Strategies utilized by people with autism and neuro-typical individuals to determine emotion in faces

Personal Section

Four years ago, I began helping out at a school for children with autism: At the time, I saw this as an opportunity to give back to my community, with no idea that it would one day end up being the topic of my scientific research. I spent my time acting as both a volunteer and social mentor during summer programs, weekend trips, special events, and school days. A year later, my involvement with the autism community evolved as I began to recruit and organize students from my own high school to participate in volunteering and fundraising events for autism. By the third year, my junior year, I helped implement a program in my high school where teenagers with autism were brought into our building once every few weeks to have lunch with their neuro-typical peers.

The original intent of such a program was to expose the kids with autism to appropriate social interaction, something many of them struggled with. The program turned out to have numerous other benefits; for one, it opened the eyes of my own peers to the hardships that people with disabilities face. Additionally, it was this program that first got me thinking that autism might be the perfect fit for the topic of my research. Observing the interactions between the teenagers with autism and their neuro-typical peers, I quickly noticed their seemingly deficient ability to gauge the emotions of the people to whom they were talking. As one would imagine, this makes maintaining a conversation substantially more difficult. These observations all happened around the time during which I was focused on developing a research project, so I decided I'd look into the current literature to determine whether what I'd been witnessing was a legitimate, documented problem for children with autism. And I found that, in many cases, it was.

From that point forward, autism was no longer simply a field in which I focused my volunteering efforts, but a disorder by which I would be captivated on an academic and scientific level. There was (and still is) so much about autism that is unknown, ranging from its causes to its

manifestations to its treatment and so much more. If research enables scientists, behavior specialists, educators, and even policymakers to understand strategies people with autism are currently using to judge emotion in faces—rendering them ineffective at this task—, then there might be hope for guiding them towards the use of more efficient, appropriate strategies.

Playing a part in this type of research has meant a lot to me. I've participated in many different types of research throughout high school, both biological and behavioral, and the common thread they shared, the aspect of research that drew me in, was the process. No matter what the specific topic or subject was, the process of making observations to understand a question or phenomenon was rather satisfying to an inquisitive mind like mine. That being said, working on a project dealing with a population of people I cared about on a personal level brought a whole other level of satisfaction to me. I was able to witness the problems I was tackling in my research before I started, and this not only helped me develop my project, but it also kept me motivated.

Students ought not to be turned off by behavioral research because they don't think it is "science-y" enough. I've learned that there are so many ways to combine science and math even in the context of behavioral studies. Behavioral projects can be so much more than simply handing out and analyzing surveys or questionnaires. I've done biology projects as well, and while it may be easier on the surface to see how math can be incorporated into these projects, behavioral projects can also be filled with high-level science and mathematics. It is rather apparent in the next section of this article how I've used math to create my materials and analyze my results. There are many upsides to behavioral research. If scientists are lucky, they are able to see the effect their discoveries have on others. Working with human subjects on behavioral research, as I did in this project, had numerous benefits in this regard. Researchers have a constant reminder of whom they're striving to help, and this can make the entire process more enjoyable.

I conducted my research in my high school and at a school for children with autism. In my school, the data collection was supervised by my research teacher, and the research at the other site was supervised by classroom teachers. While I have worked in labs before, this particular project was not done in that setting with a mentor. The entire project was designed independently, and the only people I consulted for feedback were my research teacher, who assisted with my design and data analysis, and one of the directors at the school for children with autism, who helped me shape my project to be completely appropriate in all aspects for subjects with autism. I will admit that doing research in a lab is a truly awesome experience. You have access to equipment, opportunities, information, and ideas you wouldn't have otherwise. Plus, you get to pick the brains of some really renowned men and women in science. It's nothing to scoff at. That being said, you do run the risk of working on a project that you might not be as interested in or that you might not have played as big a hand in as you would have liked. If you do an in-school project, you really own the project with no questions asked.

