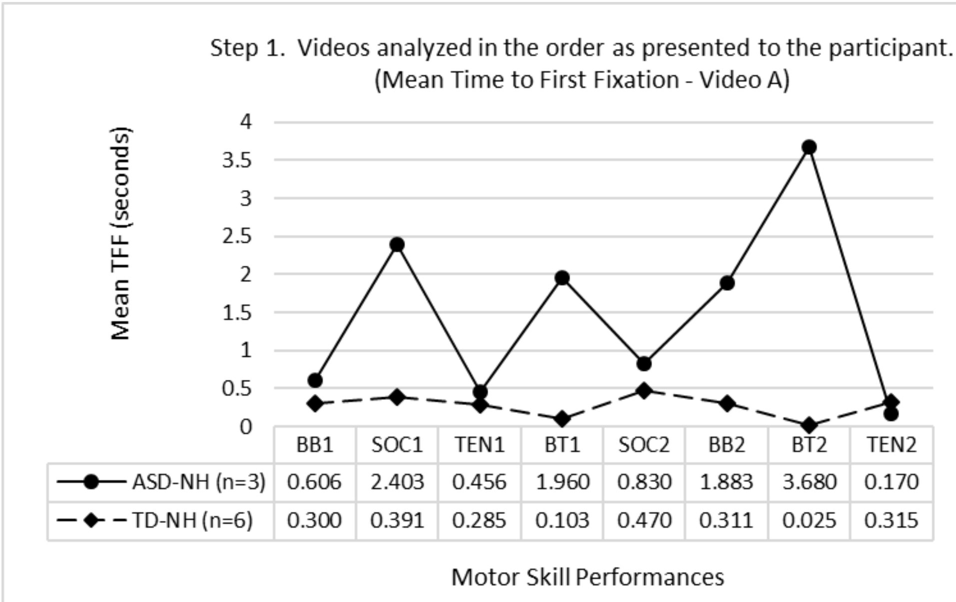
In Step 1, the raw data of the eight motor skill performances were examined as they were presented to the participant during the experiment (e.g., two blocks of four skill videos in a randomized order). Descriptive statistics and graphic illustrations were inspected to determine if order effect influenced the group means. For example, a trend in the data that may have evidenced boredom or fatigue in watching the videos over a 2-minute period. After inspection of the descriptive statistics and graphic illustrations, it appeared that order effect did not influence the group means (e.g., no trends in the data were detected). The results are presented accordingly.

Step 1. Videos analyzed in the order as presented to the participant for TFF (non-highlighted videos A & B).

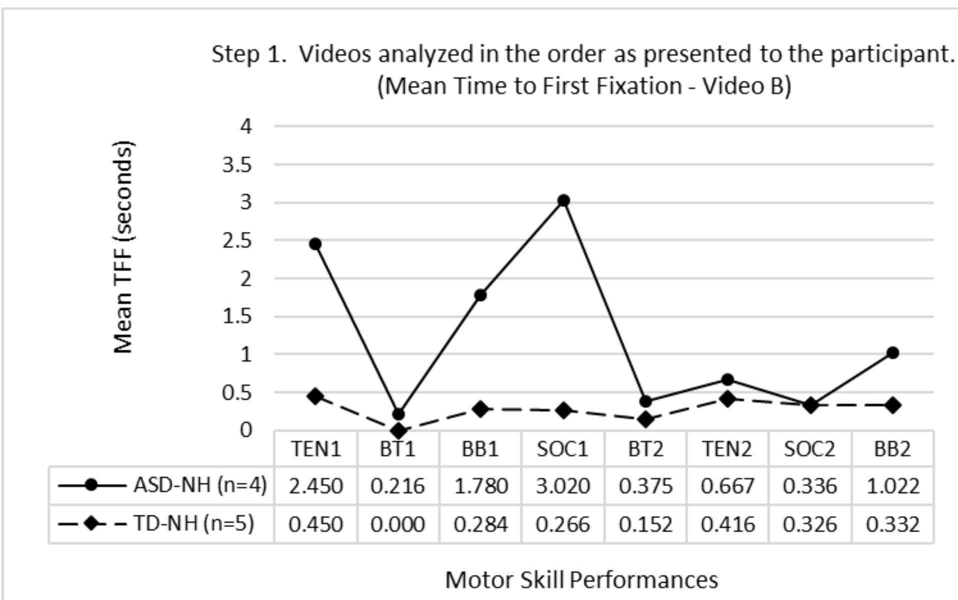
	Block 1				Block 2			
Video A	BB_1	SOC_1	TEN_1	BT_1	SOC_2	BB_2	BT_2	TEN_2
ASD (*n*=3)	.606 (.515)	2.403 (2.935)	.456 (.410)	1.960 (3.394)	.830 (.790)	1.883 (1.906)	3.680 (6.373)	.170 (.149)
TD (*n*=6)	.300 (.164)	.391(.082)	.285 (.107)	.103 (.160)	.470 (.133)	.311 (.136)	.025 (.061)	.315 (.090)
diff.	+0.306	+2.012	+0.171	+1.857	+0.360	+1.572	+3.655	-0.145

	Block 1				Block 2			
Video B	TEN_1	BT_1	BB_1	SOC_1	BT_2	TEN_2	SOC_2	BB_2
ASD (*n*=4)	2.450 (4.195)	.216 (.188)	1.780 (2.32)	3.02 (3.693)	.375 (.384)	.667 (.346)	.336 (.125)	1.022 (1.525)
TD (*n*=5)	.450 (.073)	.000 (.000)‡	.284 (.083)	.266 (.041)	.152 (.144)	.416 (.098)	.326 (.055)	.332 (.261)
diff.	+2.000	+0.216	+1.496	+2.754	+0.223	+0.251	+0.010	+0.690

Note. Mean TFF measured in seconds. Standard deviations are in parentheses. Motor skills performances: BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; *diff.* = difference. (.000)‡ = prior to the onset of each video, a "cross-hair" was placed in the center of the screen to provide a consistent starting point. The (.000) time may have been due to the cross-hair overlying the action AOI of the ball toss.



	BB1	SOC1	TEN1	BT1	SOC2	BB2	BT2	TEN2
ASD-NH (n=3)	0.606	2.403	0.456	1.960	0.830	1.883	3.680	0.170
TD-NH (n=6)	0.300	0.391	0.285	0.103	0.470	0.311	0.025	0.315



	TEN1	BT1	BB1	SOC1	BT2	TEN2	SOC2	BB2
ASD-NH (n=4)	2.450	0.216	1.780	3.020	0.375	0.667	0.336	1.022
TD-NH (n=5)	0.450	0.000	0.284	0.266	0.152	0.416	0.326	0.332

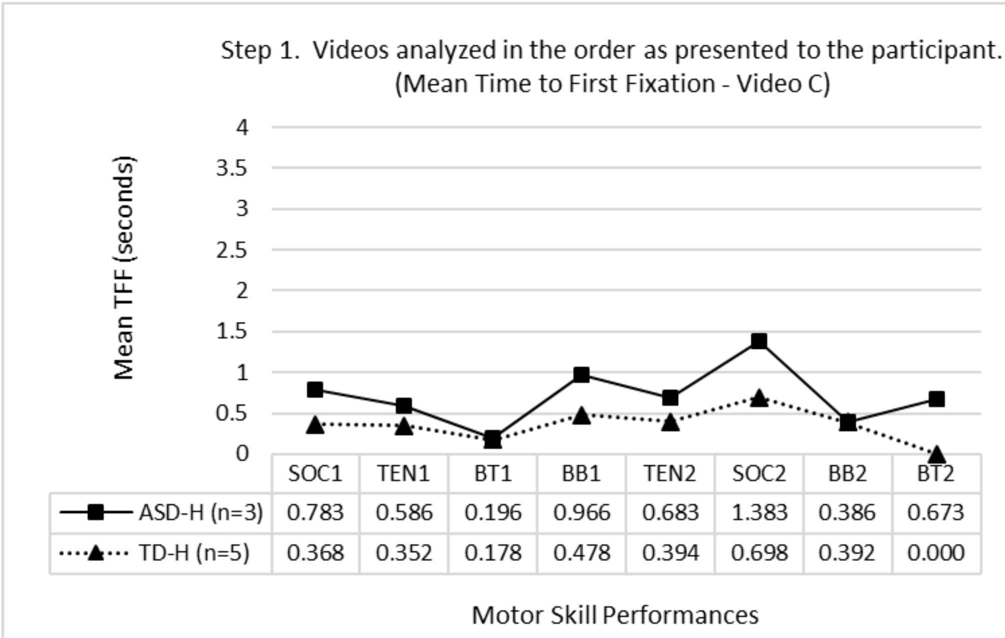
Step 1. Videos analyzed in the order as presented to the participant for TFF (non-highlighted videos A &B).

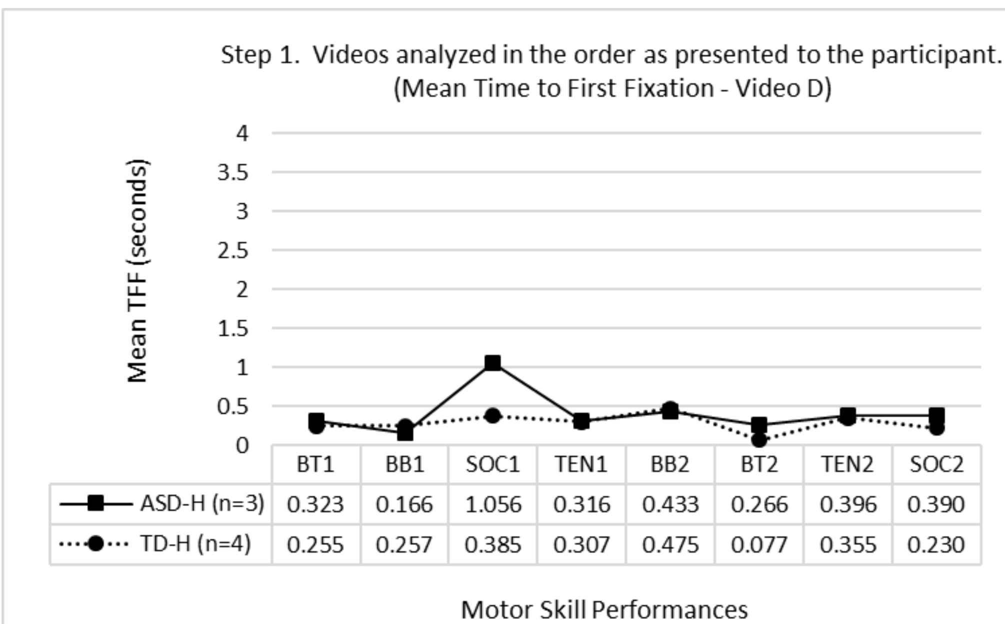
Step 1. Videos analyzed in the order as presented to the participant for TFF (highlighted videos C & D).

	Block 1				Block 2			
Video C	SOC_1	TEN_1	BT_1	BB_1	TEN_2	SOC_2	BB_2	BT_2
ASD (*n*=3)	.783 (1.179)	.586 (.446)	.196 (.173)	966 (.659)	.683 (.144)	1.383 (1.99)	.386 (.104)	.673 (.750)
TD (*n*=5)	.368 (.060)	.352 (.142)	.178 (.287)	478 (.244)	.394 (.146)	.698 (.402)	.392 (.279)	(.000)‡
diff.	+0.415	+0.234	+0.018	+0.488	+0.289	+0.685	-0.006	+0.673

	Block 1				Block 2			
Video D	BT_1	BB_1	SOC_1	TEN_1	BB_2	BT_2	TEN_2	SOC_2
ASD (*n*=3)	.323 (.287)	.166 (.149)	1.056 (1.095)	.316 (.025)	.433 (.301)	.266 (.299)	.396 (.125)	.390 (.079)
TD (*n*=4)	.255 (.294)	.257 (.250)	.385 (.135)	.307 (.079)	.475 (.287)	.077 (.104)	.355 (.163)	.230 (.153)
diff.	+0.068	-0.091	+0.671	+0.009	-0.042	+0.189	+0.041	+0.160

Note. Mean TFF measured in seconds. Standard deviations are in parentheses. ASD-autism spectrum disorder, TD-typically development; Motor skills performances: BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; *diff.* = difference. (.000)‡ = prior to the onset of each video, a "cross-hair" was placed in the center of the screen to provide a consistent starting point. The (.000) time may have been due to the cross-hair overlying the action AOI of the ball toss.





Step 1. Videos analyzed in the order as presented to the participant for TFF (highlighted videos C & D).

