# Affective Social Quest (ASQ)

## Teaching Emotion Recognition with Interactive Media & Wireless Expressive Toys

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Submitted to the
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Abstract

In this thesis, I investigate new ways to use affective computing and multimedia tools to augment a child's learning of emotional expression. I develop the hypothesis that these tools can be particularly useful to children with autism and their practitioners. I test the hypothesis by building a candidate research system that comprises a screen on which are shown emotionally charged animated movie clips, together with a set of stuffed dolls through which a child can interact with the movies. Each doll embodied an emotional expression: happy, angry, sad, and surprise. In operation, the test children are shown one of 200 emotive clips and they respond by touching the doll whose expression matches that of the clip. An online guide and registration system allows a therapist to control and monitor the interactions. Six volunteer test children used the system at the Dan Marino Center in Ft Lauderdale and their reactions were observed. This served as verification that a system that manipulated movies and haptic interfaces was feasible and second, such a system could augment and potentially automate some of the human-intensive, repetitive aspects of existing behavioral therapy techniques. All six children responded to and attended to the system, with five of them completing three one-hour day visits comprising multiple sessions. Some children showed improvement in their matching of emotions and one child demonstrated generalization in a home setting.

Thesis Supervisors:
Andy Lippman, Associate Director of the Media Laboratory
Rosalind Picard, Associate Professor of Media Arts and Sciences

# Affective Social Quest (ASQ)

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**Katharine Howard Blocher**

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Reader:

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# Chapter 1. INTRODUCTION

### *An Observation*

*affect scenario:*

*Imagine you're waiting to meet an old friend you haven't seen in years. You've been looking forward to this opportunity for some time and you have arrived ten minutes early in anticipation of this exciting moment. After fifteen minutes you feel quite anxious. You wonder if you have the right meeting place and check your notes to be certain that this is the correct park, the Japanese Gardens, and then you re-check the time. For the next five minutes you wait patiently, but after ten more minutes pass you imagine something may have happened. Then, ranges of feelings go through you: concern, disappointment, frustration, and then anger. After ten more minutes, your friend finally arrives. You look closely at her to see if you can catch a hint of what may have caused the delay. You read distress and angst on her face and the angry feelings you felt subside as you try to support her and listen empathetically to what happened that caused her to be late. This situation has affected your initial embrace.*

*autistic scenario:*

*While you're conversing you appreciate that your friend chose the Japanese Gardens as a meeting place because of its beautiful ambiance. Sitting on a bench overlooking the pond, you both admire the scenery. Suddenly a little boy sits between you and your friend. He is intensely engaged in watching the sun's reflection wiggling off the top of the water and the brilliantly colored Koi swimming in the pond. You and your friend both look at each other in surprise. Your friend attempts to get this young boy's attention. She asks him what his name is in a happy lilting voice, yet the boy doesn't respond. She asks again as she bends down to look at him. The boy says, "goldfish big," but doesn't look at her. You begin to feel a little awkward. You hear a mother calling a boy's name. You look toward the voice and see that she recognizes her son because she is quickly walking towards you with a concerned expression on her face. This little fellow seems to be hypnotized by the fish and shows no reaction to his mother's voice. When the mother arrives, she gently reaches for her son by firmly grabbing his wrist and preventing him from squirming away from her, then apologizes to the women for his behavior. She explains that he has autism. After they leave, you realize the little boy seemed unaffected by what just happened.*

### *Explanation*

There are many different modes of communication besides words. The scenarios above illustrate how we rely on nonverbal cues in social communication to understand each other. The idiosyncratic nature of the boy's way of communicating offers a glimpse of how different those with autism engage socially. Humans use affect recognition and expression to detect meaning (Picard 97, Cole 98, Baron-Cohen 93). In the example above, before the friend spoke any words to explain her delay, information about what may have happened to her friend and the state of her emotions was expressed through her body language. In the second scenario, the boy's idiosyncratic behavior created confusion because of his nonverbal behavior and the odd way he interacted. Communication by means of vocalization, facial expression, posture, and gesture express affect (emotion) and convey subtle information more powerfully and efficiently than the spoken language (Sigman and Capps 97, Cole 98). Affective communication is necessary in order for people to understand each other in social situations. Imagine not being able to do this because of an affect disability, as with the autistic boy.

### *Motivation*

Helping individuals who may be socially isolated due to an incapacity of emotion motivates this research. Those with autism unwillingly experience isolation due to a specific neurological disorder that affects their emotional communication: expression and recognition of emotion. Creating a communication bridge to help them understand emotion expression is the core of this thesis.

The goal was to build a computer system that would organize and display emotionally expressive media and guide the child's interaction with this media in an effort to facilitate learning of emotion expression recognition. The system is an example of Affective Computing, "computing that relates to, arises from, or deliberately influences emotions" (Picard 97, p 3). A new form of interaction was also explored in place of the traditional keyboard and mouse – the use of dwarf-dolls as a physical interaction. Through these objectives, the research explores the potential for using computing and physical interfaces in therapy.

The thesis question asks: "Through the use of engaging multimedia elements and affective computing, can autistic children be engaged in their interaction with the application long enough to possibly learn to recognize basic emotions?" If successful, could this potentially help them with social and affective communication in real life situations? Generalization to everyday life situations will not be answered in this thesis, although the attempt is to identify the merits of using technology to facilitate whether autistic children can engage in the use of an automated system to learn to recognize different displays of emotional expression.

It is our goal to create a computer-based affective system that can synthesize social communication in order to promote the recognition of affective information. The system design builds on empirical findings regarding what engages autistic children (inanimate objects) and how they process information (visual images.) The computer application offers a puzzle matching game with video clips to match emotional expressions. This multimedia tool presents different ways that an emotion may be communicated. Analogous to a foreign language, autistic children may learn social communication as a second language and choose to use it in social situations.

Additionally, through an automated approach to teaching emotion recognition, this type of application may be helpful in other teaching methods. The most common treatment for young children with learning disabilities is specialized instruction prior to mainstream primary education in an attempt to prepare them for typical assimilation by the time they are six years old and start school. Pre-schooling is commonly referred to as early intervention and behavior analysis is one type of intervention. This approach to teaching behavior and social skills may include discrete trial sessions; time spent one-on-one with a practitioner to learn a specific task. Technically, discrete trial is a structured time trial where a particular stimulus prompts a specific response and receives a consequence that will either reinforce that response or will promote a different response. The time demand on the practitioner using discrete trial or other behavior-analytic treatments might be long and highly expensive due to one-to- one teacher to student ratios, manual data collection, data analysis, and procedural modifications. An automated intervention application with novel play-like elements might offer a complimentary method for behavior analytic training procedures. A goal for the application presented in this thesis is emotion recognition, though its success suggests the possible benefits for other areas of development.