Mathematics played a much larger role in my research that I initially anticipated. Simply put, to create the faces I used in my experiments (to be viewed later on in the "research section"), I had to manipulate the degree of emotion in each face. I worked intensely with angles and percentages to make sure the degrees of emotion in the faces varied in equal (or, at times, unequal) increments. My whole experiment was dependent on whether or not I could control the level of emotion depicted in the faces I showed to subjects. Math was utilized heavily in my data analyses, as I learned to do various types of Chi-Square tests to calculate p-values and see if my subjects' condition (with or without autism) had an effect on their emotion processing strategies.

Working on a project like this, where I had a personal connection to the topic, was enlightening. To be able to witness a problem in my own day-to-day life, outside my academic arena, and then study that problem in an academic setting was really a gift. It made the entire thing

seem more *real*. The months I spent creating my materials or analyzing my data were more than just a long academic exercise—they were months spent trying to understand the inner workings of a very deserving but very mysterious population. I finally understood the true beauty of research, how the goal is not only to solve problems, but also to solve problems *to better society*.

Abbreviated Research Section

Abstract

People with autism spectrum disorder (ASD) determine emotions differently than neuro-typical (NT) individuals do. It has been suggested that people with ASD use "rule-based" strategies, meaning they judge the emotion of a face based on a rule they've been taught, over "template-based strategies," meaning they judge the emotion of the face by comparing it to an internal image of what a face with that emotion should look like. Happy and sad faces were placed on a PowerPoint given to 12 ASD and 29 NT subjects. On each slide was a pair of faces; subjects were instructed to "select which face looks the most REALISTICALLY like you would look if you were (ex.) happy" (NT) or to "choose happy" (ASD). The target emotion switched from happy to sad as the faces switched from happy to sad. Faces were designed to show whether subjects favored moderate or exaggerated depictions (to test the use of a rule/template based strategy) and whether they relied more on emotion in the top or bottom half of the face. Subjects with ASD favored exaggerated levels of emotion in the mouth whereas NT's favored moderate. Subjects with ASD always favored emotion in the mouth over emotion in eyes while NT subjects, for sad faces, favored emotion in eyes. For various reasons, reliance on faces with the *most* emotion in the *mouth* suggests the use of a "rule-based" strategy. Understanding the differences between the processing strategies utilized by people with autism and those utilized by neuro-typical individuals can help other researchers, behavior specialists, and educators guide children with autism towards the use of more efficient strategies one day.

Introduction

Autism Spectrum Disorder (ASD) is a disorder characterized by deficiencies in *social perception and cognition*, deficiencies in reciprocal interactions, language delays, idiosyncratic behaviors and repetitive actions[1]. Since weaknesses in social perception and cognition are prevalent in the population, the ability of people with ASD to recognize emotion in other people has become a well-studied topic, as emotion recognition is necessary for many social processes[2].

There are numerous studies that find differences in the emotion recognition capabilities of people with ASD and neuro-typical (NT) individuals[3,4]. For example, one study demonstrated that children with ASD were less able to successfully match images showing the same emotion than NT children were, and furthermore, they were less able to match images showing emotion than other images not involving emotions, such as simple objects. This same study also showed a correlation between the ability of NT children to match images showing emotion and "social behavior and play," while the ability to match images showing simple objects did not demonstrate this correlation. Thus, this study suggested that the ability to comprehend facial emotions is important for social interactions, and people with ASD are deficient in this ability[3]. Another study, with 40 subjects with ASD compared to controls matched by age and intelligence, had all subjects instructed to first identify certain emotions in faces and then to identify certain colors. The ASD subjects were just as able as the NT subjects to identify colors, but less able to identify emotions[4].

However, there are also many studies that indicate emotion-processing capabilities of people with Autism are more similar to those of NT individuals, and perhaps this discrepancy in findings is due to a differing degree of functionality of the subjects[5,6]. One such study included the recognition of emotions such as anger, fear, disgust, happiness, sadness, and surprise. Twenty children with ASD were compared to 20 NT children, and there were no significant differences in the abilities of the two groups of subjects to identify any of these emotions[5]. Another study had 13 children with

Asperger Syndrome (a high-functioning form of ASD) and 13 NT children, all matched in terms of age and verbal IQ. The results suggested some differences in emotion recognition capabilities, as the children with Asperger's were deficient in identifying facial emotions paired with mismatching words—but there were no significant differences between the groups in identifying the simple emotions of faces[6].