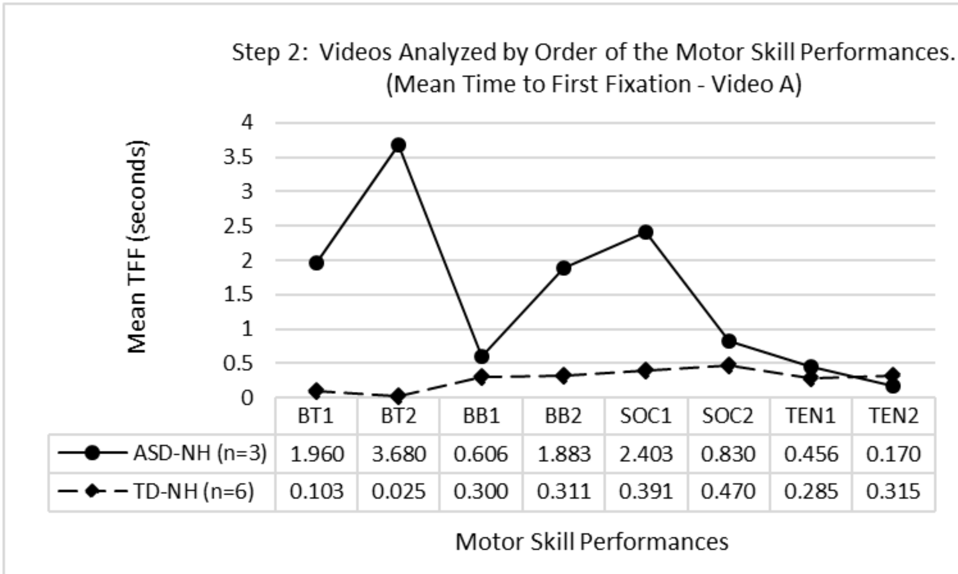
Step 2. Videos analyzed by order of the motor skill performances

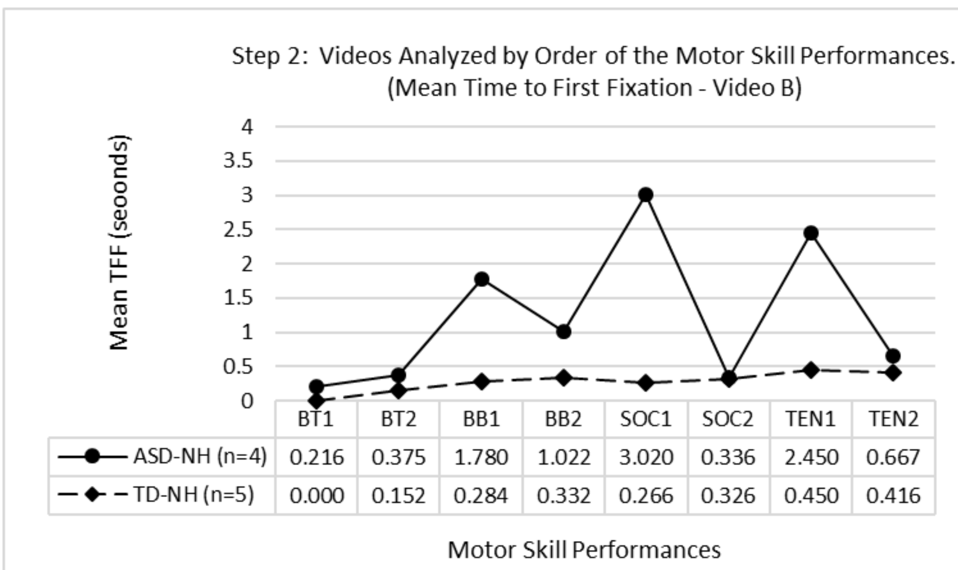
In Step 2, the raw data of the eight motor skill performances were examined side-by-side (i.e., BT1, BT2; BB1, BB2; SOC1, SOC2; and TEN1, TEN2). Descriptive statistics and graphic illustrations were inspected to determine if order effect influenced the group means (e.g., differences in the group mean between the first and second observation of the motor skill performances). After inspection of the descriptive statistics and graphic illustrations, it appeared that order effect did not influence the group means (e.g., no trends in the data were detected). The results are presented accordingly.

Step 2. Videos analyzed by order of the motor skill performances for TFF (non-highlighted videos).

Video A	BT_1	BT_2	BB_1	BB_2	SOC_1	SOC_2	TEN_1	TEN_2
ASD (*n*=3)	1.960 (3.394)	3.680 (.6.373)	.606 (.515)	1.883 (1.906)	2.403 (.2.935)	.830 (.790)	.456 (.410)	.170 (.149)
TD (*n*=6)	.103 (.160)	.025 (.061)	.300 (.164)	.311 (.136)	.391 (.082)	.470 (.133)	.285 (.107)	.315 (.090)
diff.	+1.857	+3.655	+0.306	-1.572	+2.012	+0.360	+0.171	-0.145
Video B	BT_1	BT_2	BB_1	BB_2	SOC_1	SOC_2	TEN_1	TEN_2
ASD (*n*=4)	.216 (.188)	.375 (.384)	1.780 (2.32)	1.022 (1.525)	3.02 (3.693)	.336 (.125)	2.450 (4.195)	.667 (.346)
TD (*n*=5)	(.000)‡	.152 (.144)	.284 (.083)	.332 (.261)	.266 (.041)	.326 (.055)	.450 (.073)	.416 (.098)
diff.	+0.216	+0.223	+1.496	+0.690	+2.754	+0.010	+2.000	+0.251

Note. Mean TFF measured in seconds. Standard deviations are in parentheses. ASD-autism spectrum disorder, TD-typically development; Motor skills performances: BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; *diff.* = difference. (.000)‡ = the zero time to TFF was a result of the "cross-hair" being centered over the BBT_1 action AOI.



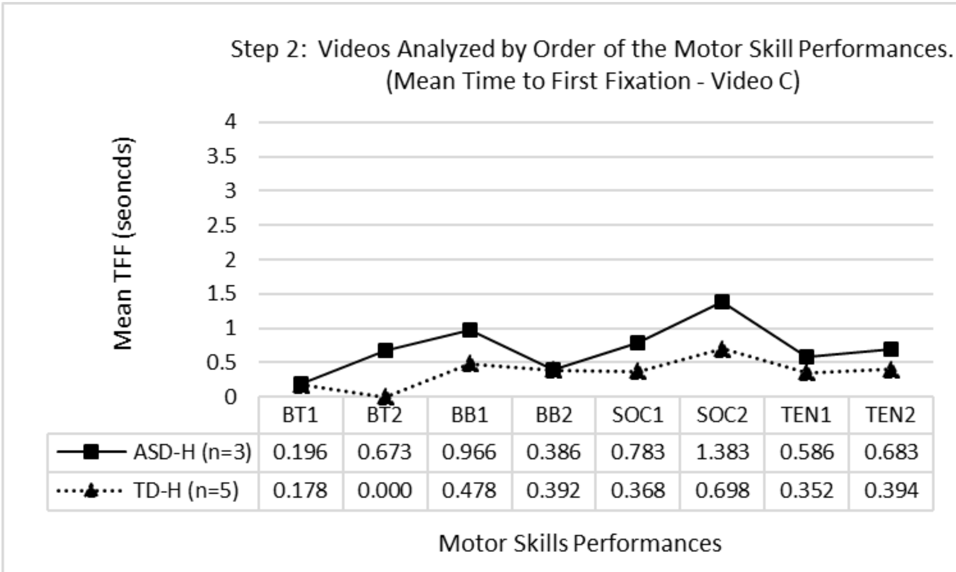


Step 2. Videos analyzed by order of the motor skill performances for TFF (non-highlighted videos).

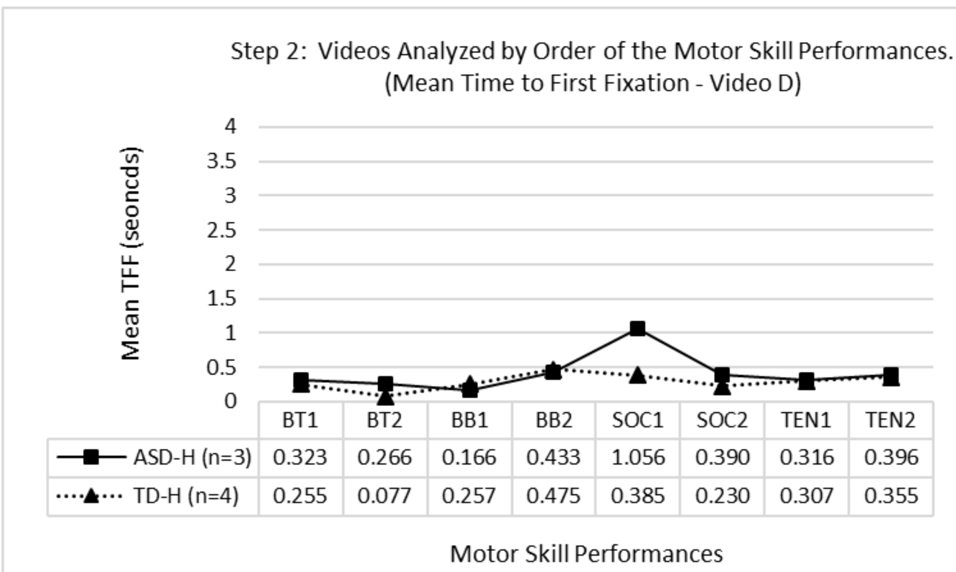
Step 2. Videos analyzed by order of the motor skill performances for TFF (highlighted videos).

Video C	BT_1	BT_2	BB_1	BB_2	SOC_1	SOC_2	TEN_1	TEN_2
ASD (*n*=3)	.196 (.173)	.673 (.750)	.966 (.659)	.386 (.104)	.783 (1.179)	1.383 (1.99)	.586 (.446)	.683 (.144)
TD (*n*=5)	.178 (.287)	.000 (.000)‡	.478 (.244)	.392 (.279)	.368 (.060)	.698 (.402)	.352 (.142)	.394 (.146)
diff.	+0.018	+0.673	+0.488	-0.006	+0.415	+0.685	+0.234	+0.289
Video D	BT_1	BT_2	BB_1	BB_2	SOC_1	SOC_2	TEN_1	TEN_2
ASD (*n*=3)	.323 (.287)	.266 (.299)	.166 (.149)	.433 (.301)	1.056 (1.095)	.390 (.079)	.316 (.025)	.396 (.125)
TD (*n*=4)	.255 (.294)	.077 (.104)	.257 (.250)	.475 (.287)	.385 (.135)	.230 (.153)	.307 (.079)	.355 (.163)
diff.	+0.068	+0.189	-0.091	-0.042	+0.671	+0.160	+0.009	+0.041

Note. Mean TFF measured in seconds. Standard deviations are in parentheses. ASD-autism spectrum disorder, TD-typically development; Motor skills performances: BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; *diff.* = difference. (.000)‡ = Prior to the onset of each video, a "cross-hair" was placed in the center of the screen to provide a consistent starting point. The (.000) time may have been due to the cross-hair overlying the action AOI of the ball toss.



	BT1	BT2	BB1	BB2	SOC1	SOC2	TEN1	TEN2
ASD-H (n=3)	0.196	0.673	0.966	0.386	0.783	1.383	0.586	0.683
TD-H (n=5)	0.178	0.000	0.478	0.392	0.368	0.698	0.352	0.394



	BT1	BT2	BB1	BB2	SOC1	SOC2	TEN1	TEN2
ASD-H (n=3)	0.323	0.266	0.166	0.433	1.056	0.390	0.316	0.396
TD-H (n=4)	0.255	0.077	0.257	0.475	0.385	0.230	0.307	0.355

Step 2. Videos analyzed by order of the motor skill performances for TFF (highlighted videos).

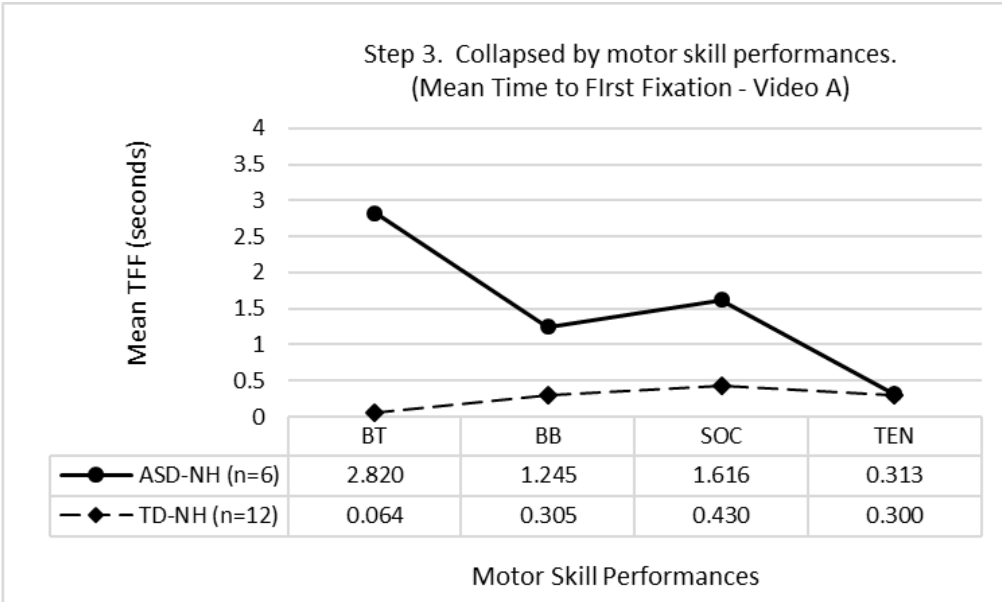
Step 3. Collapsed by motor skill performances for TFF

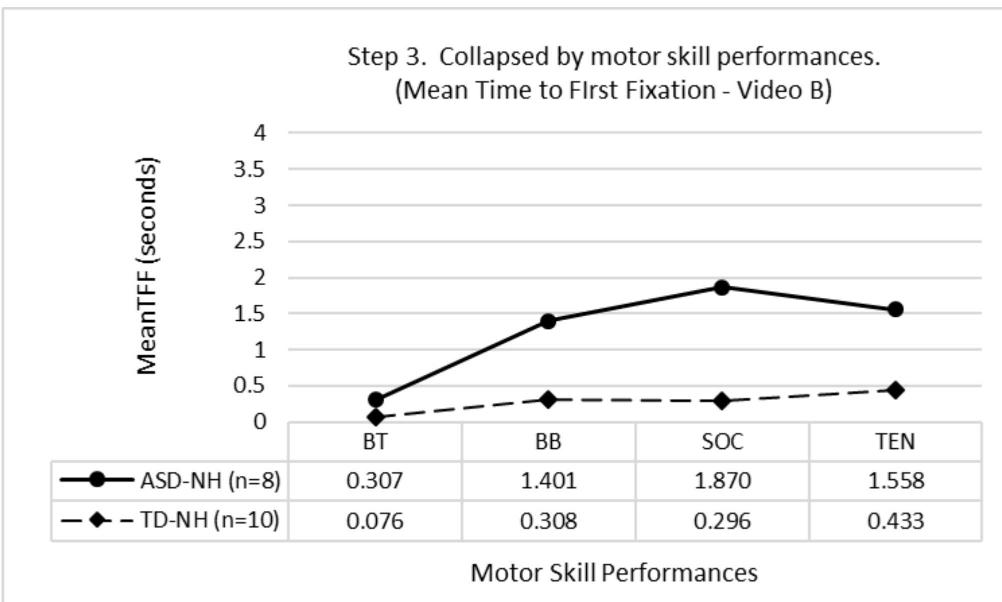
In Step 3, the raw data of each motor skill performances were collapsed into a single item (e.g., BT_1 and BT_2 were collapsed into BT). The purpose of collapsing the data was to increase the (*n*) and reduce the variability of the small data sets. The results are presented accordingly.