### *Affective Social Quest*

Affect – or emotion – may be displayed by means of vocalization, facial expression, posture, and gesture. Experience gives most of us an understanding of nuances of expression and affect. Because we experience ourselves in relation to other people, when another person does not provide the response we seek and expect, or any response at all, it not only affects our perception of that person but how we experience ourselves. As in the observation above, the autistic child did not sense the way those around him felt, nor did he respond in a comprehensible way, leading to an awkward social situation.

Recognizing and expressing affect is a vital part of social participation. Unfortunately, those with autism have their primary learning disability in this area with other deficits in language, motor and perceptual development. Their development of social communication is very low compared to neurologically typical children who learn social cues naturally while growing up. Along the autistic spectrum, varying deficits distinguish the child's level of autism as compared to a normal child who is considered to have no deficits. At one end -- where the child has few deficits -- is the high functioning end of the spectrum. Asperger children, on the other hand, are high functioning children who are distinguished by their typical verbal ability, and sometimes are not labeled with autism but referred to as those with Asperger syndrome. High-functioning or Asperger children who are especially bright with minimal language deficits have a self-awareness that socially they are supposed to blend in. At the same time they are aware that they don't blend in and that they don't know how to (O'Neil 99). In trying to comprehend social nuances in communication or social behavior to blend in during everyday interaction, they get frustrated, not only with themselves but with their teachers too, and often give up learning. What may help an autistic child in this case is an ever-patient teacher.

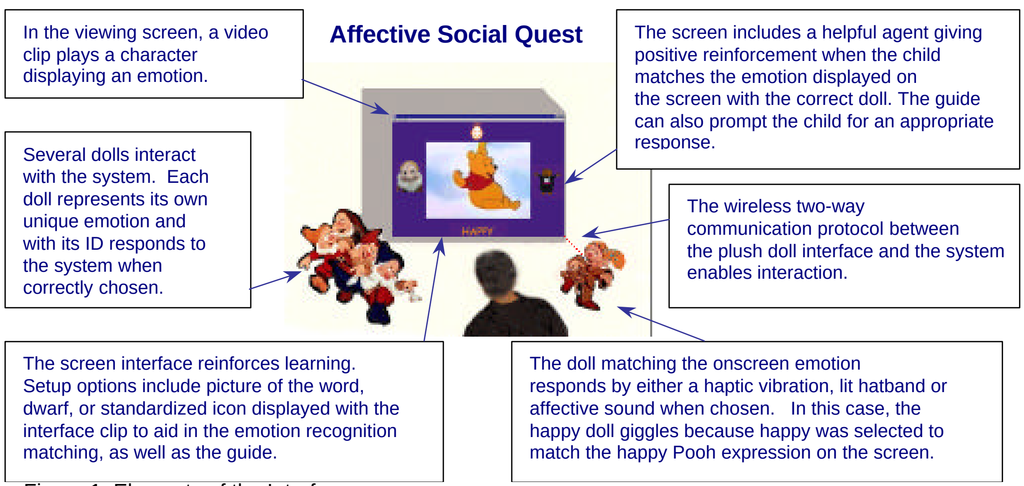


Figure 1: Elements of the Interface

This thesis presents an approach to creating that teacher: a persistent and unresentful aid that progressively introduces basic emotional expressions, guides recognition development through matching, and records the child's success. The system embeds multiple subsystems to teach emotion recognition to autistic children with a heterogeneous disorder. Children with this type of disorder have a wide variety of IQ's – and a wide variety of developmental levels – and need various systems, or ways, to interact with an environment appropriate to their deficit level. Although the application developed for this research does not come close to the abilities of a highly trained human practitioner, it is designed to offload some of the more tedious parts of the work.

With a computer running video that communicates with independent toy like objects, the system synthesizes interactive social situations in order to promote the recognition of affective information, as shown in figure 1. This system will not tire because of impatience and can be a safe place for the child to explore. We call it ASQ, for *affective social quest*. The goal of ASQ is to provide an engaging environment to help children -- specifically autistic children -- visually recognize social displays of affect.

# Chapter 2. BACKGROUND

*Affective Social Quest* builds on prior technology and therapeutic principles that serve as context for this work. A technological motivation section describes how research in the Media Lab and in industry relates to ASQ. Following is a section devoted to the therapeutic motivation behind this work. Theories of human development and autism are presented along with the current methods of therapy for autistic children and those that relate specifically to teaching affect recognition and expression.

## *Technological Motivation*

The Media Lab has several research areas from which this research draws from. This thesis research addresses the interests of three diversified disciplines: Digital Life researches how bits, people, and things exist in an interconnected world, Toys of Tomorrow researches tech-toys, and Affective Computing researches ways for a computer to recognize and respond appropriately to emotion. The following section offers a brief background of each area.

### *Digital Life*

With the innovation of embedded technology, objects have become more sophisticated, advancing ways technology can offer convenience and personalization to people through devices used every day. Digital Life is the extension of technology into these objects.

Ted Selker projects that some computer "experiences will be interactive, some will be vicarious, and others will be voyeuristic"(Selker 97, p89). At present, one object serves multiple uses. For instance, a car with a mobile phone and an onboard global positioning system (GPS) that can store personalized keywords may soon be able to contact the driver when information is most relevant and timely. For example, when approaching a local grocery the car can remind the driver that the kitchen ordered groceries that are ready for pick up. Roberto Tuchman, Director of a center focused on PDD intervention programs, the Dan Marino Center, recognized how this type of technology could also provide a therapeutic remediation for attention deficit disorder (ADD), serving as a reminding and sequencing aid to manage domestic responsibilities (Tuchman 99).

Digital life in every day objects provides the ability to select, arrange, modify, and communicate with the data, similarly to the way we communicate with people. Data once serially processed can now be randomly accessed, dynamically processed, and wirelessly accessible. Object functionality becomes customizable, flexible, efficient, and personalized, and for some therapeutic. When a design incorporates visual and natural mapping between humans and things, interaction appears natural by building on relationships that have meaning to people (Norman 90).