Some studies suggest *differences* in the emotion recognition process rather than *deficiencies* in emotion recognition. Individuals with ASD and NT individuals were asked to view a face with a certain emotion for 750 milliseconds. Afterwards, they had to pick a face from an assortment of faces that had the corresponding emotion. The brief amount of time ensured that the subjects couldn't really spend time thinking it through. The subjects with ASD did worse on this task than the NT subjects did but not worse on tasks involving simple emotion identification[7]. This study indicates that people with ASD can determine emotion, just that they do it differently, and, furthermore, there is a range of emotion decoding skills. They may be using a strategy that requires more time than is required by NT individuals. One possible strategy known as a "rule-based" strategy involves utilization of rules individuals with ASD have been taught, such as "upturned mouth means happy" to determine the emotion in the face. This is in contrast to the hypothesized "template-based" strategy utilized by NT individuals, where they determine the emotion of a face by comparison with an internal image of what a "happy" face looks like[8]. This possible difference in strategy was investigated by presenting subjects with ASD and NT subjects with an assortment of faces, each with a given emotion. The faces varied in the degree of emotion present. The subjects were instructed to "choose which of the images looks like a REAL person would look if they are feeling (e.g.) happy." The data indicated that people with ASD were more inclined to pick the faces with the more exaggerated depiction of an emotion to be the most realistic, suggesting the use of a rule-based strategy. As long as the face fit the "rule"—no matter how exaggerated it was—it was

selected. The NT subjects picked the more moderate depictions of emotions that were similar to how actual faces looked, and in this way, they were seen as utilizing template-based strategies[8].

All of the previous studies examined strategies utilized for emotion recognition, but much of the literature on ASD has to do with *facial* recognition and the strategies used for *this* task. There is much literature concerning the use of strategies involving particular regions of the face. For example, many experiments have been done to see whether subjects are influenced more by the top half of the face or the bottom half of the face for facial recognition. Children with ASD were better at recognizing faces using individual mouth cues, while NT children were better at recognizing faces with individual eye cues[9]. Another experiment looked solely at NT individuals, and the subjects there showed strength in eye-based identification[10].

This current experiment was designed to further analyze strategies utilized for emotion recognition in the population of people with ASD. It's goal was to examine the influence of degree of emotion on emotion recognition of happy and sad faces—previous studies suggest that this would be indicative of the use of a rule or template-based strategy. Additionally, the goal was to examine whether subjects rely on emotion in the top or bottom half of the face to determine the overall emotion of that face and to understand what this says about emotion processing strategies.

Method

Generation of Faces—Images of faces with varied features were generated. Adobe PhotoShop was utilized to create 10 faces for each emotion (happiness and sadness). The curvature of the mouth (up or down), eyebrow angle, and percent eyelid coverage of the eyes varied to create faces ranging from virtually no emotion to very exaggerated levels of emotion (Figure 1). The images were made up of a black background, a grey face, black eyebrows, grey eyelids, white eyes with black centers and black mouths. The line and oval tools were used to create these images. For each emotion, a face with a very exaggerated depiction of that emotion was first created. Then, by

utilizing the percentage tools, angle tools, and shift tools, the intensity of the emotion was decreased by a consistent amount 9 times so that there were 10 faces for each emotion all the way down to a face with no emotion. For happy faces, as the degree of emotion decreased, the curvature of the smile decreased, the eyes widened, and outer corners of eyebrow pulled up while inner corners pulled down. For sad faces, as the degree of emotion decreased, the corners of the mouth turned down less, the eyelids drooped less, the outer corners of eyebrow pulled up while inter corners pulled down, and the eyebrows moved farther apart.