Step 3. Collapsed by motor skill performances for TFF.

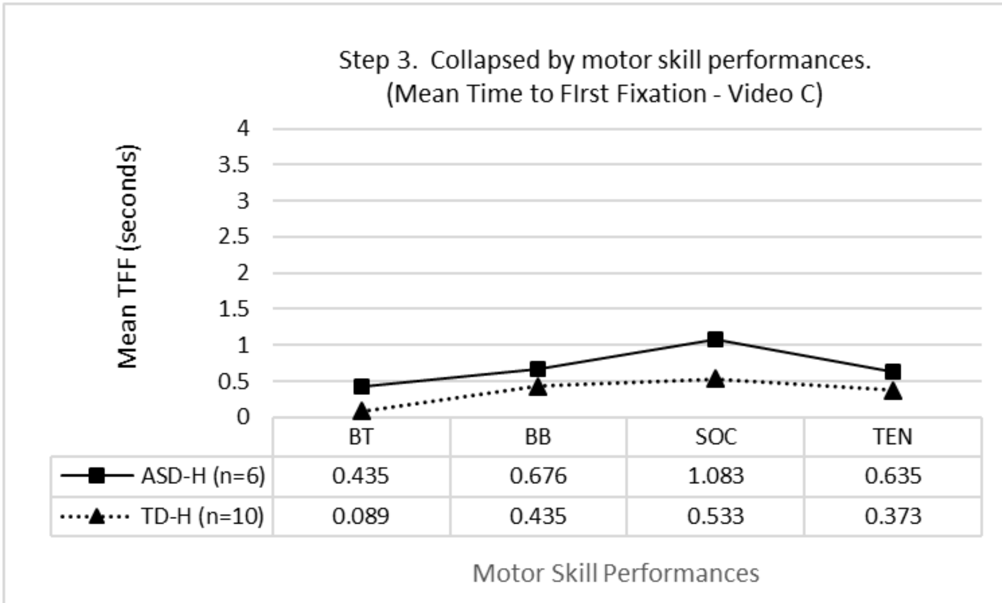
	BT	BB	SOC	TEN
Video A:				
ASD-NH (*n*=6)	2.820 (4.663)	1.245 (1.431)	1.616 (2.106)	0.313 (0.317)
TD-NH (*n*=12)	0.064 (0.122)	0.305 (0.144)	0.430 (0.113)	0.300 (0.095)
diff.	+2.756	+0.940	+1.186	+0.013
Video B:				
ASD-NH (*n*=8)	0.307 (0.304)	1.401 (1.867)	1.870 (2.980)	1.558 (2.915)
TD-NH (*n*=10)	0.076 (0.125)	0.308 (0.184)	0.296 (0.056)	0.433 (0.083)
diff.	+0.231	+1.093	+1.574	+1.125
Video C:				
ASD-H (*n*=6)	0.435 (0.552)	0.676 (0.528)	1.083 (1.503)	0.635 (0.301)
TD-H (*n*=10)	0.089 (0.213)	0.435 (0.251)	0.533 (0.322)	0.373 (0.137)
diff.	+0.346	+0.241	+0.550	+0.262
Video D:				
ASD-H (*n*=6)	0.295 (0.264)	0.300 (0.258)	0.723 (0.784)	0.356 (0.091)
TD-H (*n*=8)	0.166 (0.225)	0.366 (0.275)	0.307 (0.157)	0.331 (0.121)
diff.	+0.129	-0.066	+0.416	+0.025

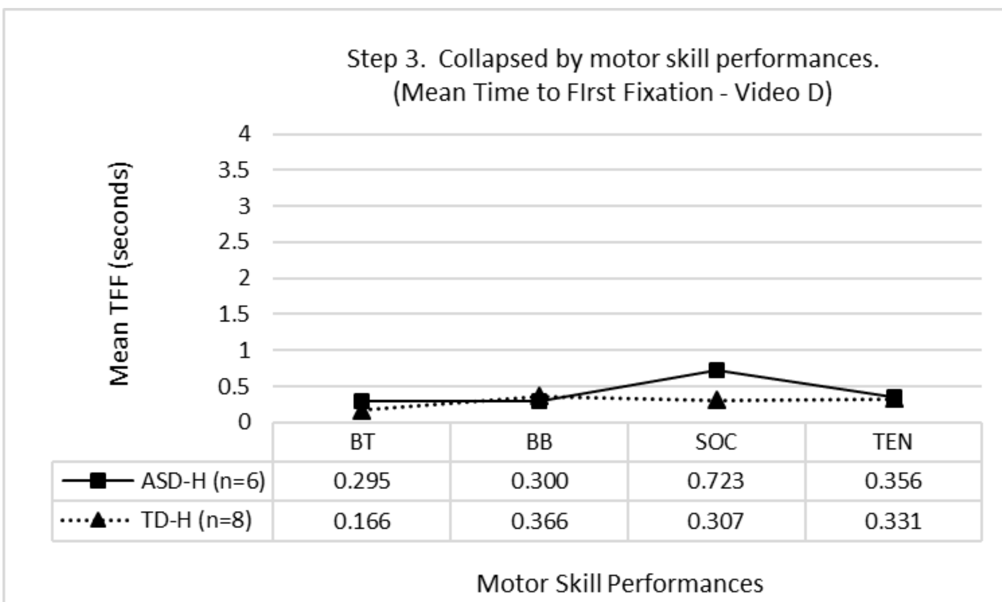
Note. Mean TFF measured in seconds. Standard deviations are in parentheses. Motor skills performances: BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; *diff.* = difference; Groups: ASD-NH = ASD-non-highlight, TD-NH = TD-non-highlight, ASD-H = ASD-highlight, TD-H = TD-highlight.





Step 3. Collapsed by motor skill performances for TFF.





Step 3. Collapsed by motor skill performances for TFF (highlighted videos).

Step 4. Collapsed by conditions for TFF

In Step 4 of the preliminary analysis, the raw data were collapsed by condition. For example, the non-highlighted videos A & B were collapsed to formulate the non-highlighted condition (NH); and the highlighted videos C & D were collapsed to formulate the highlighted condition (H). As a result of this step, four groups were identified and coded accordingly: (a) ASD non-highlighted condition (ASD-NH) (n = 14), (b) TD non-highlighted condition (TD-NH) (n = 22), (c) ASD highlighted condition (ASD-H) (n = 12), and (d) TD highlighted condition (TD-H) (n = 18). The results are presented accordingly. *Note.* The four-step preliminary analysis was completed for each of the eye-tracking metrics (i.e., time to first fixation, total visit duration, and visit count).

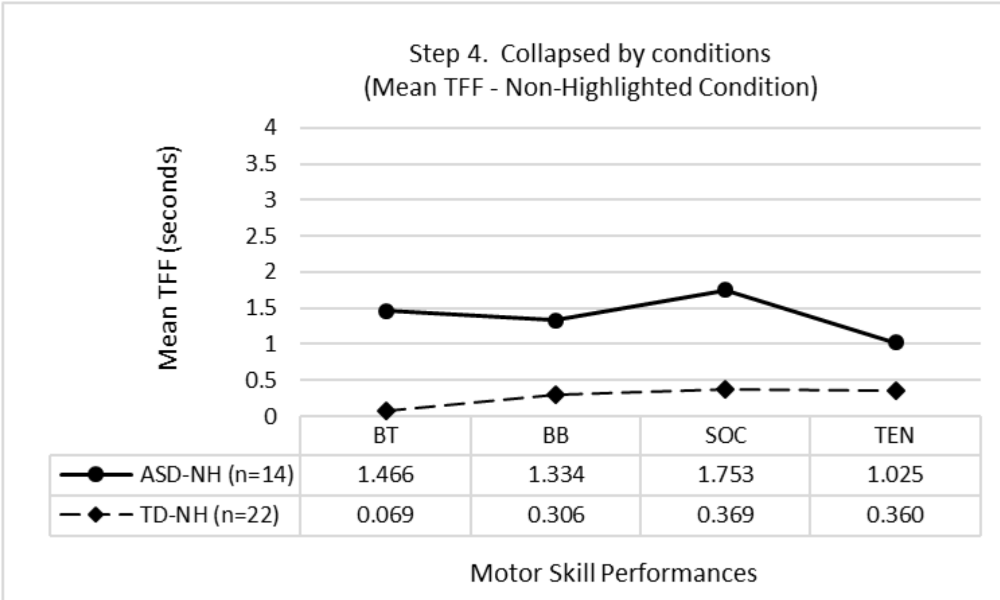
Preliminary Analysis for Total Visit Duration and Visit Count

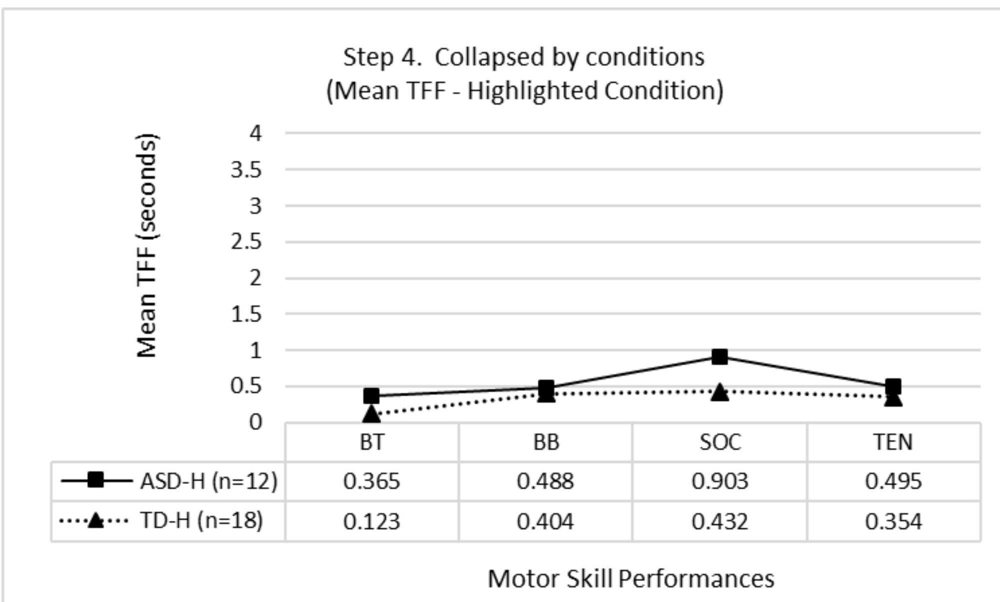
The same preliminary analyses were conducted for the Total Visit Duration (see Appendix R) and Visit Count (see Appendix S).

Step 4. Collapsed by conditions for TFF.

Condition	BT	BB	SOC	TEN
ASD-NH (*n*=14)	1.466 (3.287)	1.334 (1.634)	1.753 (2.511)	1.025 (2.241)
TD-NH (*n*=22)	0.069 (0.121)	0.306 (0.159)	0.369 (0.113)	0.360 (0.111)
ASD-H (*n*=12)	0.365 (0.419)	0.488 (0.442)	0.903 (0.158)	0.495 (0.257)
TD-H (*n*=18)	0.123 (0.215)	0.404 (0.257)	0.432 (0.280)	0.354 (0.128)

Note. Mean TFF measured in seconds. Standard deviations are in parentheses. Motor skills performances: BT-ball toss, BB-basketball, SOC-soccer, and TEN-tennis. ASD-NH = ASD-non-highlighted; TD-NH = TD-non-highlighted; ASD-H = ASD-highlighted; TD-H = TD-highlighted.

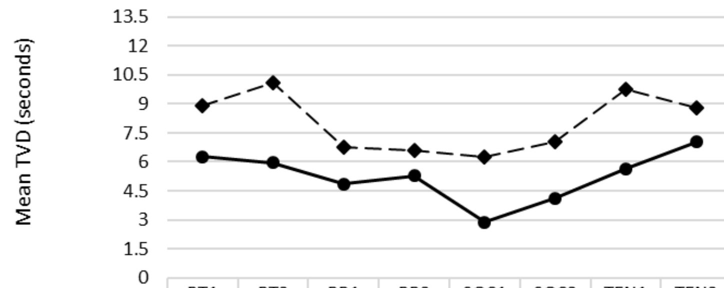




Step 4. Collapsed by condition for TFF.