### *Toys of Tomorrow*

From animatronics in theme parks to battery powered barking toy dogs, embedded technology seemingly makes people feel like these dolls act with emotion. Mattel's *Tickle Me Elmo* transcended moving doll parts to sensing dolls using the innovative idea of embedding voice systems in toys; when the doll is tickled, the doll giggles. Around the same time, the Media Lab and Apple Computer collaborated on the development of a toy called Noobie. The goal was to build an environment that allows computer animals to be played with and explored in the same way real animals are; by touching (Druin 87, p12). Noobie entertained and educated children by displaying educational media footage about animals on its tummy monitor. Children touched different parts of this oversized soft interface to see how the Noobie, short for "New Beast," would react (Druin 87).

A decade later demonstrates a reduction in size of embedded technology by the toys available today. Japan's Bandai created the virtual pet, a Tomagotchi. The little pet inside this hand-held toy relied on its owner to feed, bathe, educate and entertain it to keep it alive. Neglect resulted in a wailing, incessant beep to communicate the need for basic care. When ignored over time the virtual pet would die. Initially available only in Japan, these rudimentary artificially intelligent pets became popular and Americans were buying them on the black market until sold in the United States. Later versions became so sophisticated that two Tomagotchi-type systems could interact with each other and perform fighting games. This infrared communication worked with a personal computer too. New features could be downloaded from the manufacturer's web site and then uploaded into the hand-held companion (Saunders 97).

The next rave of tech toys for children was released in Christmas 1998. Tiger Electronics, LTD. developed a 'special plush toy' (toy-biz lingo for a stuffed animal with embedded technology) that became the next high-in-demand purchase known as Furby. Furby is a Gremlin-esque small stuffed toy with the pet like features of the Tomagotchi. A toy ad-agency executive responded to the question "what was the one thing that made them distinctive and unique and desirable?" by answering, "it was a friend that a child could nurture" (Kirsner 98, p197). Furby has 300 different combinations of eye, ear, and mouth movements. Two microprocessors control the 8000-rpm motor cams that drive the mechanical animated motion of the Furby. Sensors, referred to as attitude sensors, detect whether the plush toy is standing or held upside down. Furby has a microphone so the toy can respond to sound, has light sensors for the toy to switch into sleep mode, and has pressure sensors for the toy to detect petting. Furby moves, blinks and speaks two languages, English and Furbish -- the Furby language (Kirsner 98). Americans paid above market price during the 1998 holiday season to own a Furby, and not only one, but two of them. Two Furbys were preferred because they could interact with each other. With infrared transceivers between the Furby eyes, Furbys appeared to communicate by talking to each other. Additionally, Furbys speak in their emotion riddled native Furbish language until they seemingly learn English from their caretakers. These dolls were cleverly programmed to produce certain familiar English words over time. The magic of the Furby and similar interactive toys are their invisible mechanisms and their initially unpredictable human-like behavior. Sherry Turkle is researching children interacting with Furby toys and shared her observation that these children perceive these special plush toys to be 'sort-of-alive' objects (Turkle 99).

Another toy with affect is interactive Barney, developed by Microsoft for its ActiMates line of dolls. Barney is a special plush toy designed to complement popular child television characters and has a TV/PC pack accessory to interact with the television or the computer. ActiMates Barney is an upgraded version of the earlier Playskool Talking Barney. Barney includes pressure sensors in the hands, feet, and tummy to activate an internal voice-storage unit like the Playskool version, but has an added wireless feature for the doll to communicate with a computer system or video program. The doll's voice recordings play when certain scenarios appear on the screen. This separately sold package offers two-way interactive communication via radio frequency (RF) signals between the doll and a transmitter box to talk to CD-ROMs for the personal computer or VHS for television. Barney stores approximately 2,000 word responses forming random word subsets as phrases that appropriately match events triggered by interaction with the child or system. Its large word vocabulary, along with its light-sensitive eyes for playing peek-a-boo, contribute to the doll's magic and its seeming aliveness.

Researchers at the Media Lab have been creating their own family of plush computer toys as well. A research group known as Synthetic Characters, led by Bruce Blumberg, developed an interactive game called "Swamped" (Johnson 99). The behavior of a chicken was modeled in the software where certain behaviors could be activated by the way the plush doll chicken was controlled. Although the application design focuses on behavior, the tangible interface of the external physical doll relates to the external physical interface of the dwarves.

'Swamped' includes a soft plush chicken, a sensor-embedded doll used to control the same onscreen character via radio frequency. The system interpolates the chicken's movement and models that behavior in order to interact with an animated virtual raccoon. The interactive game resembles the Coyote and Roadrunner cartoon, with a conniving raccoon trying to steal eggs from the chicken who tries to protect them by distracting the raccoon. Raw sensor data is used by the game's gesture recognition system to control the behavior of the raccoon based on the interactive behavior of the chicken. Thirteen sensors are embedded in the chicken for interpreting the user's intent: doll's attitude (position) using pitch and roll sensors, gyroscope sensing roll velocity, magnetometers for orientations with respect to magnetic north, flexion sensors for wing position, squeeze sensors embedded in the body and beak, and a potentiometer to sense rotation (Johnson 99, p4). The interactive tetherless *sympathetic interface*, controlling a synthetic animated character in a 3D virtual environment, entertains with its musical and animated representation of user control (Johnson 99). For example, when the chicken beak is squeezed the virtual character squawks, if moved right-to-left for walking, a walking melody plays, and when this motion is accelerated, a faster tempo plays and the chicken runs. Embedded technology from Toys of Tomorrow relates to the ASQ project. As shown in Figure 1, the dwarves use a similar embedded technology of wireless communication in plush toys.

Another related soft interface for therapeutic aid developed by Marina Umaschi Bers encouraged children to communicate emotional narratives while in the hospital. Plush dolls were the interface to a computer screen and helped children create narrative stories to entertain and counsel them as they recovered from cancer treatment at Boston's Children Hospital (Umaschi Bers 97, Umaschi Bers 98). Research like Umaschi Bers SAGE and the author's ASQ explore ways technology may promote health. Both are therapeutic systems focused on enhancing mental well-being for children; the SAGE environment encourages terminally ill children to express their feelings, while the ASQ environment remediates empathetic disabled children to recognize emotion. Another Media Lab related project that uses plush toys and embedded systems is Dana Kirsch's project 'Affective Tigger', an affective responsive plush toy. Like ASQ, its goal concerns communicating emotion with a computer.