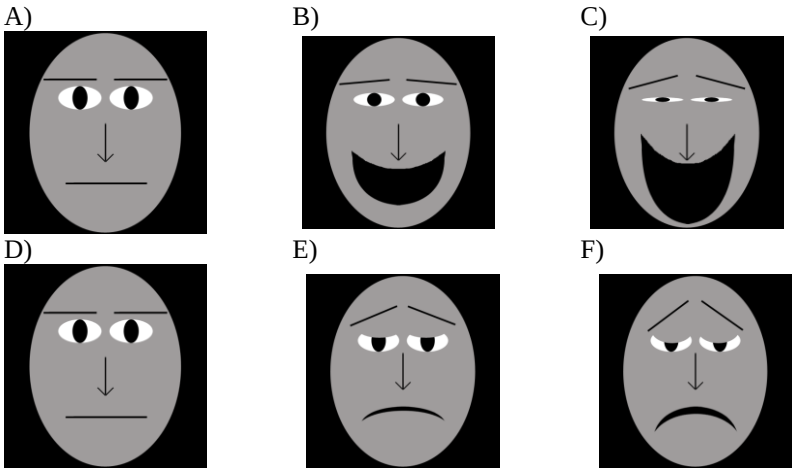


Figure 1. Three faces that were created for the each emotion, happy and sad. (A) No emotion. (B) Happy face with moderate level of emotion. (C) Happy face with exaggerated level of emotion. (D) No emotion (E) Sad face with moderate level of emotion. (F) Sad face with exaggerated level of emotion.

Choice of Faces for Further Use in Study—Eight NT 10th and 11th grade high school students determined which face (out of the 10 faces per emotion) was the most realistic depiction of either a happy or sad face. These faces were considered to be "normal" faces with a moderate level of emotion (Figure 1. B, E). For the study, a face with no emotion (Figure 1. A, D), and an "exaggerated" face (Figure 1. C, F) for each emotion were also used. The exaggerated face was the face that had the most exaggerated depiction of that emotion that the design would allow for.

Creation of Faces Used in Study—The three faces for each emotion (Fig. 1) were combined in 8 different ways, putting the top half (eyes, eyebrows) of one face with the bottom half (mouth) of another to create faces with varied levels of emotion in the top and bottom halves of the

faces (Table 1). Each face was given a label indicating the level of emotion in the top and bottom of the face, with "9" indicating exaggerated emotion, "5" moderate emotion, and "0" no emotion. For example, face **T0b5** had no emotion in the top half of the face and a moderate level in the bottom.

Table 1
8 Faces Used for Testing

Face Label	T0b5	T0b9	T5b0	T5b5	T5b9	T9b0	T9b5	T9b9
Degree of Emotion in Top Half of Face	None	None	Mod.	Mod.	Mod.	Exag.	Exag.	Exag.
Degree of Emotion in Bottom Half of Face	Mod.[1]	Exag.[2]	None	Mod.	Exag.	None	Mod.	Exag.

[1]Mod.=Moderate
[2]Exag.=Exaggerated

Creation of PowerPoint for Testing—These 8 faces were arranged into two major groups of four comparisons for each emotion. All of the comparisons were put on individual slides.

In the first group, the degree of emotion in one feature (either the mouth or the eyes/eyebrows) was held constant between the faces while the degree of emotion in the other feature varied. These were happy slides (or "pages" for the subjects with ASD) 9, 10, 11 and 12 (Figure 2. A) and sad slides 10, 11, 12 and 6 (Figure 2. B).