Appendix S. Preliminary Data Analysis for Total Visit Duration (TVD)

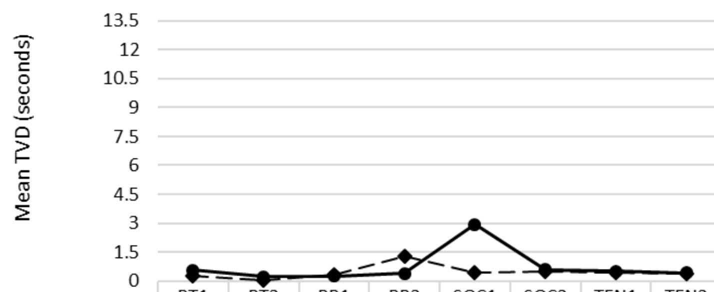
Step 2: Videos Analyzed by Order of the Motor Skill Performances.
(Mean TVD- Video A - Action AOI)



	BT1	BT2	BB1	BB2	SOC1	SOC2	TEN1	TEN2
ASD-NH (n=3)	6.280	5.943	4.860	5.267	2.863	4.113	5.633	7.036
TD-NH (n=6)	8.935	10.116	6.745	6.583	6.233	7.063	9.756	8.820

Motor Skill Performances

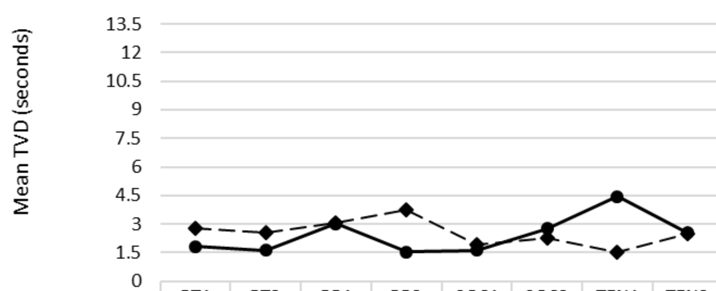
Step 2: Videos Analyzed by Order of the Motor Skill Performances.
((Mean TVD- Video A - Cone AOI)



	BT1	BT2	BB1	BB2	SOC1	SOC2	TEN1	TEN2
ASD-NH (n=3)	0.557	0.217	0.253	0.383	2.927	0.593	0.497	0.420
TD-NH (n=6)	0.246	0.048	0.333	1.280	0.430	0.506	0.408	0.363

Motor SkillsPerformances

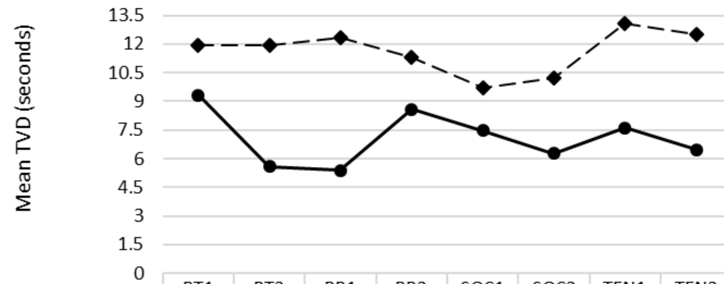
Step 2: Videos Analyzed by Order of the Motor Skill Performances.
((Mean TVD- Video A - Head AOI)



	BT1	BT2	BB1	BB2	SOC1	SOC2	TEN1	TEN2
ASD-NH (n=3)	1.837	1.627	3.027	1.550	1.627	2.760	4.450	2.527
TD-NH (n=6)	2.776	2.538	3.093	3.760	1.896	2.286	1.548	2.505

Motor Skill Performances

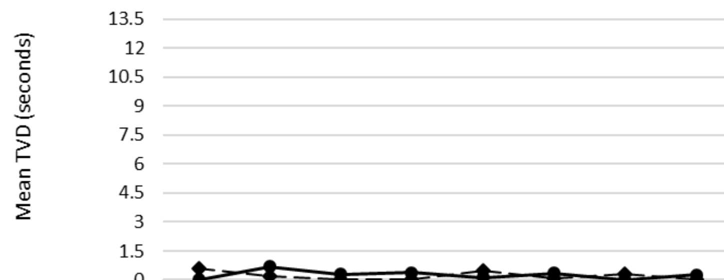
Step 2: Videos Analyzed by Order of the Motor Skill Performances.
(Mean TVD- Video B - Action AOI)



	BT1	BT2	BB1	BB2	SOC1	SOC2	TEN1	TEN2
ASD-NH(n=4)	9.338	5.580	5.378	8.573	7.460	6.268	7.617	6.485
TD-NH (n=5)	11.910	11.936	12.334	11.324	9.682	10.240	13.054	12.524

Motor Skill Performances

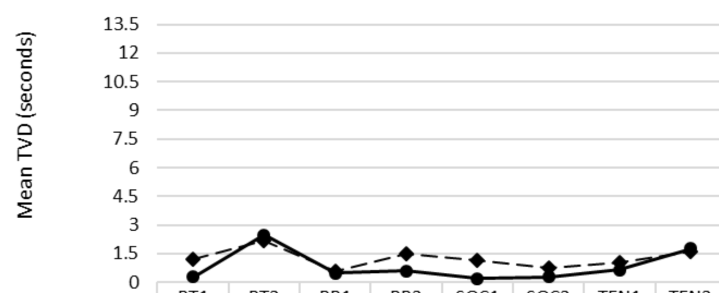
Step 2: Videos Analyzed by Order of the Motor Skill Performances.
(Mean TVD- Video B - Cone AOI)



	BT1	BT2	BB1	BB2	SOC1	SOC2	TEN1	TEN2
ASD-NH(n=4)	0.000	0.700	0.308	0.395	0.135	0.345	0.000	0.275
TD-NH (n=5)	0.580	0.172	0.000	0.052	0.462	0.084	0.320	0.000

Motor Skill Performances

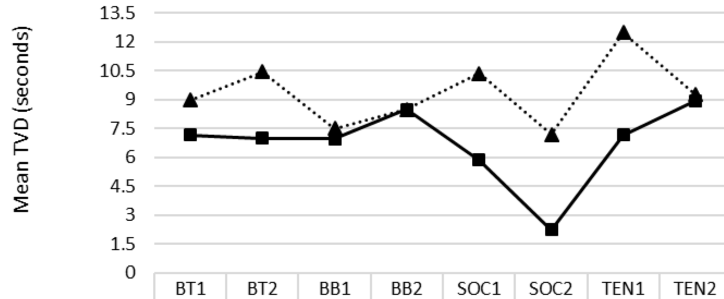
Step 2: Videos Analyzed by Order of the Motor Skill Performances.
(Mean TVD- Video B - Head AOI)



	BT1	BT2	BB1	BB2	SOC1	SOC2	TEN1	TEN2
ASD-NH(n=4)	0.278	2.478	0.495	0.598	0.213	0.283	0.667	1.780
TD-NH (n=5)	1.184	2.182	0.600	1.518	1.170	0.780	1.022	1.588

Motor Skill Performances

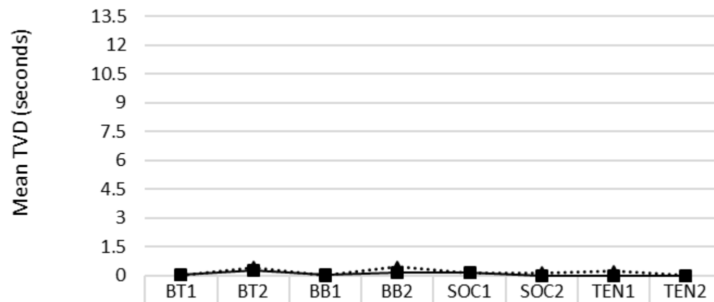
Step 2: Videos Analyzed by Order of the Motor Skill Performances.
(Mean TVD- Video C - Action AOI)



	BT1	BT2	BB1	BB2	SOC1	SOC2	TEN1	TEN2
ASD-H (n=3)	7.150	6.980	6.963	8.477	5.856	2.233	7.150	8.937
TD-H (n=5)	8.976	10.436	7.494	8.496	10.362	7.170	12.470	9.246

Motor Skill Performances

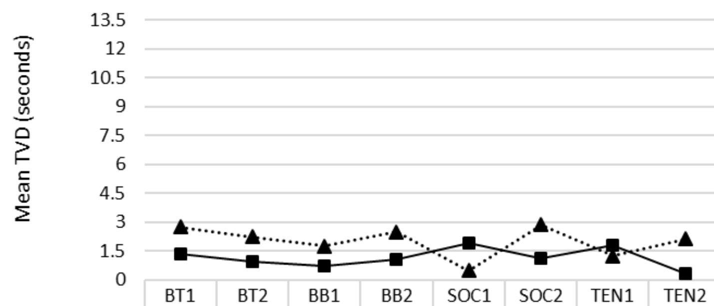
Step 2: Videos Analyzed by Order of the Motor Skill Performances.
(Mean TVD- Video C - Cone AOI)



	BT1	BT2	BB1	BB2	SOC1	SOC2	TEN1	TEN2
ASD-H (n=3)	0.067	0.297	0.023	0.177	0.150	0.000	0.000	0.000
TD-H (n=5)	0.040	0.426	0.000	0.446	0.132	0.138	0.232	0.000

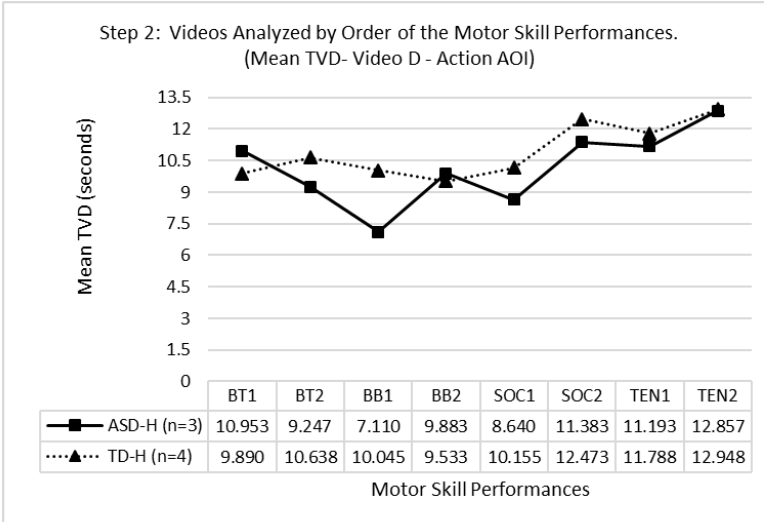
Motor Skill Performances

Step 2: Videos Analyzed by Order of the Motor Skill Performances.
(Mean TVD- Video C - Head AOI)

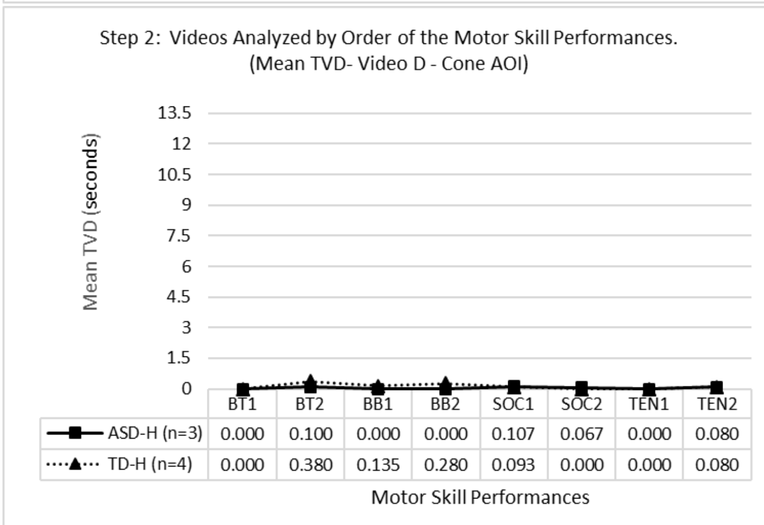


	BT1	BT2	BB1	BB2	SOC1	SOC2	TEN1	TEN2
ASD-H (n=3)	1.320	0.943	0.713	1.073	1.907	1.113	1.803	0.350
TD-H (n=5)	2.734	2.230	1.744	2.484	0.498	2.864	1.256	2.134

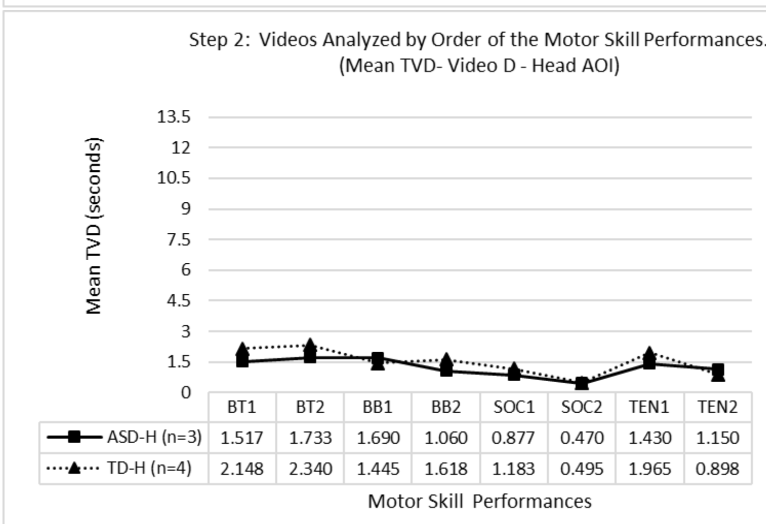
Motor Skill Performances



	BT1	BT2	BB1	BB2	SOC1	SOC2	TEN1	TEN2
ASD-H (n=3)	10.953	9.247	7.110	9.883	8.640	11.383	11.193	12.857
TD-H (n=4)	9.890	10.638	10.045	9.533	10.155	12.473	11.788	12.948