### *Affective Computing*

Affect in humans plays a critical role in rational decision-making, in perception, in human interaction, and in human intelligence (Picard 97). Affective technology may be embedded into systems in a way that resembles empathetic communication. An early example of affective computing is the 1966 program called 'Eliza.' It is a text-based application that imitates a psychotherapist interacting with a user (Picard 97, page 116). It was sometimes effective with its users because they attributed a shared understanding to it based on Eliza's response. Jonathan Klein researched the affect of empathy on human subjects who had been frustrated while using a computer game (Klein 98). CASPER (for Computer-aided Active Support for Personal Emotion Regulation) takes the format of an online agent practicing social emotional feedback strategies to reduce their frustration. Subjects that received narrative empathetic listening responses showed more interest and continued their interaction with the system more than those who received no response. The research illustrated the benefit of a computer system's empathetic understanding and response to user frustration (Klein 98). Another project for detecting frustration was developed by Jocelyn Scheirer. Working with Raul Fernandez and Rosalind Picard, she developed frustration detection glasses -- 'Expression Glasses' -- that detect a user's facial expression from forehead and eyebrows using sensors to map the muscle movement up or down to a level of "interest" or "confusion" (Scheirer 99). Later she developed 'Touch Phone,' a phone pressure sensor and software display for detecting the amount of pressure applied to the handset of a telephone (Scheirer 99). These technologies may facilitate communication of signals that can carry certain kinds of affective information.

Dana Kirsch developed one of the first affective systems embedded in a toy. “Affective Tigger” ascertains the way the toy is being treated by its user and responds with an affective gesture. Tigger, the bouncing tiger from the ‘Winnie the Pooh’ stories, uses embedded sensors to detect the way it is being handled. The doll uses two different sensor systems in its ears and mouth to communicate its affective state, which in turn is based on two other sensors that detect the amount of pressure when petted or velocity of movement when bounced. The plush doll conveys inappropriate behavior by moving its ears downward to display sad when it is petted roughly or bounced too hard. When happy, Tigger says positive Tigger phrases and the ears perk up (Kirsch 99). Embedded affect in toys adds a feature of perception from the doll perspective and would be a nice addition to an upgraded version of the dwarf technology.

Affective computing strives to teach the emotionless computer to recognize emotion in people. Several methods have been explored as first stages to achieve system recognition of a person’s emotional state. Some preliminary ways of gathering user data that may later be helpful for detecting user affective states have been mentioned: ‘CASPER’ identifies directly reported frustration, ‘About Face’ and ‘Touch Phone’ analyze expressive movements, and Tigger’s attitude sensors identify haptic movement.

Other research explores physiological data of the user. One project of Elias Vyzas, Jennifer Healey and Rosalind Picard studies physiological data in humans as they intentionally express basic emotion in the ‘emotion recognition of an actor project.’ The computer collects the user’s blood volume pressure (BVP) for heart rate, skin conductivity with galvanic skin response (GSR), electromyogram (EMG) for facial tension in the jaw, and respiration. These physiological data are extracted and analyzed while the actor deliberately tries to feel these emotions. The data was used to develop algorithms to discriminate between eight emotional states (Healey & Picard 98, Vyzas & Picard 99).

Alex Pentland and the Media Lab's Perceptual Computing group explore visual recognition systems, some of which focus on face recognition. Pattern matching algorithms in these systems match facial features and their location on the face to code or interpret close matches to static images using a Facial Action Coding System (FACS) (Pentland 98). Irfan Essa and Alex Pentland extended Paul Eckman's FACS work by building a system that characterized the way the expression moves across the face as opposed to focusing on the detection of human expression (Essa & Pentland 95). Research to extend these systems to recognize human emotional expression is ongoing.

A computer can process information and search through images to match features quickly by searching for patterns. What a computer cannot discern is that an up-turned mouth might mean a person is happy. That feature needs to be programmed in order to correlate with human expressions that may mean happy. Affective visual cues include more than lip formation on the face. They include other features of the face, body posture and gesture. Also, a representation for a single emotion could use various combinations of these modes to express the same emotion. Computers have difficulty generalizing. The computer cannot infer the many ways happiness can be expressed. The computer cannot presently distinguish if an emotion with an up-turned mouth, for happy, and body posture of hands-on-hip, for angry, could mean happy in some cases, but also could carry other meaning, like angry. One could consider a computer to be autistic for these reasons.

*Affective Social Quest* is designed to teach emotion recognition to people. Although this work is about teaching affect to children with autism, it has a broad range of applications in aiding all children to learn how to access emotions. A similar approach may also be possible for teaching computers emotion recognition. ASQ stores over 200 video segments displaying basic emotion expression and could later be re-used for coding the different ways an expression, say for happy, could be understood by a vision system. The goal is to store many samples of emotion images, or frames in a video clip, which correlate with a particular emotion category. Paul Eckman identified six discrete emotions that are treated as distinct from each other: happiness, sadness, anger, fear, surprise, and disgust (Eckman 92). ASQ selected four of these emotions for its pilot: happiness (happy), sadness (sad), angry, and surprise. ASQ uses the emotion labels with other labeled representations -- word, icon, and doll face -

- and displays them on the screen for the autistic child. This helps the child scaffold different representations for an emotion so that they might learn through cognitive inference to generalize the many ways one emotion may be displayed.

### *Therapeutic Motivation*

Improving the social well-being of autistic individuals motivates the work of this research as well. Children with autism have a neurological disorder that affects their interpersonal perception and communication (Hobson 98, Sigman & Capps 97). Generally, children learn social cues visually by associating interactions around them and mimicking that behavior. Autistic children process information differently, yet how they internally process communication is still a mystery. Research and clinical work point to intervention methods that help these children learn and possibly adapt to mainstream educational programs. The goal has been to focus on their strengths to overcome their deficits. This section briefly describes how normal children develop socially and contrasts that development with that of autistic children. Following is information about autism specifically, and about how the technological motivation addresses the therapeutic motivation.

### *Development Theories*

Early work on cognition is credited to Jean Piaget, who studied human development by extending his background in biology and epistemology. He is known for genetic epistemology and most famous for his intellectual development theory, referred to as 'constructivism,' which proposes that learning happens by doing (Piaget 70, Craig 76, Hala 97, Papert 99). Piaget believed activities in life are assimilated into our understanding of the world and that novel actions either 'go over one's head' or are accommodated into one's model of the world. According to Piaget, this process happens by means of interaction with an object, not a person (Piaget 70, Hala 97).

B.F. Skinner extended Pavlovian animal behavior to human behavior using antecedent reinforcements to create secondary associations. For example, the sound of a bell could be made to cause a dog to salivate by pairing the bell sound with the presentation of edible treats and then slowly thin the reinforcement, the treat, to extinction. Skinnerian behavior analysis resembles Piaget by being principled in the act of doing something. However, Skinner's interest focused more on how to modify behavior, referred to as operant behavior.