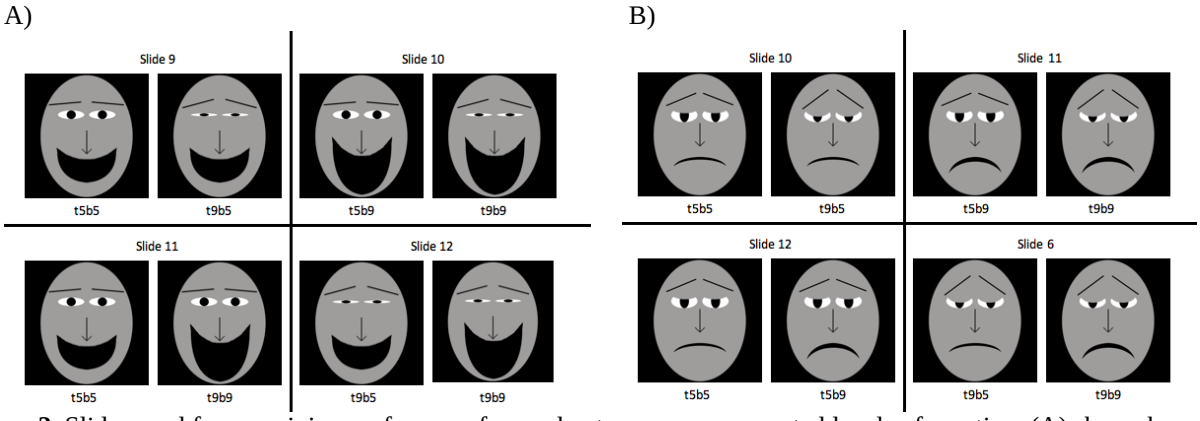


Figure 2. Slides used for examining preferences for moderate versus exaggerated levels of emotion. (A) shows happy faces, while (B) shows sad faces. In each comparison, the degree of emotion in one feature was held constant, and it varied in the other feature. In comparisons 1 & 2 (top comparisons), the degree of emotion in the mouth was constant, and it varied in the eyes/eyebrows. In 3 & 4 (bottom comparisons), the degree of emotion in the eyes/eyebrows was constant, and it varied in the mouth.

The comparisons in the second group compared faces with emotion in one feature and no emotion in the other to faces with emotion/no emotion in the opposite features. These were happy slides 3, 5, 1 and 7 (Figure 3. A) and sad slides 1, 7, 2 and 4 (Figure 3. B).

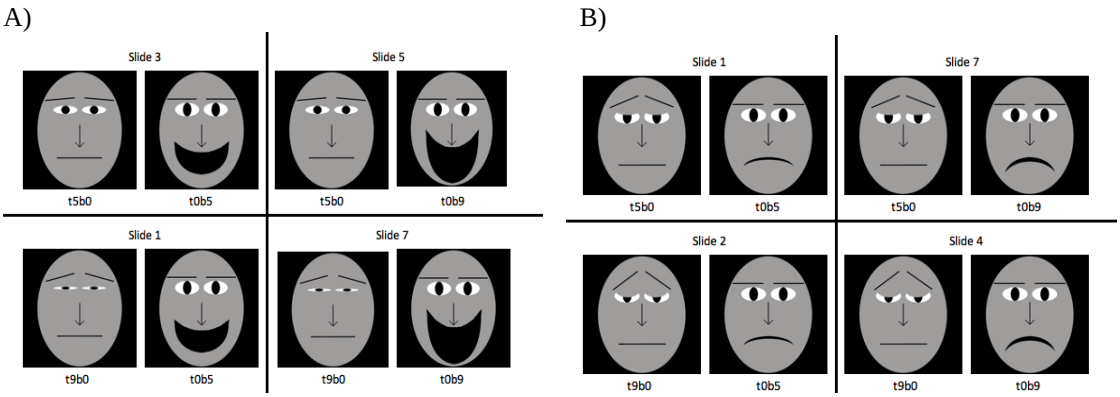


Figure 3. Slides used for examining reliance on mouth or eyes in determining emotion. (A) shows happy faces, while (B) shows sad faces. All four of the comparisons (comparisons 5, top left, 6, top right, 7, bottom left, and 8, bottom right) have one face that has emotion in the eyes and no emotion in the mouth and another face that has emotion in the mouth and no emotion in the eyes.