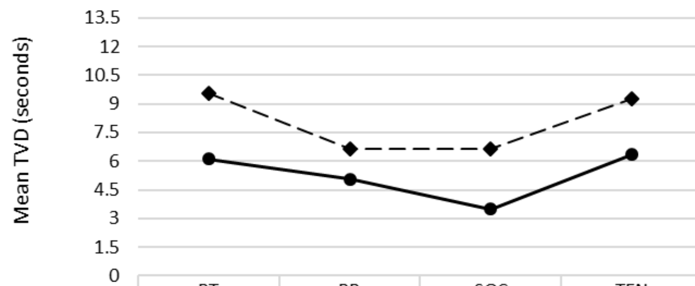


	BT1	BT2	BB1	BB2	SOC1	SOC2	TEN1	TEN2
ASD-H (n=3)	0.000	0.100	0.000	0.000	0.107	0.067	0.000	0.080
TD-H (n=4)	0.000	0.380	0.135	0.280	0.093	0.000	0.000	0.080



	BT1	BT2	BB1	BB2	SOC1	SOC2	TEN1	TEN2
ASD-H (n=3)	1.517	1.733	1.690	1.060	0.877	0.470	1.430	1.150
TD-H (n=4)	2.148	2.340	1.445	1.618	1.183	0.495	1.965	0.898

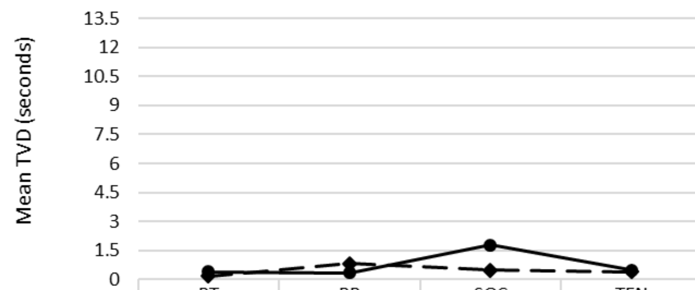
Step 3. Collapsed by motor skill performances.
(Mean TVD- Video A- Action AOI)



	BT	BB	SOC	TEN
ASD-NH (n=6)	6.112	5.063	3.488	6.335
TD-NH (n=12)	9.526	6.664	6.648	9.288

Motor Skill Performances

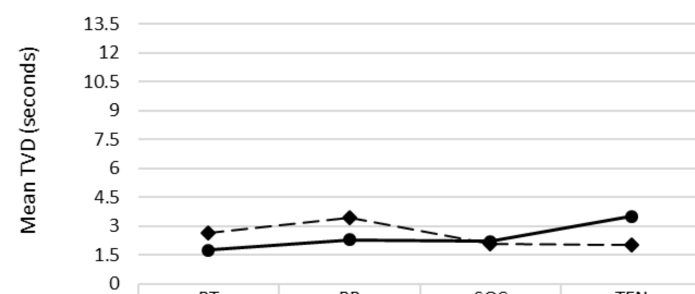
Step 3. Collapsed by motor skill performances.
(Mean TVD- Video A - Cone AOI)



	BT	BB	SOC	TEN
ASD-NH (n=6)	0.387	0.318	1.760	0.458
TD-NH (n=12)	0.148	0.807	0.468	0.386

Motor Skill Performances

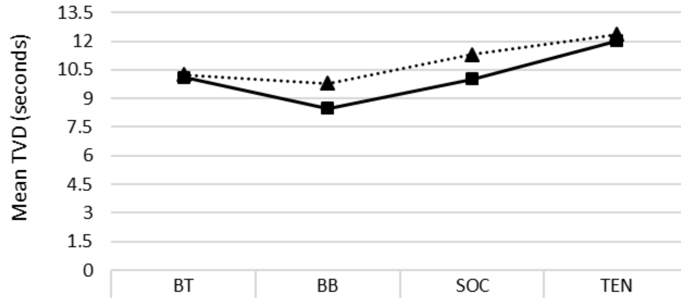
Step 3. Collapsed by motor skill performances.
(Mean TVD- Video A- Head AOI)



	BT	BB	SOC	TEN
ASD-NH (n=6)	1.732	2.288	2.193	3.488
TD-NH (n=12)	2.658	3.427	2.092	2.027

Motor Skill Performances

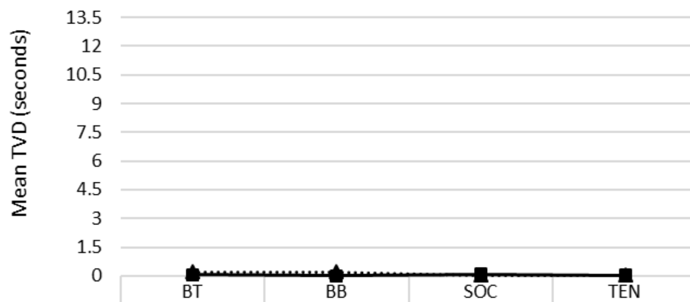
Step 3. Collapsed by motor skill performances.
(Mean TVD- Video D - Action AOI)



	BT	BB	SOC	TEN
ASD-H (n=6)	10.100	8.497	10.012	12.025
TD-H (n=8)	10.264	9.789	11.314	12.368

Motor Skill Performances

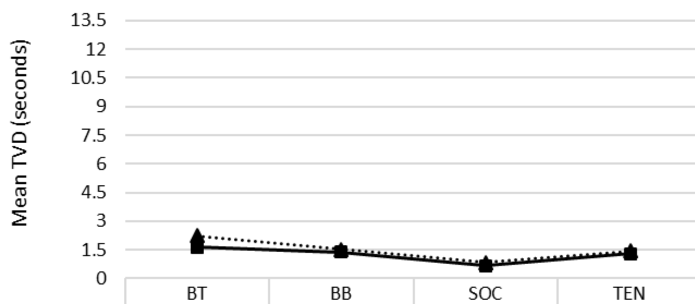
Step 3. Collapsed by motor skill performances.
(Mean TVD- Video D - Cone AOI)



	BT	BB	SOC	TEN
ASD-H (n=6)	0.050	0.000	0.087	0.040
TD-H (n=8)	0.190	0.208	0.046	0.040

Motor Skill Performances

Step 3. Collapsed by motor skill performances.
(Mean TVD- Video D - Head AOI)

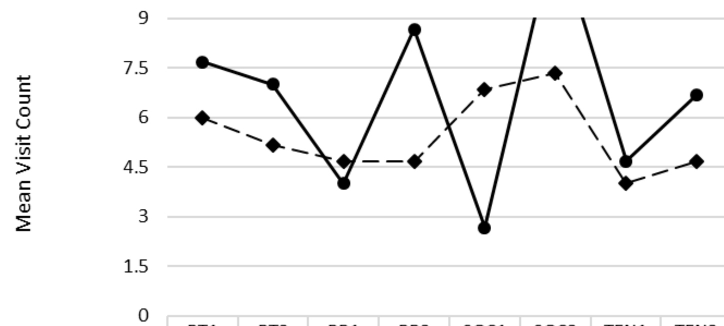


	BT	BB	SOC	TEN
ASD-H (n=6)	1.625	1.375	0.673	1.290
TD-H (n=8)	2.244	1.531	0.839	1.431

Motor Skill Performances

Appendix T. Preliminary Data Analysis for Visit Count (VC)

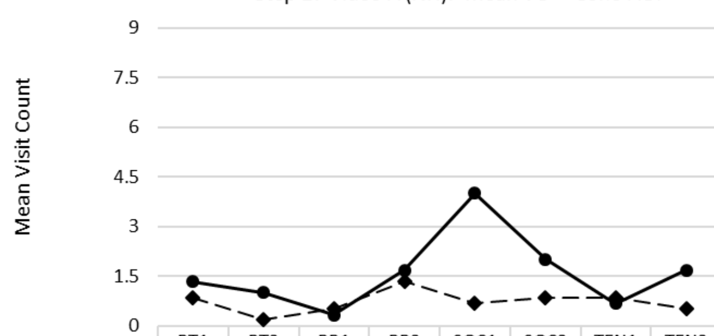
Step 2: Video A (NH): Mean VC - Action AOI



	BT1	BT2	BB1	BB2	SOC1	SOC2	TEN1	TEN2
ASD-NH (n=3)	7.67	7.00	4.00	8.67	2.67	11.67	4.67	6.67
TD-NH (n=6)	6.00	5.17	4.67	4.67	6.83	7.33	4.00	4.67

Motor Skill Performances

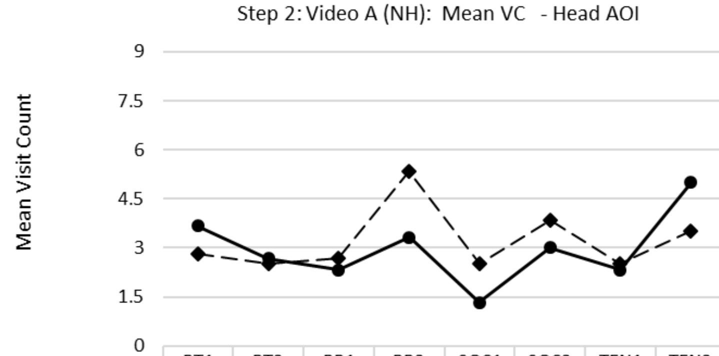
Step 2: Video A (NH): Mean VC - Cone AOI



	BT1	BT2	BB1	BB2	SOC1	SOC2	TEN1	TEN2
ASD-NH (n=3)	1.33	1.00	0.33	1.67	4.00	2.00	0.67	1.67
TD-NH (n=6)	0.83	0.17	0.50	1.33	0.67	0.83	0.83	0.50

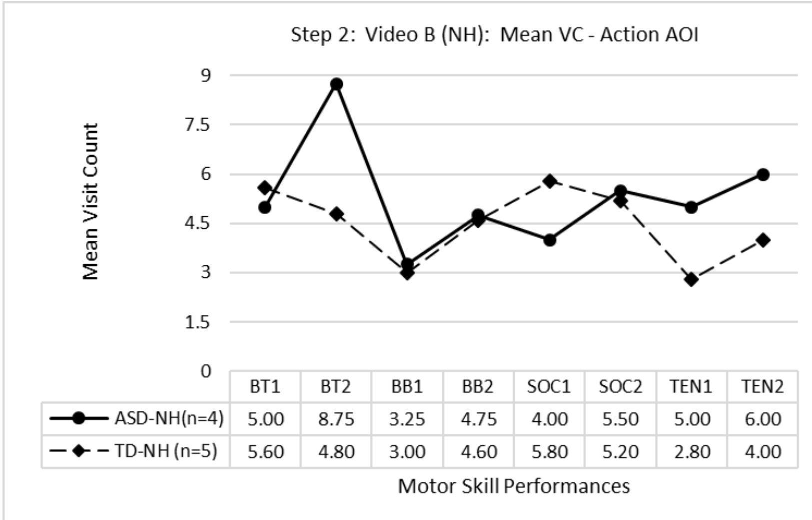
Motor Skill Performances

Step 2: Video A (NH): Mean VC - Head AOI

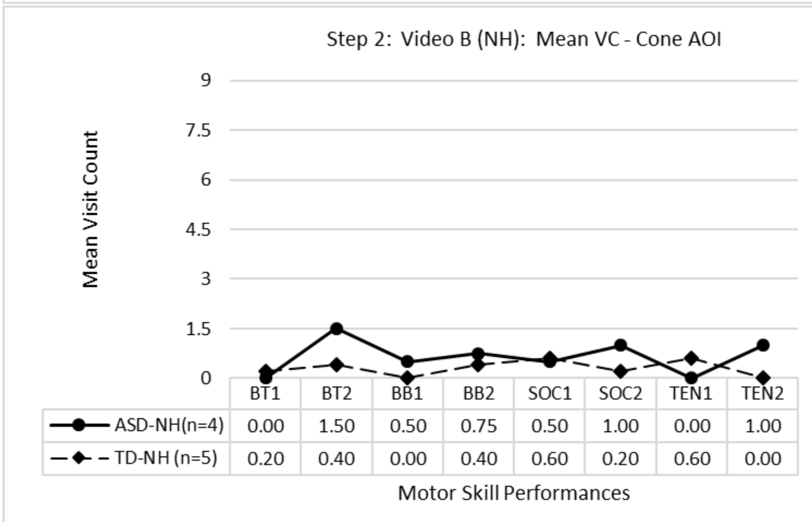


	BT1	BT2	BB1	BB2	SOC1	SOC2	TEN1	TEN2
ASD-NH (n=3)	3.67	2.67	2.33	3.33	1.33	3.00	2.33	5.00
TD-NH (n=6)	2.83	2.50	2.67	5.33	2.50	3.83	2.50	3.50

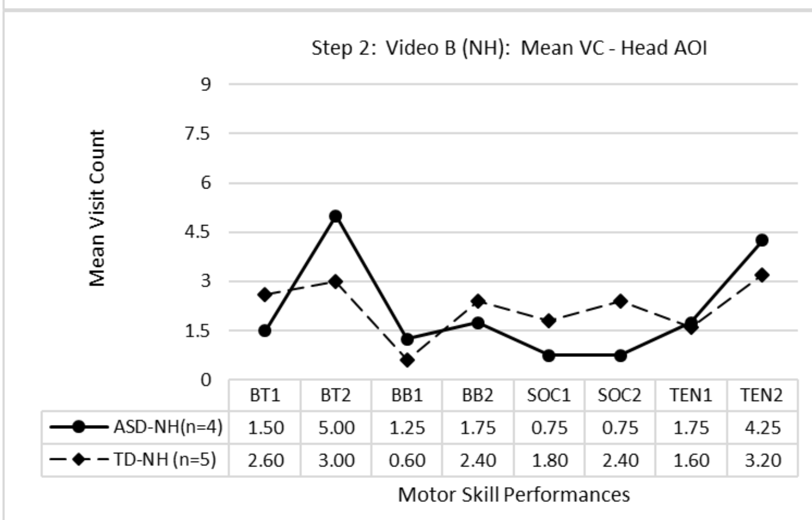
Motor Skill Performances



	BT1	BT2	BB1	BB2	SOC1	SOC2	TEN1	TEN2
ASD-NH(n=4)	5.00	8.75	3.25	4.75	4.00	5.50	5.00	6.00
TD-NH (n=5)	5.60	4.80	3.00	4.60	5.80	5.20	2.80	4.00