The approach in operant behavior is to change one's behavior with reinforcement (Pierce 99). Both Piaget and Skinner attributed human development to action without addressing people or the affect of people. Lev Semenovich Vygotsky on the other hand attributed knowledge to the interaction between humans via communication and calls this interaction 'interpsycholgogical' (Hala 97). He believed that without interaction between people, understanding would be irrelevant. Peter Hobson refers to Vygotsky's 'interpsychological category' of mental functioning as the area on which to focus attention. He argues that prior study of "cognition focused on development through configuration of behavior-cum-experience (objects) ignores the nature of the transactions that occur between people" (Baron-Cohen 93, p208). Additionally, Peter Salovey and John Mayer, and later Dan Goleman add that understanding emotions contributes to higher cognitive development by increasing what they call 'emotional intelligence' (Salovey & Mayer 90, Goleman 96, Salovey 97). On the continuum of emotional intelligence, the better people are able to discriminate and recognize emotion, the better they may be able to modulate their behavior to best succeed in situations. According to this theory, interpersonal communication is the method by which individuals can differentiate self and other.

Social Cognition studies social communication as the method for learning, which contrasts traditional cognition's focus on development through interaction with objects. Social cognition focuses on the shared understanding of two people comprehending an intended message exchanged between one another. In autism literature this is referred to as theory-of-mind. Simon Baron-Cohen popularized theory-of-mind in *Mindblindess* (MIT Press 95) by describing individuals with autism as not being able to infer other people's mental states. The social-interactive and communication problem caused by their cognitive disorder limits them from forming abstract associations. This 'metarepresentational' association of how people socially relate to each other is referred to as joint-attention. Joint-attention is the ability to share affect; how people share affective communication relates to this research. According to Tuchman, interaction with others necessitates recognition of affect first and then the desire to share that affect (Tuchman 99). ASQ attempts to help children with autism to go through this process. The building blocks to achieve metarepresentation include mastering emotion recognition, then sharing that affect through joint-attention, and lastly seeing another's point-of-view with theory-of-mind. An overview of communication development may offer an explanation for how affect may be important for helping children understand social communication.

### *Communication*

Normally communication implies that some message is transferred. Language uses words (strings of phonetic aggregations) and grammar (syntactic and semantic constraints or combinatorial rules of theory of a language) to articulate a message (Hala 97). Other modes of communication enrich the meaning of a message. Eye contact, gesture, and melody in language (prosody), along with posture, act like adjectives to the spoken word. Children with language delays and distorted developmental disorders, such as autism, are characterized by a lack of relatedness to people (Hala 97, p95). According to theory-of-mind thinking, language communicates thoughts and feelings to others; there is no language if there is no one to communicate with or no shared understanding. Peter Hobson and Roberto Tuchman describe the development of social cognition as a precursor to theory-of-mind. Hobson believes that the sharing of communication is not innate but nurtured in the child's infant development (Baron-Cohen 93, p 209) Development in very early child communication suggests that children develop modes of communication other than language to indicate relatedness.

Prior to communication, a more important aspect of development occurs: the awareness of self and of the existence of objects and other beings. First forms of communication occur with infant cries, vocalizing the intent need for a caretaker. Sending that signal and receiving a response leads to the first awareness that the cry is a tool for communication. Whether or not an infant recognizes this internally, it sets the stage for further development of communication based on the recognition of signals transferred, i.e., social communication.

Other modes of registering communicative information in infant years are through messages via senses (sight, hearing, olfaction, taste, touch, and proprioception (feeling pressure). The senses carry content concerning an object or person in an infant's surroundings. Additionally, communication occurs through sight via common modes like body gesture and facial expression, and through hearing using prosody, pitch, and tone. Each of these channels of communication orients the infant to others. An infant's ability to differentiate between people is easy to detect when the infant signals a request for the primary caregiver, yet when others try to soothe the infant, the crying wail continues until the infant senses the appropriate person (Hala 97).

A parent's communication with a child is often through the child requesting something. In this case caretaker to child sharing occurs, which includes affective content. An infant has her own feelings and, when attended to by others, observes expressed feelings from that person and can modulate the initial request to a sharing experience between self and other. Recognizing an affective expression in interpersonal relating is the basic level of communication and sharing (Baron-Cohen 93, p 209). The process of recognition helps the child differentiate affect and helps conceptualize others as separate people with their own psychological attitudes and experiences.

These early stages of shared communication foster future development of communication. Children learn effective methods for conveying the message intended. If they need something, often a cry is attempted. As children explore other methods and mimic the ways they see others interact, communication begins to include interpretations of the learned signals and becomes part of the child's relatedness to others. Autistic children interact differently.

Hobson proposes his hypothesis that the autistic deficit "arose through the child's lack of basic perceptual-affective abilities and propensities required for a person to engage in personal relatedness" (Baron-Cohen 93, p 205). Requests for objects are usually direct and often without sharing information in a social way; sensorialy expressed. Newly walking infants will often point to things that they want to share with someone, whereas autistic children will approach an object of interest and 'grab assistance' if it is out of reach, without an interest in sharing information about that object. The child tends to regard people as a source to attain physical needs, not emotional needs. Why they use this mode of interaction is unclear.

Another theory, based on genetic epistemology, suggests an inborn pre-wired ability to experience reciprocal, affective personal relations with others in order to become engaged. According to this theory, expressions and actions with others 'naturally' involve sharing feelings (Baron-Cohen 93, p 204). Piaget attributed affect to genetic epistemology, which may be why he did not focus on emotion as part of cognitive development.

Affect or emotion has received limited research attention until late in the twentieth century. Recently, two neurologists, Joseph LeDoux and Antonio Damasio, proposed neuroanatomical structures and processes that suggest significant roles for emotion in cognition, such as in perception and relational decision making (LeDoux 94, Damasio 94). The exact way that the brain processes emotion has been an open question and is now starting to be illuminated with the help of the research developments in neuro-technology.

Emotion theorists are in dispute over the nature of emotions. Peter Lang believes that emotions are continuous along at least two dimensions -- arousal and valence – and he suggests that one feels an emotion to a certain degree. Arousal is the positive or negative emotion experienced and valence is the degree that that emotion is felt (Lang 90, p382). Paul Eckman on the other hand, believes that emotions are primary discrete entities and that more complex emotions form from combinations of these primary ones (Eckman 92). There are also many other theories of emotion, but no general agreement on precisely how to describe emotions.