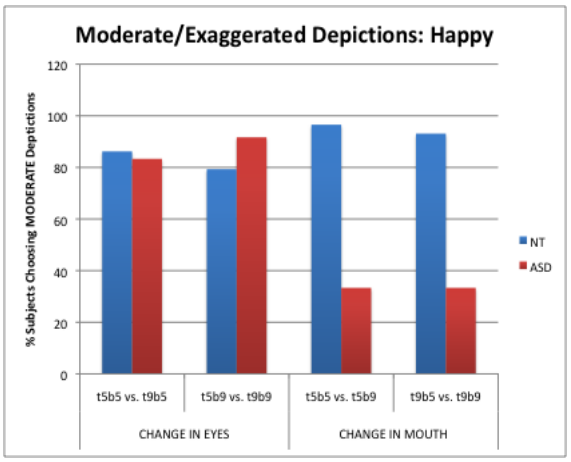
For presentation to subjects, the slides were randomly organized into a slide show. Halfway through, the target emotion switched from happy to sad. The subjects had as much time as needed.

Presentation and Data Collection—This Power Point was presented to 29 NT 9th and 10th grade high school teenagers (N=29), and they were instructed to choose "which faces look the most REALISTICALLY like you would look if you were (ex.) happy." NT subjects were given a sheet of paper on which they could write their selections (either face A or B). For the 12 subjects with ASD (N=12), ranging in ages from 11-20, the PowerPoint was turned into a booklet. The booklet that was created was identical to the PowerPoint used by the NT subjects, but instead, the subjects with ASD could circle their selections right on the pages rather than having to look at a screen and write their selections on a separate sheet. Because of differences in cognitive ability, the instructions were altered for the subjects with ASD; they were instructed to "choose happy." Each subject's preference for a particular face was recorded. The data were separated into the two groups—ASD and NT. The percentage of subjects in each group that selected one face over the other in each comparison was observed. Chi-square tests were used.

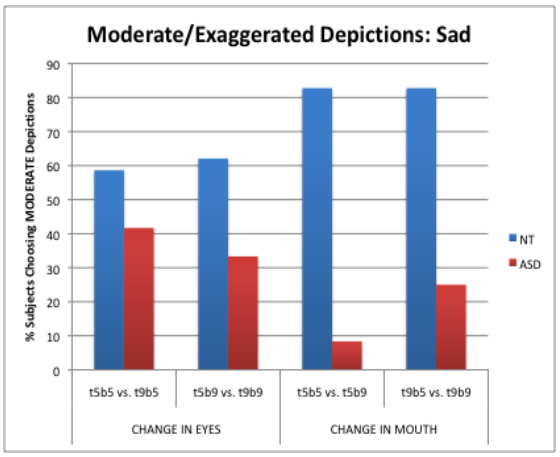
Results

Preference for Moderate or Exaggerated Degrees of Emotion—The goal of this portion of the study was to observe subjects favored the faces with either the moderate or exaggerated levels

of emotion. This portion compared faces with the degree of emotion in one feature (either the mouth or the eyes/eyebrows) held constant and the degree of emotion in the other feature varying between the two faces. For all "happy face" comparisons in this experiment, the NT subjects consistently chose the faces with the more moderate levels of an emotion. In the first two happy face comparisons (where the level of emotion in the top of the face varied) the subjects with ASD selected the more moderate levels of the happy emotion. However, in the next two comparisons (level of emotion in the *bottom* varied), subjects with ASD favored the more *exaggerated* depictions of emotion (Figure 5. A). For sad faces, the NT subjects still consistently chose faces with the more moderate levels of an emotion, but the preferences were weaker. In comparisons 1-4 the subjects with ASD chose the faces with a more *exaggerated* depiction of an emotion. (Figure 5. B).