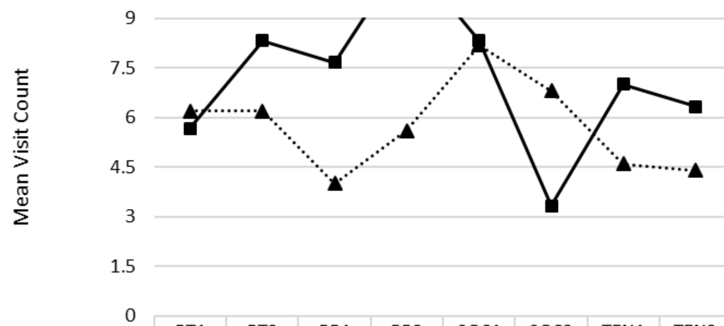


	BT1	BT2	BB1	BB2	SOC1	SOC2	TEN1	TEN2
ASD-NH(n=4)	0.00	1.50	0.50	0.75	0.50	1.00	0.00	1.00
TD-NH (n=5)	0.20	0.40	0.00	0.40	0.60	0.20	0.60	0.00



	BT1	BT2	BB1	BB2	SOC1	SOC2	TEN1	TEN2
ASD-NH(n=4)	1.50	5.00	1.25	1.75	0.75	0.75	1.75	4.25
TD-NH (n=5)	2.60	3.00	0.60	2.40	1.80	2.40	1.60	3.20

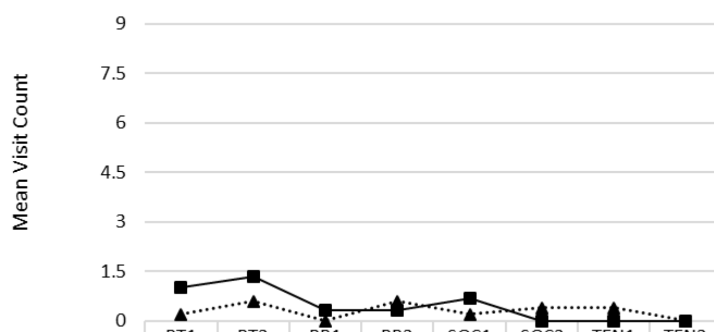
Step 2: Video C (H): Mean VC - Action AOI



	BT1	BT2	BB1	BB2	SOC1	SOC2	TEN1	TEN2
ASD-H (n=3)	5.67	8.33	7.67	11.00	8.33	3.33	7.00	6.33
TD-H (n=5)	6.20	6.20	4.00	5.60	8.20	6.80	4.60	4.40

Motor Skill Performances

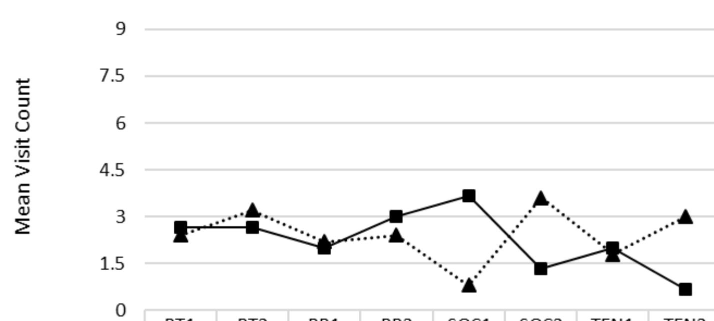
Step 2: Video C (H) : Mean VC - Cone AOI



	BT1	BT2	BB1	BB2	SOC1	SOC2	TEN1	TEN2
ASD-H (n=3)	1.00	1.33	0.33	0.33	0.67	0.00	0.00	0.00
TD-H (n=5)	0.20	0.60	0.00	0.60	0.20	0.40	0.40	0.00

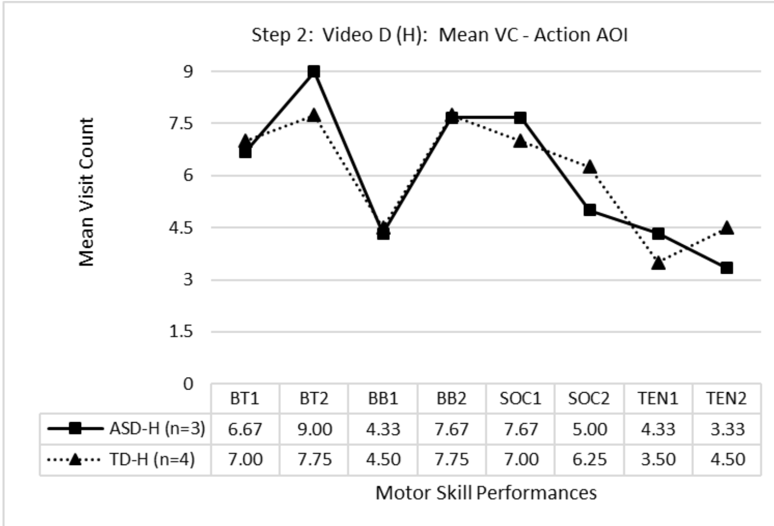
Motor Skill Performances

Step 2: Video C (H) : Mean VC - Head AOI

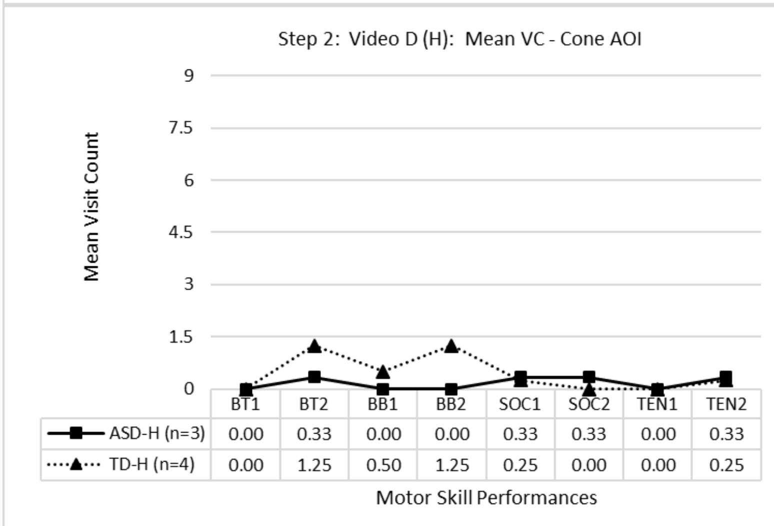


	BT1	BT2	BB1	BB2	SOC1	SOC2	TEN1	TEN2
ASD-H (n=3)	2.67	2.67	2.00	3.00	3.67	1.33	2.00	0.67
TD-H (n=5)	2.40	3.20	2.20	2.40	0.80	3.60	1.80	3.00

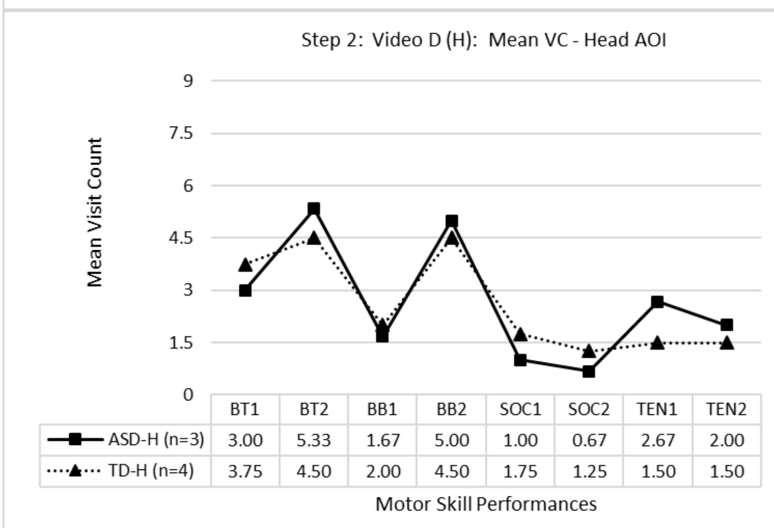
Motor Skill Performances



	BT1	BT2	BB1	BB2	SOC1	SOC2	TEN1	TEN2
ASD-H (n=3)	6.67	9.00	4.33	7.67	7.67	5.00	4.33	3.33
TD-H (n=4)	7.00	7.75	4.50	7.75	7.00	6.25	3.50	4.50

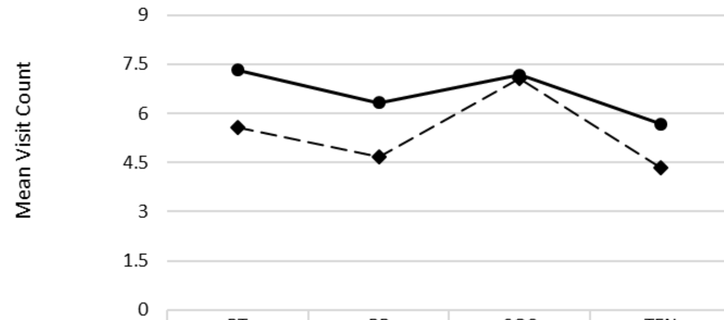


	BT1	BT2	BB1	BB2	SOC1	SOC2	TEN1	TEN2
ASD-H (n=3)	0.00	0.33	0.00	0.00	0.33	0.33	0.00	0.33
TD-H (n=4)	0.00	1.25	0.50	1.25	0.25	0.00	0.00	0.25



	BT1	BT2	BB1	BB2	SOC1	SOC2	TEN1	TEN2
ASD-H (n=3)	3.00	5.33	1.67	5.00	1.00	0.67	2.67	2.00
TD-H (n=4)	3.75	4.50	2.00	4.50	1.75	1.25	1.50	1.50

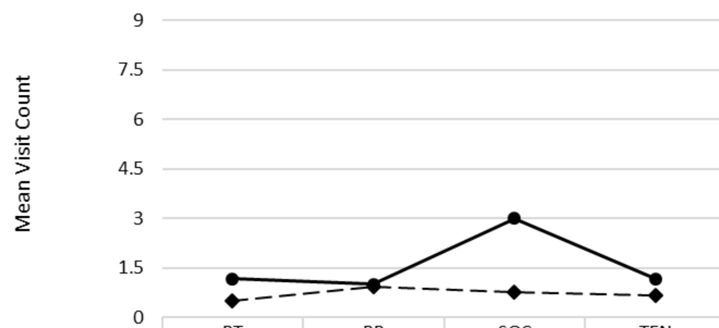
Step 3: Video A (NH): Mean VC- Action AOI



	BT	BB	SOC	TEN
ASD-NH (n=6)	7.33	6.33	7.17	5.67
TD-NH (n=12)	5.58	4.67	7.08	4.33

Motor Skill Performances

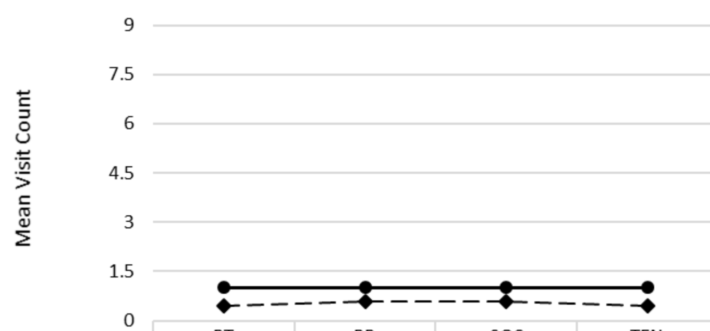
Step 3: Video A (NH): Mean VC - Cone AOI