What many are beginning to realize is that emotion plays an important role in human development and problem solving. "Early in development, care givers assign meaning to a range of vocal as well as non-vocal behaviors, and the means of communication become increasingly conventionalized through reciprocal social exchanges" (Cohen & Volkmar 97, page 515). Children with autism adopt unconventional methods of communication by focusing on their own immediate needs and the properties of the physical world rather than social interactions and socioemotional concerns (Cohen & Volkmar 97, page 514). They adopt idiosyncratic ways of expressing themselves, which may result from their limited ability to imitate others in social situations.

### ***Autism***

*Background*

Autism strikes between one to two per thousand children for the more severe cases, and between four to ten per ten thousand worldwide for less severe cases, most of them males (Cohen & Volkmar 97, p 847, Sigman 98). Leo Kanner, once head of the John Hopkins clinic, published a chapter in a book on child psychiatry in 1943 called ‘Autistic Disturbances of Affective Contact.’ He described children with a rare and interesting childhood affliction that he labeled *early infantile autism,* a disorder not yet clinically identified. Around the time of Kanner’s publication, Hans Asperger from Austria independently described the same child disturbance using ‘autistic’ to describe the disorder (Frith 91).

In *Anthropologist from Mars,* Oliver Sacks describes Kanner’s initial thought that autism might be a dysfunction in early development between care taker and child, and that Kanner referred to it as the bad parenting ‘refrigerator mother’ (Sacks 93, p107). Bruno Bettelheim in 1967 furthered this hypothesis in his published work *The Empty Fortress: Infantile autism and the birth of the self* (Free Press, NY). In the past twenty years autism has been found to be neurologically based. In autistic symptomatology, it is expressed as the atypical function of an affected individual’s brain (Cohen & Volkmar 97, section 7). Autism is a neurologically determined behavioral disorder, yet no prenatal or perinatal factors attributable to the disorder are clearly identified (Tuchman 93). One observation is that the brain size of autistic children is larger than that of typical children. Also, autistic children sometimes suffer from insomnia and may not prune neurotransmitters in their sleep like normal children (Tuchman 93).

Even with what is known about autism, often the disorder goes undetected until a child is expected to speak. A child pediatrician might not suspect autism until the child shows a restrictive use of or delay in verbal abilities, even though a parent may notice something peculiarly unique about their child, which they may not be able to articulate.

*Detection Markers*

Early psychological markers for diagnosing autism include difficulties with communication, socialization, and symbolism (Prizant 98). Early signs most easily observed in autistic children include preservation, stubbornness, inattention, inflexibility, and tantrums. In 1992, Baron-Cohen developed what may possibly be the simplest diagnostic approach to detecting autism with CHAT, Checklist for Autism in Toddlers (Cohen & Volkmar 97). They developed a questionnaire, administered in pediatric offices, for parents to evaluate their child's development. CHAT was designed to assess the joint-attention of their child as observed by family members. Results from the questionnaire are used to identify how many behaviors are absent in their child. This mini index for early detection was targeted at children who were at least eighteen months old.

One marker for autism is a child's limited display of proto-declarative pointing, a joint-attention act, for indicating a desire for an object or shared event. Pointing imparts communication; it conveys need or desire. Another observation for early detection is gaze monitoring. Limited shifting of eye gaze between other people or between people and objects may represent delays in social development. Eye gaze signals the intent to share interest or meaning and strengthens social interaction. The third identifying trait involves a child's play. Idiosyncratic behavior in pretend play, such as playing with a toy in a way that doesn't mimic the family's behavior in everyday life (for example, playing with a doll's eyes versus combing a doll's hair) indicates a symbolic aberration. Children who display a lack of all three behavioral characteristics have later been found to be developmentally retarded.

In the 1996 Baron-Cohen study which included 16,000 questionnaire responses, 93% of the children whose parents noticed that their children had developmental delays in all three areas – pointing, eye-gaze and play -- were later diagnosed with autism (Prizant 98).

Not included in the Baron-Cohen study, but commonly found with autistic children, is their peculiar way of comprehending. Generalization is the ability to take what is learned in one setting and show that accomplished skill in a different environment. Autistic children usually have difficulty with this. A child may learn to tie his shoe in the house, yet if you ask him to tie his shoe in the car he may not be able to do it; what he learned in the house may not connect to something he could do in the car and he was unable to generalize how to tie his shoe.

Some believe that autistic children have a sensory integration disorder, where their senses are either hyper- or hypo- stimulated, which seems to explain their reactions to certain sensory communication.

Touch and proprioception affect some children with autism; these children dislike being held or touched; however, they often love to roll their entire body on the floor. Some shriek at sounds that can only be distinguished by the frequency of that sound and are not necessarily audible by everyone. Others are aroused by light reflections or fixate on a single object for long periods of time. Some children dislike how certain things look, particularly if they differ from what they expect. They may appear obsessive about appearances to the degree of exactness. Communication channels for autistic children present a distortion in their world and may affect the way they learn early communication.

*Terminology*

Autism is the best-recognized and most frequently occurring subset in a group of disorders collectively known as the pervasive development disorders (PDD) (Siegel 96). Children are categorized as having one or more of these descriptive disorders along the PDD spectrum: autistic disorder, Rett syndrome, childhood disintegrative disorder, Asperger's syndrome, or Not Otherwise Specified (PDD / NOS). Tuchman describes a broader continuum of disorders that closely relate to autism, such as attention deficit disorder, deficits in attention motor coordination, perception semantic-pragmatic language disorder, Asperger's syndrome, high-functioning autism, fragile X syndrome, PDD / NOS, autism, and then autism, and then children with both autism and mental retardation (Tuchman 98).

*Behavioral Modification*

Many different approaches for behavior intervention are available to parents of autistic children. There are two popular styles. One is a one-on-one behavioral approach, known as *applied behavioral analysis* (ABA). This type of intervention was developed by B.F. Skinner and popularized for autistic children by Ivar Lovaas. The other is a station-based independent approach, known as T.E.A.C.C.H. (Treatment and Education of Autistic and related Communication Handicapped Children,) developed by Gary Mesibov in North Carolina. A common behavioral analytic treatment is one-to-one discrete trial teaching that focuses on a child's development of one specific behavior skill until some measure of success has been achieved. The process includes repeated trials at set intervals for learning one task, like learning the proto-declarative pointing mentioned earlier, and uses positive stimulus to reward successes. One task may take as long as one month to master, with four to six hours of training per day. In contrast, T.E.A.C.C.H. focuses on self-care skills and managing disruptive behavior and has a child focus on individually customized programs in quiet stations independently. According to this method, each child has different strengths and weaknesses, so each development strategy is customized to the child.