A)



B)

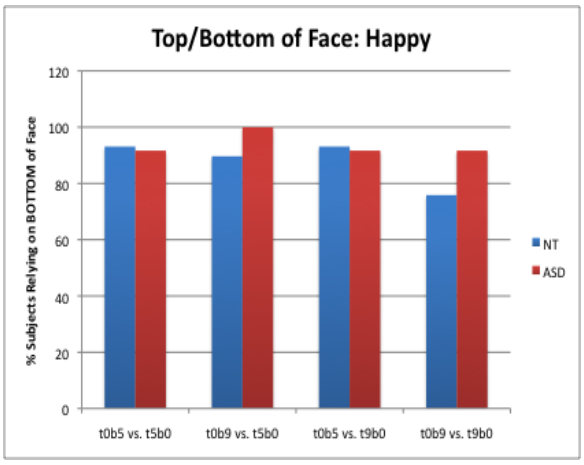
Figure 5. Graphs with data showing whether subjects favor more moderate or more exaggerated depictions of an emotion as the best representation of that emotion. (A) shows the data for happy faces, and (B) shows the data for sad faces. For all graphs, the first set of bars indicates the data for comparison 1, the second set for comparison 2, the third for 3 and the fourth for 4. These graphs indicate what percentage of subjects in each group chose faces with more moderate depictions of emotion over the faces with more exaggerated depictions.

Chi-square tests were done on the NT subjects to determine whether NT subjects had a significant preference for one face over another. For happy tests, all of the data showed a significant preference for one, with p-values ranging from .001-.05. For sad tests, the first two comparisons showed no clear preference, with p-values of .5 and .3, and the second two showed preference with p-values of both .01. Because of a smaller sample size, chi-square tests were not done on the ASD

subjects. Chi-square tests *between* groups suggest that the subjects' condition (ASD or NT) didn't have an effect on their preferences for happy OR sad comparisons 1 & 2, but they did for 3 & 4.

Reliance on Top or Bottom Half of Face—The goal of this portion was to observe the importance of the top versus the bottom half of the face in recognizing the overall emotion of that face. Faces that had emotion in the eyes and no emotion in the mouth were compared to faces that had emotion in the mouth and no emotion in the eyes. For the happy faces, the NT *and* ASD subjects consistently chose the faces that indicated reliance on emotion in the mouth region (Figure 6. A). For the sad faces, the NT subjects consistently chose the faces that indicated a reliance on emotion in the *eye* region. Conversely, the subjects with ASD found the faces with emotion in the *mouth* region to be the best indicator of sadness (Figure 6. B).

A)



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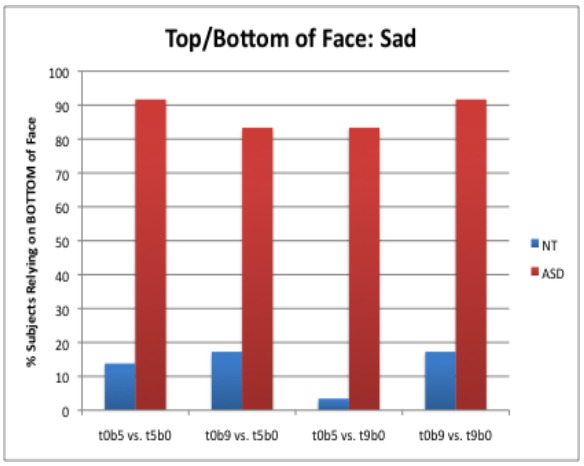

Figure 6. Graphs with data showing whether subjects are influenced more by emotion in the top half or the bottom half of the face (A) shows the data for happy faces, and (B) shows the data for sad faces. For all graphs, the first set of bars indicates the data for comparison 5, the second set for comparison 6, the third for 7 and the fourth for 8. These graphs indicate what percentage of subjects in each group chose faces with emotion in the bottom half of the face (mouth) over faces with emotion in the top half of the face.

Chi-square tests were also done in this portion of the experiment on the data obtained from the NT individuals. For the happy and sad tests, all of the data showed a significant preference for one face, with p-values ranging from .001-.05. Chi-square tests between the groups (ASD and NT) indicate that, for the happy comparisons, there was no significant effect of the subjects' condition on their preferences, while, for sad comparisons, there was.