	BT	BB	SOC	TEN
ASD-NH (n=6)	1.17	1.00	3.00	1.17
TD-NH (n=12)	0.50	0.92	0.75	0.67

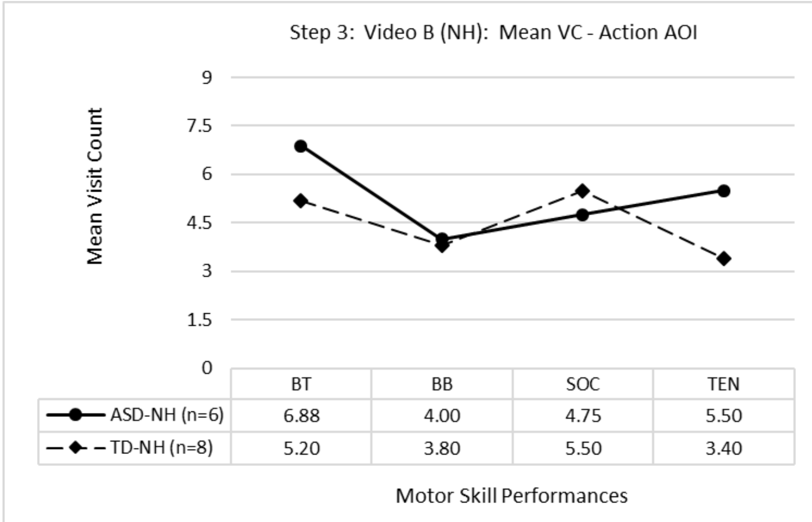
Motor Skill Performances

Step 3: Video A (NH): Mean VC - Head AOI

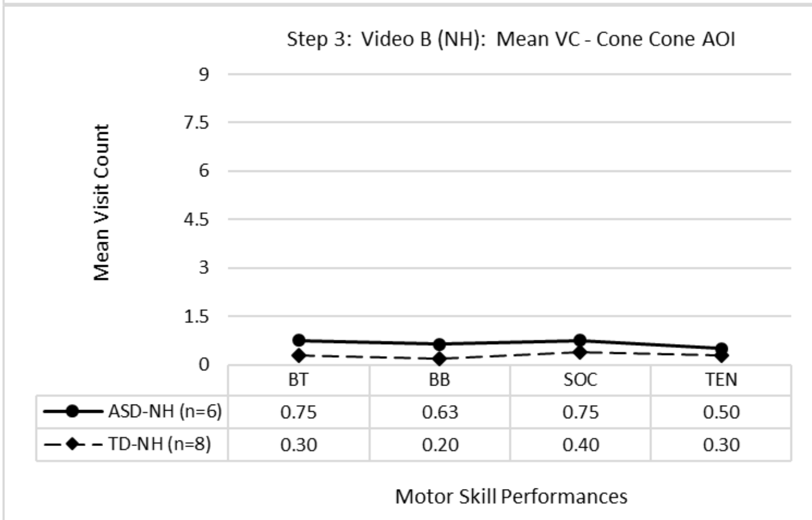


	BT	BB	SOC	TEN
ASD-NH (n=6)	3.17	2.83	2.17	3.67
TD-NH (n=12)	2.67	4.00	3.17	3.00

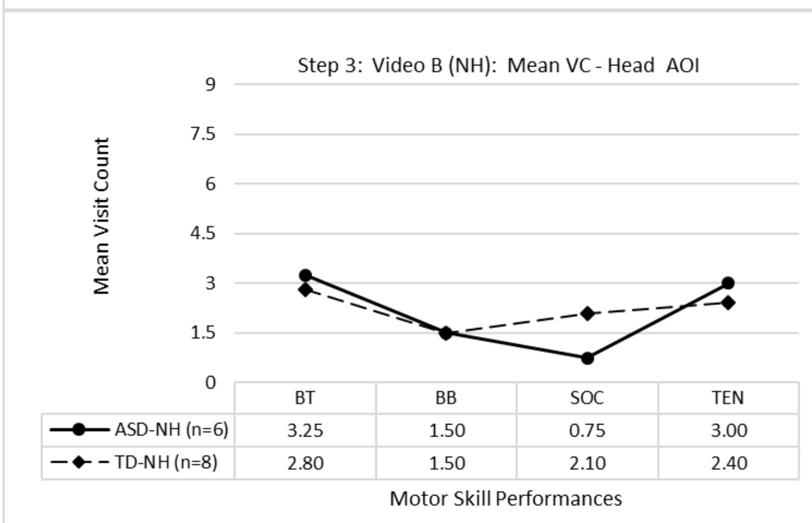
Motor Skill Performance



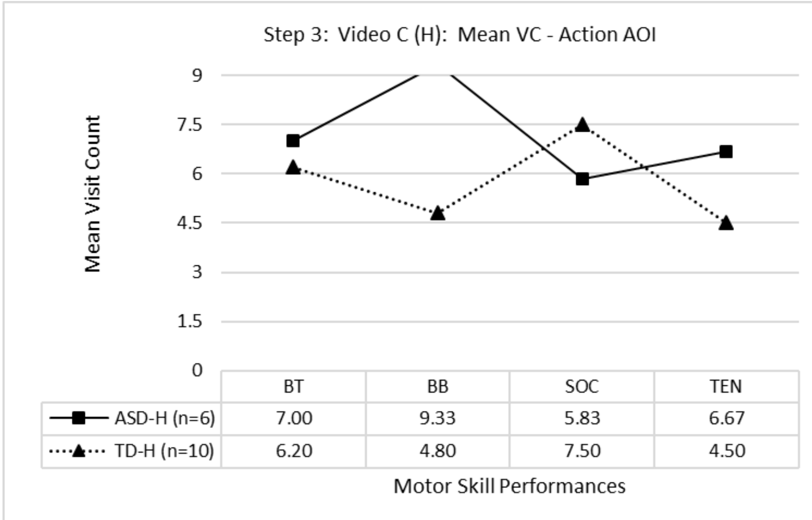
	BT	BB	SOC	TEN
ASD-NH (n=6)	6.88	4.00	4.75	5.50
TD-NH (n=8)	5.20	3.80	5.50	3.40



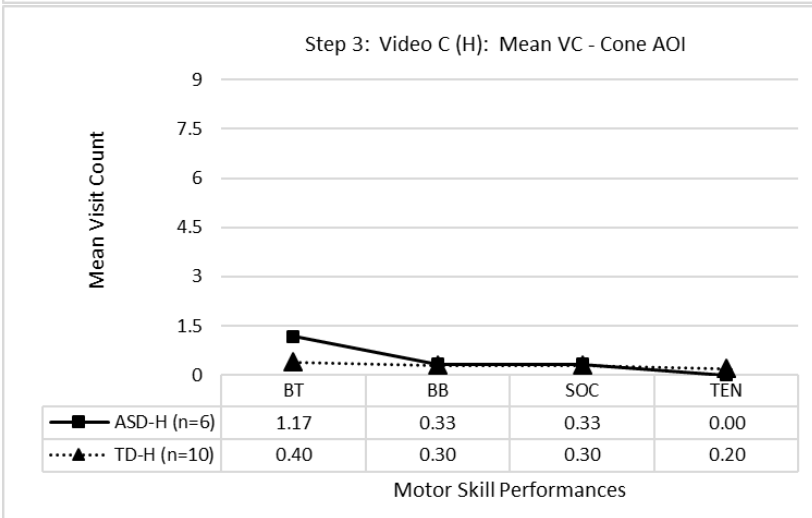
	BT	BB	SOC	TEN
ASD-NH (n=6)	0.75	0.63	0.75	0.50
TD-NH (n=8)	0.30	0.20	0.40	0.30



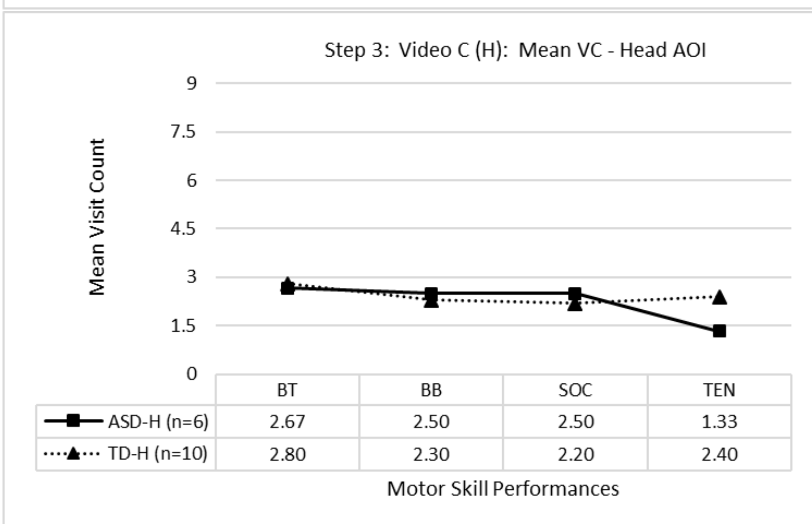
	BT	BB	SOC	TEN
ASD-NH (n=6)	3.25	1.50	0.75	3.00
TD-NH (n=8)	2.80	1.50	2.10	2.40



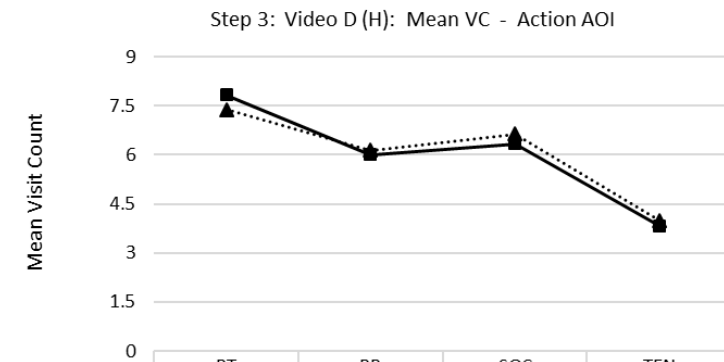
Step 3: Video C (H): Mean VC - Action AOI
Mean Visit Count
9
7.5
6
4.5
3
1.5
0
BT
BB
SOC
TEN
ASD-H (n=6)
7.00
9.33
5.83
6.67
TD-H (n=10)
6.20
4.80
7.50
4.50
Motor Skill Performances



Step 3: Video C (H): Mean VC - Cone AOI
Mean Visit Count
9
7.5
6
4.5
3
1.5
0
BT
BB
SOC
TEN
ASD-H (n=6)
1.17
0.33
0.33
0.00
TD-H (n=10)
0.40
0.30
0.30
0.20
Motor Skill Performances

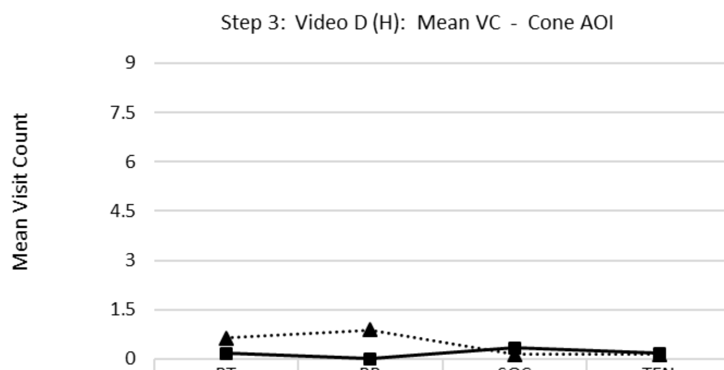


Step 3: Video C (H): Mean VC - Head AOI
Mean Visit Count
9
7.5
6
4.5
3
1.5
0
BT
BB
SOC
TEN
ASD-H (n=6)
2.67
2.50
2.50
1.33
TD-H (n=10)
2.80
2.30
2.20
2.40
Motor Skill Performances



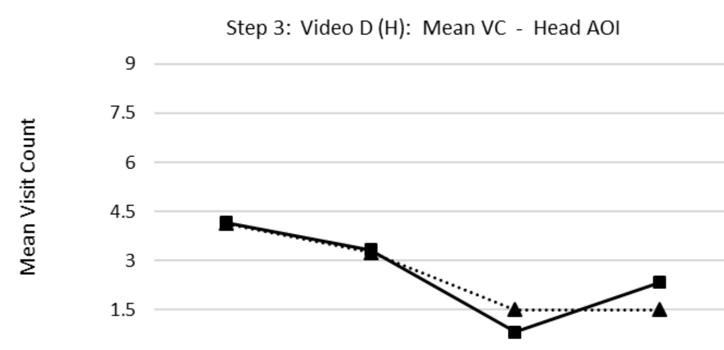
	BT	BB	SOC	TEN
ASD-H (n=6)	7.83	6.00	6.33	3.83
TD-H (n=8)	7.38	6.13	6.63	4.00

Motor Skill Performances



	BT	BB	SOC	TEN
ASD-H (n=6)	0.17	0.00	0.33	0.17
TD-H (n=8)	0.63	0.88	0.13	0.13

Motor Skill Performances



	BT	BB	SOC	TEN
ASD-H (n=6)	4.17	3.33	0.83	2.33
TD-H (n=8)	4.13	3.25	1.50	1.50

Motor Skill Performances

Appendix U. Trends in the Data for Time to First Fixation (TFF)

Trends in the Data for Time to First Fixation (TFF)

Table 19. *Summary of Results for Time to First Fixation (TFF).*

Motor Skills	ASD-NH (*n* =14)	TD-NH (*n*=22)	*diff.*	*U / t*	*Z / df*	*p*	
BT	1.466 (3.287)	0.069 (0.121)	**+1.397**	89.0	-2.126	.033	
BB	1.334 (1.634)	0.306 (0.159)	**+1.028**	93.0	-1.981	.048	
SOC	1.753 (2.511)	0.369 (0.113)	**+1.384**	96.5	-1.590	.112	
TEN	1.025 (2.241)	0.360 (0.111)	**+0.665**	149.0	-0.162	.871	1-RQ1
	ASD-H (*n*=12)	TD-H (*n*=18)					
BT	0.365 (0.419)	0.123 (0.215)	**+0.242**	56.0	-2.322	.020	
BB	0.488 (0.442)	0.404 (0.257)	**+0.084**	96.0	-0.508	.611	
SOC	0.903 (1.158)	0.432 (0.280)	**+0.471**	106.5	-0.064	.949	
TEN	0.495 (0.257)	0.354 (0.128)	**+0.141**	66.0	-1.780	.075	
	ASD-NH (*n*=14)	ASD-H (*n*=12)					
BT	1.466 (3.287)	0.365 (0.419)	**+1.101**	72.5	-0.306	.759	
BB	1.334 (1.634)	0.488 (0.442)	**+0.846**	65.0	-0.978	.328	2-RQ2
SOC	1.753 (2.511)	0.903 (1.158)	**+0.850**	63.0	-0.816	.414	
TEN	1.025 (2.241)	0.495 (0.257)	**+0.530**	65.5	-0.952	.341	
	TD-NH (*n*=22)	TD-H (*n*=18)					
BT	0.069 (0.121)	0.123 (0.215)	**-0.054**	178.0	-0.653	.514	
BB	0.306 (0.159)	0.404 (0.257)	**-0.098**	168.5	-0.803	.422	3-RQ2
SOC	0.369 (0.113)	0.432 (0.280)	**-0.063**	185.0	-0.354	.723	
TEN	0.360 (0.111)	0.354 (0.128)	**+0.006**	176.0	-0.599	.549	

Note. TFF measures are in seconds; Standard deviations are in parentheses; *diff.* = between group mean differences; Motor skills performances: BT-ball toss, BB-basketball, SOC-soccer, TEN-tennis; Groups: ASD-NH = ASD-non-highlight, TD-NH = TD-non-highlight, ASD-H = ASD-highlight, TD-H = TD-highlight.