Behavioral interventions for some young children with autism may be successful in preparing them to assimilate into mainstream educational programs. High-functioning and Asperger children are more likely to succeed in the transition to special education programs in public schools because these children have few language deficits and this helps them overcome difficult situations, though these skills don't necessarily help them in social situations. Behavior analysis is the process of breaking down behavior that most people master without thinking into discrete fragments that can be memorized (Volkmar 99). Identifying and encouraging a child's strengths may encourage their weak areas to evolve (Prizant 98). Creating specifically tailored intervention programs for each individual offers him/her the most potential for success and the possibility of blending in. The best results are said to be achieved for children who receive early intervention before they reach the age of five years old.

Children diagnosed with autism or any disorder along the pervasive development disorder (PDD) spectrum are advised to start a specialized program once they have been diagnosed, some as early as twelve months old (Prizant 98), though generally at eighteen months old. These interventions, which usually apply to all levels of PDD, seek to enhance the development and well being of the child by addressing particular sets of difficulties (Sigman & Capps 98). The kinds of programs differ enormously, but most include strategies to help children develop social and communication skills, such as how to behave appropriately with other children and with groups of children, along with verbal language skills. Practitioners agree that teaching these children to recognize emotion in others is one of the most problematic areas. Because autistic children lack perceptual-affective abilities, complex communication such as humor and sarcasm often goes without recognition or understanding.

Many programs instruct children using emotion words and icon representations, yet systematic observations or experimental investigations of specific social behaviors are few (Fein 87, Lubin 99, Tuchman 99, Sigman & Capps 97). One procedure for teaching emotion is to show children photographs of people exhibiting emotional expressions. Figure 2 contains three learning development aid (LDA) emotion cards; here they show the emotions angry, happy, and sad. Children are seated facing a practitioner who will hold an LDA photo emotion card, such as one of the cards shown in figure 2, and provide a verbal 'prompt' e.g., "touch happy" or a similar verbal expression. If the child touches the picture then the practitioner will immediately provide enthusiastic social praise and occasionally provide access to a preferred snack, toy, or activity. The practitioner will then display another picture card depicting the same emotional content.

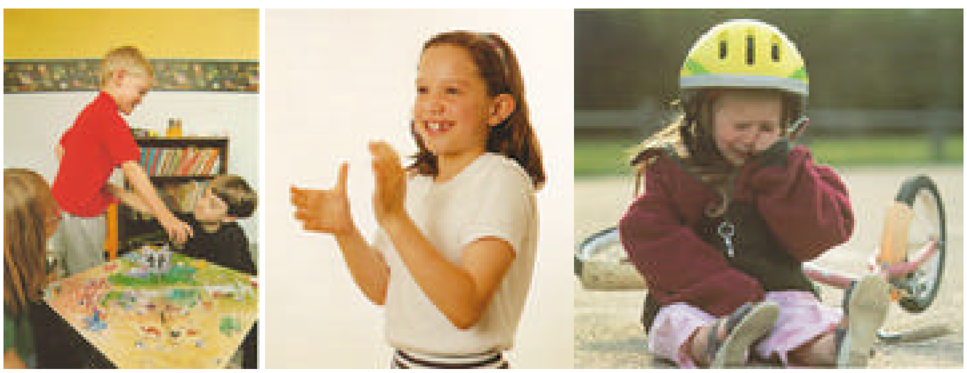


Figure 2: Photo Emotion Cards illustrating 'angry,' 'happy' and 'sad'

If the child does not touch the picture, the practitioner will repeat the verbal prompt and provide a physical prompt, e.g., pointing to the picture. If the child points to the picture after the physical prompt is provided, then physical assistance will be given to insure that the child touches the picture.

In addition, software tools that augment the child's training are available. Most applications focus on verbal development, object matching, or event sequencing. Laureate is the most popular software developer of programs specifically designed for autistic children. Laurette software is designed for autistic children to solve 'what if' scenarios and help them decide what the next action in a sequence could be. Sequencing is difficult for PDD children. While they may include scenarios that include emotion, the focus is not on developing the child's emotion recognition.

Knowledge Adventure and Broderbund are two companies that develop educational software for all children. The screen interface uses animation and bold colors to engage children. Some autistic children might enjoy this kind of software because of its stimulation quality.

Mayer-Johnson has a "board maker" software tool that combines words with its standardized icons (Picture Communication Symbols (PCS)), to help children communicate through pictures. The PCS can be arranged on the computer to tell a story and then printed to share with others. Additionally, the software allows new pictures to be added.

Other computer-aided software designed for handicapped children shows success in enabling them to acquire direct targeted skills. Most of these computer applications require some language understanding and uses a pictorial based system in the interface. However, in reviewing literature describing some of the available systems, the author noticed that the screen captures that are included in the literature are not visually captivating.

Though these different software applications are designed to help autistic children learn certain behavioral tasks, their focus has not been on teaching autistic children emotion recognition, based on the research covered to date in this thesis.

*Strengths of the autistic mind*

Autistic children may be either gifted musically or visually, or both. They will often remember the melody to songs and have perfect pitch or rhythm when listening or demonstrating what they heard. In some cases, it is easier for them to understand a message if it is put to music (Selker 99). Temple Grandin, an autistic adult and successful author and scientist, attributes much of her success to her visually-based system of cognition, or photographic visual memory (Grandin 95). Grandin writes about her understanding of the world through a set of images she has recorded photographically in her memory. Every time she experiences a new event she searches her memory for a similar situation in order to map the current situation to that scenario. She calls her memory a video database or CD memory. This helps her comprehend new situations that otherwise would be confusing, particularly regarding social behavior.

### *Why ASQ*

Affective Social Quest builds on the strengths of autistic children's visual system with video clips and dolls. Different displays of emotional expressions presented in moving pictures may be helpful to autistic children because they will be able to see the frame by frame development of an emotional expression. Recognition of and appropriate reaction to emotional affect may be useful for everyone, but as stated earlier is a barrier to being a participant in society for the autistic. Focus on the potential for using computing and physical interfaces in therapy is the heart of this work.

The intervention programs with the most success are usually developed from behavioral analytic approaches (Maurice 96). By breaking down learning into small and separate parts of a task, success for learning that behavior is achieved over time. The time demands on these untiring practitioners are intensive; they often spend many hours with one child, patiently showing them sets of pictures and instructing them in highly repetitive tasks.

A visually based therapeutic system that entertains and educates may be used to augment the practitioner's training. This system can emphasize interaction and facilitate the intervention style of teaching; it can provide multiple views of the content inexhaustibly. While a child is enjoying the system, the practitioner is free to spend time on other aspects of the child's development such as behavioral procedures for future sessions.