Discussion

Preference for Moderate or Exaggerated Degrees of Emotions—This portion of the experiment involved choices between two faces with the same degree of emotion in one feature and varying degrees of emotion in the other. For happy faces, the data were similar between the groups when the level of emotion varied in the eyes—all subjects favored more moderate eyes. The fact that the subjects with ASD strongly favored (83% in comparison 1; 92% in comparison 2) more moderate eyes/eyebrows for happy faces demonstrated that they were sensitive to the eyes and not just the mouth. However, there was a difference seen between the groups in preference for moderate or exaggerated *mouths*. The NT subjects always significantly favored moderate emotion in the mouth, while subjects with ASD favored *exaggerated* mouths.

For sad faces, there were differences seen between the two groups in all cases. The majority of NT individuals chose the more moderate values of both features to be the best representation, while those with ASD chose the more *exaggerated* values of both features.

Reliance on Top Half or Bottom Half of Face—This portion of the experiment examined whether subjects relied more on emotion in the mouth region or the eye region, by comparing faces with emotion in one region of the face to faces with emotion in the other region. For the happy faces, the data from both the NT subjects and those with ASD were very similar. All subjects consistently chose the faces where the emotion was present in the mouth region.

A large difference, however, was seen in the response to the sad faces. NT individuals showed a reliance on emotion in the eye cues in all comparisons. Those with ASD showed a clear preference for emotion in the mouth region. These data suggest that people ASD judge emotion in faces—regardless of the emotion—primarily based on the emotion that is present in the mouth.

Trends Seen Throughout Data—In all of the slides (happy and sad), there were 18 slides that compared faces with varying degrees of emotion in the mouth. In every one of these comparisons,

the subjects with ASD always chose the face with emotion in the mouth, when compared to faces with no emotion in the mouth, or *more* emotion in the mouth, when compared to faces with less emotion in the mouth. This could help to support a proposed "rule-based" strategy. Subjects with ASD always chose exaggerated emotions over more moderate ones when the emotion was in the mouth (Figure 5. A, B). Subjects with ASD always favored faces with the emotion in the mouth over those with emotion in the eyes (Figure 6. A, B). This all suggests that subjects with ASD seem to just be looking for the face with the *most* emotion in the *mouth*. It is likely that this is the rule they have been taught to utilize. The fact that the exaggerated degree of emotion in the mouth doesn't bother them supports this further—if they are just looking for a smile, it doesn't matter how big (and unnatural) the smile may be. If they were judging using a template of a face, the exaggerated degree would bother them because it doesn't match what is realistic, or in other words, what the template would look like.

It is also plausible that the simpler instructions—"choose happy"—were not directing the subjects with ASD to look for *realistic* depictions. The instructions had to be simplified for the ASD subjects because many of them wouldn't comprehend the language in the more complex ones. And because of a higher level of cognitive processing, the NT subjects would not have been prompted to perform the task as desired with the more simple instructions. This was apparent during an early trial where the NT subjects were confused with non-specific instructions. They needed clarification concerning whether they were looking for the face with the *most* expression of an emotion or with the *most realistic* expression of an emotion.

Future Research

A larger sample size of subjects with ASD would lead to more reliable results. The data could be separated based on gender (ASD is much more prevalent in males) and level on the "spectrum." This study can also be repeated using emotions other than happy and sad, possibly more complex

emotions, such as fear or embarrassment. It would be of interest to look at developmental effects on these strategies. The same experiment could be administered to developing children to examine the strategies that they use and whether the utilization of these strategies changes as the children grow.

Conclusion

The goal of the experiment was to analyze how the mechanisms used for emotion recognition of happy and sad faces by people with ASD were different from those used by NT individuals. The first significant difference was that subjects with ASD selected exaggerated levels of emotion in the mouth whereas NT subjects selected more moderate degrees of emotion in the mouth for both happy and sad faces. The next significant difference was that subjects with ASD *always* selected faces where the emotion was in the mouth over emotion in the eyes while NT subjects, for sad faces, selected faces where the emotion was in the eyes. This clear reliance of individuals with ASD on faces with the *most* emotion in the *mouth* suggests the use of a "rule-based" strategy over a template-based strategy.

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