Major difficulties in social interaction have consistently been identified as a, if not the, central feature of autism spectrum disorders (ASDs) (Carter et al., 2005). Over the past decade, much has been learned about how individuals with ASDs process social information using a variety of techniques (Insel & Fernald, 2004). One frequently used technique for studying social differences in ASDs has been the use of eye-tracking technology (Boraston & Blakemore, 2007; Karatekin, 2007). Eye-tracking technology has emerged as a powerful tool indecode the moment by moment cognitive processes of individuals with autism spectrum disorders (ASD) (Boraston & Blakemore, 2007). Recent eye-tracking studies have shown that 20-month old toddlers with autism spectrum disorders (ASD), as compared to typically developing (TD) toddlers, attend less to faces engaging in dyadic bids for attention (Chawarska, Macari, & Shic, 2012) as well as the shared activities of others (Shic, Bradshaw, Klin, Scassellati, & Chawarska, 2011). Since attending to others, and especially to their actions, is critically linked to both social skill development and observational learning, teaching children with ASD normative strategies for viewing others and their activities may provide new opportunities for learning about their social world.

With the emergence of eye-tracking technology, much has been learned about how individuals with ASDs view naturalistic stimuli in laboratory settings (e.g., Chawarska & Shic, 2009; Jones, Carr, & Klin, 2008; Klin, Lin, Gorrindo, Ramsay, & Jones, 2009; Pelphrey et al., 2002; Shic, Bradshaw, Klin, Scassellati, & Chawarska, 2010; Speer, Cook, McMahon, & Clark, 2007). However, virtually no work has been conducted in real-life settings (i.e., outside of the laboratory). One weakness of eye-tracking studies, which rely on table-mounted eye-trackers, is that the individual wearing the eye-tracker is constrained to a specific position (e.g. a chair) and head position (i.e. typically looking forward at a computer monitor). Mounting the eye-tracker on the head of the subject allows for far less constrained interactions to occur and for greater flexibility in head movements. Recent advances in technology have now made moving eye-tracking studies from the laboratory into real world situations a possibility.

This research project focuses on the development of adaptive, gaze-contingent, eye-tracking technology to help toddlers and adults with ASD learn to allocate their attention to people and their actions in a more typical fashion. The project consists of two different parts. Given that social functioning is typically defined by social interaction and social interaction occurs in the context a dynamic flow between individuals, a real-world study that applies eye-tracking to community recreational activities will constitute the first part of the project. The data will be collected at Yale Center for British Art. The second part of the project will take place in a laboratory environment and will further research that will lead to a greater understanding of how the gaze behavior of toddlers, children and adults with ASD may be manipulated in the contexts of bids for dyadic engagement and
activity monitoring tasks. Necessary algorithms will be developed and data will be collected at the Yale Early Social Cognition Laboratory (YesCOG) and the Technology and Innovation Laboratory (TIL).

**Research Objectives:**

1) To implement, evaluate, and extend algorithms used to model gaze-dissimilarity in eye-tracking research.

From the perspective of human-computer interaction, one of the areas that researchers explored over the last decade was the use of eye-tracking technology to control and manipulate people. This research project explores the application of this technology in behavioral modifications. Last summer, I had the opportunity to learn about eye-tracking technology. Through Directed Research, I will focus on the algorithms used for calibration and to detect where individuals are looking. During this period of time, I will implement algorithms used to measure “dissimilarity” between looking patterns (Holmqvist et al., 2011; Shic, Campbell, Macari, & Chawarska, 2012) and evaluate their performance on real-world data sets provided by Dr. Scassellati, Dr. Shic and his colleagues. Based on guidance by Dr. Scassellati and Dr. Shic, I will extend these algorithms to make them more efficient and/or more precise.

2) To analyze data from typically developing children and use the gaze points as they change over time to build a statistical description of where they are most likely to look at.

Based on my experiences in (1), I will develop and implement algorithms that can describe the physical and statistical properties of typically developing children’s gaze patterns.

3) To develop adaptive, real-time algorithms for shifting attention in order to minimize (1, above).

Based on my work in (1) and (2), I will develop a real-time adaptive training system that will modify the gaze patterns of observers as they watch specifically chosen videos. The systems I will develop will include both positive (digitally enhancing particular screen locations) and negative (selectively filtering out video information) reinforcement systems. Specific instruction on real-time video processing, filtering, and manipulation will be provided by Dr. Shic and his research staff. For this part of the research project, the precision and stability of the algorithms (1) are essential to carry out behavioral instruction, given that uncertainty beyond a certain limit would err the data. Unfortunately, the stability of the eye-tracking systems and algorithms are not well described. Hence, the algorithms should be capable of adapting to changing conditions of the children and correct the drift in their attention. This requires two steps: identifying that there is a problem and correcting the problem.

4) To explore different ways of video manipulation to maximize the children’s ability to return to the correct locations.
This part of the project is yet to be defined clearly. However, exploring different ways of video manipulation can lead to a truly adaptive training system, as opposed to a training system that uses an a priori decided infrastructure for behavioral modification.

5) To develop a framework for evaluating the effectiveness of attentional strategy modification.

Based on my experiences with (3) and (4), above, I will create a general framework, which will summarize how these real-time algorithms could be used in a clinical setting. Time permitting; we will pilot these algorithms and my framework on healthy volunteers in a proof-of-concept experiment. The end goal of the experiment is to develop algorithms and a training system that can successfully modify the attentional strategies of children and possible adults.

Training Objectives:

1) To learn about eye tracking and its applications to clinical populations.
2) To gain first-hand experience in the differences between theoretical and practical algorithm performance through exposure to real, noisy, data.
3) To be educated about the medical research process, and to gain insights into how engineering and computer science can contribute to that process.
4) To learn how to reformulate and operationalize medically relevant questions mathematically.
5) To gain experience in digital media signal processing and to learn about the tradeoffs involved in the development of real-time adaptive software.
6) To be exposed to various fields of computer science, varying from human-computer interaction to machine learning and artificial intelligence.

Deliverables:

1) A final technical report that will include details on research objectives, including implementation and evaluation details as well as implications and future directions.
2) A completed demonstration system that encompasses the final developed framework, for use with children.
3) Contributions to one or more scientific abstracts or papers based on the system I help develop.