*Significant $p < .01$.

[a] = p-value computed by the independent samples t-test.

Appendix V. Trends in the Data for Total Visit Duration (TVD)

Trends in the Data for Total Visit Duration (TVD)

2-RQ3

Table 24. *Summary of Results for Total Visit Duration (TVD) - Action AOI*

Motor Skills	ASD-NH (*n*=14)	TD-NH (*n*=22)	*diff.*	*U / t*	*Z / df*	*p*
BT_{action}	6.881 (4.923)	10.616 (3.114)	**-3.735**	83.0	-2.304	.021
BB_{action}	6.156 (5.684)	9.012 (4.406)	**-2.856**	103.0	-1.655	.098
SOC_{action}	5.417 (4.936)	8.154 (3.309)	**-2.737**	99.0	-1.785	.074
TEN_{action}	6.744 (4.530)	10.880 (3.322)	**-4.136**	69.0	-2.759	.006*
	ASD-H (*n*=12)	TD-H (*n*=18)				
BT_{action}	8.583 (4.121)	9.954 (3.242)	**-1.371**	-1.018	28	.317[a]
BB_{action}	8.108 (4.462)	8.792 (2.839)	**-0.684**	100.0	-0.339	.735
SOC_{action}	7.028 (4.800)	9.898 (3.118)	**-2.870**	70.0	-1.609	.108
TEN_{action}	10.034 (4.311)	11.529 (2.878)	**-1.495**	92.0	-0.677	.498
	ASD-NH (*n*=14)	ASD-H (*n*=12)				
BT_{action}	6.881 (4.923)	8.583 (4.121)	**-1.702**	-0.946	24	.354[a]
BB_{action}	6.156 (5.684)	8.108 (4.462)	**-1.952**	62.0	-1.132	.258
SOC_{action}	5.417 (4.936)	7.028 (4.800)	**-1.611**	-0.840	24	.409[a]
TEN_{action}	6.744 (4.530)	10.034 (4.311)	**-3.290**	49.0	-1.801	.072
	TD-NH (*n*=22)	TD-H (*n*=18)				
BT_{action}	10.616 (3.114)	9.954 (3.242)	+0.662	-0.656	38	.516[a]
BB_{action}	9.012 (4.406)	8.792 (2.839)	+0.220	184.0	-0.381	.703
SOC_{action}	8.154 (3.309)	9.898 (3.118)	-0.744	-1.702	38	.097[a]
TEN_{action}	10.880 (3.322)	11.529 (2.878)	-0.649	179.5	-0.503	.615

Table 29. *Summary of Results for Total Visit Duration - Cone AOI*

Motor Skills	ASD-NH (*n*=14)	TD-NH (*n*=22)	*diff.*	*U / t*	*Z / df*	*p*
BT_{cone}	0.366 (0.527)	0.251 (0.634)	+0.115	122.5	-1.163	.245
BB_{cone}	0.337 (0.484)	0.452 (1.290)	-0.115	137.0	-0.641	.521
SOC_{cone}	0.891 (2.298)	0.380 (0.748)	+0.511	126.5	-0.966	.334
TEN_{cone}	0.275 (0.494)	0.283 (0.520)	-0.008	150.0	-0.159	.874
	ASD-H (*n*=12)	TD-H (*n*=18)				
BT_{cone}	0.116 (0.242)	0.214 (0.379)	**-0.098**	103.5	-0.227	.820
BB_{cone}	0.050 (0.152)	0.216 (0.406)	**-0.166**	92.0	-0.914	.361
SOC_{cone}	0.081 (0.129)	0.096 (0.197)	**-0.015**	102.0	-0.326	.744
TEN_{cone}	0.020 (0.069)	0.082 (0.197)	**-0.062**	97.5	-0.752	.452
	ASD-NH (*n*=14)	ASD-H (*n*=12)				
BT_{cone}	0.366 (0.527)	0.116 (0.242)	**+0.250**	61.5	-1.287	.198
BB_{cone}	0.337 (0.484)	0.050 (0.152)	**+0.287**	57.0	-1.698	.089
SOC_{cone}	0.891 (2.298)	0.081 (0.129)	**+0.810**	54.0	-1.680	.093
TEN_{cone}	0.275 (0.494)	0.020 (0.069)	**+0.255**	65.0	-1.420	.156
	TD-NH (*n*=22)	TD-H (*n*=18)				
BT_{cone}	0.251 (0.634)	0.214 (0.379)	+0.037	193.5	-0.147	.883
BB_{cone}	0.452 (1.290)	0.216 (0.406)	+0.236	191.5	-0.218	.827
SOC_{cone}	0.380 (0.748)	0.096 (0.197)	+0.284	159.5	-1.258	.209
TEN_{cone}	0.283 (0.520)	0.082 (0.197)	+0.201	164.5	-1.198	.231

Table 34. *Summary of Results for Total Visit Duration - Head AOI*

Motor Skills	ASD-NH (*n*=14)	TD-NH (*n*=22)	*diff.*	*U / t*	*Z / df*	*p*
BT_{head}	1.529 (2.265)	2.215 (2.184)	-0.686	110.5	-1.415	.157
BB_{head}	1.293 (2.411)	2.351 (2.602)	-1.058	91.5	-2.033	.042
SOC_{head}	1.081 (2.357)	1.584 (1.338)	-0.503	79.5	-2.453	.014
TEN_{head}	2.194 (2.865)	1.669 (1.280)	+0.495	145.0	-0.293	.770
	ASD-H (*n*=12)	TD-H (*n*=18)				
BT_{head}	1.378 (1.181)	2.376 (1.825)	**-0.998**	-1.067	28	.106[a]
BB_{head}	1.134 (1.159)	1.855 (1.674)	**-0.721**	83.5	-1.038	.299
SOC_{head}	1.092 (1.295)	1.307 (1.567)	**-0.215**	96.5	-0.491	.623
TEN_{head}	1.183 (1.177)	1.578 (1.261)	**-0.395**	-.861	28	.396[a]
	ASD-NH (*n*=14)	ASD-H (*n*=12)				
BT_{head}	1.529 (2.265)	1.378 (1.181)	**+0.151**	66.0	-0.927	.354
BB_{head}	1.293 (2.411)	1.134 (1.159)	**+0.159**	61.0	-1.185	.236
SOC_{head}	1.081 (2.357)	1.092 (1.295)	**-0.011**	67.0	-0.934	.350
TEN_{head}	2.194 (2.865)	1.183 (1.177)	**+1.011**	85.5	-0.180	.857
	TD-NH (*n*=22)	TD-H (*n*=18)				
BT_{head}	2.215 (2.184)	2.376 (1.825)	-0.161	179.0	-0.517	.605
BB_{head}	2.351 (2.602)	1.855 (1.674)	+0.496	190.0	-0.218	.828
SOC_{head}	1.584 (1.338)	1.307 (1.567)	+0.277	163.5	-0.939	.347
TEN_{head}	1.699 (1.280)	1.578 (1.261)	+0.121	.299	38	.767[a]

3-RQ3

4-RQ4

1-RQ3

Appendix W. Trends in the Data for Visit Count (VC)

Trends in the Data for Visit Count (VC)

Table 39. *Summary of Results for Visit Count (VC) - Action AOI*

Motor Skills	ASD-NH (n=14)	TD-NH (n=22)	*diff.*	U / t	Z / df	p
BT_{action}	7.07 (4.46)	5.41 (2.11)	+1.66	110.0	-1.435	.151
BB_{action}	5.00 (4.15)	4.27 (2.49)	+0.73	148.0	-0.196	.845
SOC_{action}	5.79 (4.89)	6.36 (3.95)	-0.57	134.0	-0.654	.513
TEN_{action}	5.57 (3.03)	3.91 (1.82)	+1.66	101.0	-1.736	.083
	ASD-H (n=12)	TD-H (n=18)				
BT_{action}	7.42 (3.40)	6.72 (3.56)	+0.70	0.533	28	.598[a]
BB_{action}	7.67 (4.56)	5.39 (2.66)	+2.28	76.5	-1.343	.179
SOC_{action}	6.08 (4.46)	7.11 (3.51)	-1.03	-0.705	28	.487[a]
TEN_{action}	5.25 (2.99)	4.28 (1.49)	+0.97	97.5	-0.450	.653
	ASD-NH (n=14)	ASD-H (n=12)				
BT_{action}	7.07 (4.46)	7.42 (3.40)	**-0.35**	-0.219	24	.829[a]
BB_{action}	5.00 (4.15)	7.67 (4.56)	**-2.67**	-1.561	24	.132[a]
SOC_{action}	5.79 (4.89)	6.08 (4.46)	**-0.29**	-0.161	24	.873[a]
TEN_{action}	5.57 (3.03)	5.25 (2.99)	**+0.32**	0.271	24	.788[a]
	TD-NH (n=22)	TD-H (n=18)				
BT_{action}	5.41 (2.11)	6.72 (3.56)	**-1.31**	163.0	-0.959	.338
BB_{action}	4.27 (2.49)	5.39 (2.66)	**-1.12**	150.0	-1.318	.188
SOC_{action}	6.36 (3.95)	7.11 (3.51)	**-0.75**	-0.626	38	.535
TEN_{action}	3.91 (1.82)	4.28 (1.49)	**-0.37**	-0.690	38	.494[a]

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Table 44. *Summary of Results for Visit Count - Cone AOI*

Motor Skills	ASD-NH (n=14)	TD-NH (n=22)	*diff.*	U / t	Z / df	p
BT_{cone}	0.93 (1.14)	0.41 (0.67)	+0.52	117.0	-1.377	.168
BB_{cone}	0.79 (1.25)	0.59 (1.10)	+0.20	138.0	-0.608	.543
SOC_{cone}	1.71 (3.20)	0.59 (0.96)	+1.12	122.0	-1.149	.250
TEN_{cone}	0.79 (1.37)	0.50 (0.80)	+0.29	149.0	-0.200	.842
	ASD-H (n=12)	TD-H (n=18)				
BT_{cone}	0.67 (1.15)	0.50 (0.86)	+0.17	105.0	-0.152	.879
BB_{cone}	0.17 (0.39)	0.56 (0.92)	-0.39	87.0	-1.146	.252
SOC_{cone}	0.33 (0.49)	0.22 (0.43)	+0.11	96.0	-0.663	.507
TEN_{cone}	0.08 (0.29)	0.17 (0.38)	-0.09	99.0	-0.647	.518
	ASD-NH (n=14)	ASD-H (n=12)				
BT_{cone}	0.93 (1.14)	0.67 (1.15)	+0.26	60.0	-1.523	.128
BB_{cone}	0.79 (1.25)	0.17 (0.39)	+0.62	71.0	-0.749	.454
SOC_{cone}	1.71 (3.20)	0.33 (0.49)	+1.38	58.0	-1.492	.136
TEN_{cone}	0.79 (1.37)	0.08 (0.29)	+0.71	65.0	-1.421	.155
	TD-NH (n=22)	TD-H (n=18)				
BT_{cone}	0.41 (0.67)	0.50 (0.86)	-0.09	193.0	-0.165	.869
BB_{cone}	0.59 (1.10)	0.56 (0.92)	+0.03	195.5	-0.082	.935
SOC_{cone}	0.59 (0.96)	0.22 (0.43)	+0.37	157.0	-1.360	.174
TEN_{cone}	0.50 (0.80)	0.17 (0.38)	+0.33	162.0	-1.292	.196

Table 49. *Summary of Results for Visit Count - Head AOI*

Motor Skills	ASD-NH (n=14)	TD-NH (n=22)	*diff.*	U / t	Z / df	p
BT_{head}	3.21 (3.66)	2.73 (1.98)	+0.48	149.0	-0.165	.869
BB_{head}	2.07 (2.23)	2.86 (2.40)	-0.79	123.5	-1.006	.314
SOC_{head}	1.36 (2.31)	2.68 (2.10)	-1.32	84.5	-2.304	.021
TEN_{head}	3.29 (3.38)	2.73 (2.05)	+0.56	148.0	-0.197	.844
	ASD-H (n=12)	TD-H (n=18)				
BT_{head}	3.42 (2.11)	3.39 (2.35)	+0.03	.033	28	.974[a]
BB_{head}	2.92 (2.27)	2.72 (1.74)	+0.20	.265	28	.793[a]
SOC_{head}	1.67 (2.15)	1.89 (1.60)	-0.22	89.5	-0.804	.421
TEN_{head}	1.83 (1.19)	2.00 (1.50)	-0.17	-.323	28	.749[a]
	ASD-NH (n=14)	ASD-H (n=12)				
BT_{head}	3.21 (3.66)	3.42 (2.11)	-0.21	67.5	-0.859	.391
BB_{head}	2.07 (2.23)	2.92 (2.27)	-0.85	61.5	-1.179	.238
SOC_{head}	1.36 (2.31)	1.67 (2.15)	-0.31	72.0	-0.662	.508
TEN_{head}	3.29 (3.38)	1.83 (1.19)	+1.46	73.5	-0.554	.580
	TD-NH (n=22)	TD-H (n=18)				
BT_{head}	2.73 (1.98)	3.39 (2.35)	-0.66	168.5	-0.811	.417
BB_{head}	2.86 (2.40)	2.72 (1.74)	+0.14	192.5	-0.152	.879
SOC_{head}	2.68 (2.10)	1.89 (1.60)	+0.79	157.0	-1.135	.256
TEN_{head}	2.73 (2.05)	2.00 (1.50)	+0.73	162.0	-0.996	.319

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