Because people with autism are visual thinkers, providing them with contextual scenarios that correlate with an emotional behavior, as well as providing depictions of various emotional expressions, may contribute to building their own memory databases, as Temple Grandin did.

Cognitively, actors are able to mimic affect when they portray a character. They learn how to communicate and express in a social way, so as to be believed by their audience. A more advanced actor will use a personal memory experience to evoke an emotion on demand (Hagan 73). For autistic children, this same approach to acting can be adopted even if they do not internally feel the emotion, but can simulate the correct expression. This process can be compared to learning to communicate in a second language. We are not proposing to modify the cognitive processing an autistic child uses to display emotional expressions, but offer for consideration an alternative approach to help him/her integrate socially at will.

## Chapter 3.
## SYSTEM DESCRIPTION

Affective Social Quest, developed in Java, ties together several systems: a therapeutic setup interface with an online guide, a media element rich screen interface with a video clip presentation in the center, and a set of wireless plush dolls for the input device interface. Presented are the design goals with an explanation of how and why aspects were chosen, the challenges faced in development and the operating modules for the apparatus used in the child testing.

### *Application Design*

#### *Design Goals*

The design goal of the system includes three objectives. The first objective was to provide a series of clips to children registered in the system and record their responses as measured by their touching a doll. Second, to provide a practitioner with a customizable interface for each child. Third, to provide different modes of operation for heterogeneous-type group.

In the original design a play-based environment was considered in which the child could interact with the system so that the child would drive the interaction. In this design concept, the doll initialized the system when picked up. Picking up the doll would activate the doll to express itself by making an affective sound, lighting up, or jiggling. These doll mechanisms were to reinforce the affective expression on the doll's face and demonstrate the emotional quality of that doll. Picking up the doll would establish a feedback loop between the doll and the system and retrieve a video clip to match that emotion. When the doll was set down in front of the screen, the video was to play a scene where an actor or animated character would express the same emotion as the doll. Each time the character on the screen would evoke an emotion, the doll would express that same emotion as well, for example when the character on the screen would giggle the doll would giggle too. Each time the doll expressed itself, a new scene would emerge on the screen showing another way that that emotion could be shown. When a new character would appear on the screen, the doll would express itself again, a new scene would appear, and so on, thus completing a system loop.

The advantage of this design was the child-driven approach and the entertaining way the system interacted because of the child's selection. Though this approach could be fun, there was concern that this approach might create confusion for an autistic child. Also an autistic child's ability to recognize emotion using this style of interaction could not be measured. Because meaningful data could not be collected on how well the child distinguished the different basic emotions, a different approach was implemented.

ASQ displays an animated show and offers pedagogical picture cues -- the dwarf's face, word, and Mayer-Johnson icon -- as well as an online guide that provides audio prompts to encourage appropriate response behavior from the child. The task was to have the system act as an ever-patient teacher. This led to a design focused on modeling antecedent interventions used in operant behavior conditioning. In essence, ASQ represented an automated discrete trial intervention tool for teaching emotion recognition. Now the video clip initializes the interaction instead of the doll.

The current system starts with a clip displaying a scene with a primary emotion (antecedent) for the child to identify and match with the appropriate doll (target behavior.) After a short video clip plays, it returns to a location in the clip and freezes on that image frame, which reinforces the emotion that the child is prompted to select. The child then indicates which emotion he recognizes in the clip, or frame, and selects the appropriate doll matching that expression. The doll interface, which is the only input device to the system, creates a playful interaction for the child.

Surprisingly, a play-mode still remained part of the system and promoted social interaction when used in a different context, play versus training. By assigning dolls to each person seated around the computer, this interaction creates social play between group members and their doll, which serves as their avatar. When an emotion displays on the screen anyone can interact using his or her doll to match the emotion shown. For example, if Johnny recognizes the happy emotion on the screen and player Jody has that doll, Johnny can say, "Jody, you have the happy doll," thus promoting joint-attention. Johnny and Jody now share communication and affect; communication when Johnny tells Jody to match emotion with his doll, and affect when matching the doll to the displayed emotion.

The system, *affective social quest*, gives a child the ability to view a sequence of movie segments on the screens that demonstrate basic emotions. By the system prompts, the child also has multiple representations for the emotion presented. Within the application the child can see several expressions for each emotion from a variety of clips. The dolls and characters associated with a particular emotion will hopefully encourage the child to mimic the vocalization, facial expression, posture or gesture they see on the screen.

### *Practitioner Interface*


Figure 3: Child Screen Mode

The screen interaction has two different parts: child and practitioner. The child interface displays elements that were configured by the practitioner. The number of available options enhances the interaction capabilities by allowing the practitioner to set up a specific training plan for each child session, as done in manual behavior analytic trials. Presented are the screen layouts for the practitioner and the reasons for choosing that interface.

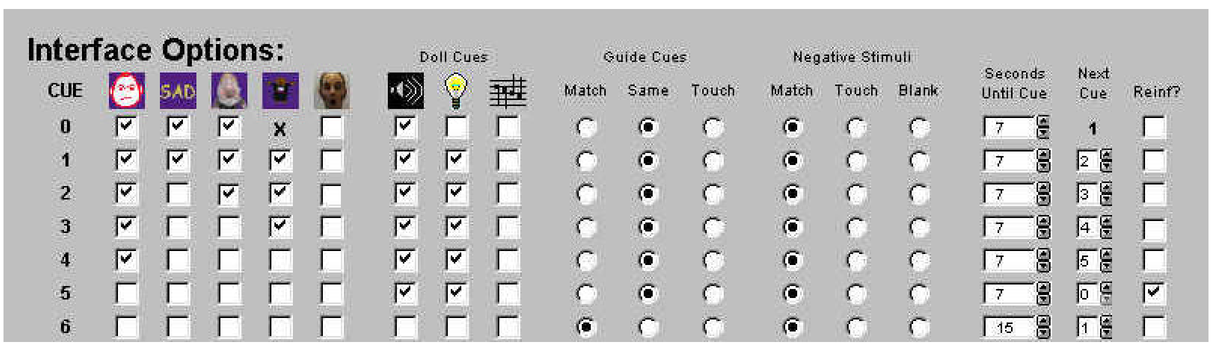



Figure 4: Practitioner mode

A configuration interface set up by the practitioner before a child session offers flexibility and customization for each session. Based on the interface options and clip configuration setup for a session, the screen may include one or all of the following picture aids: Mayer-Johnson standardized icons representing the emotion, the word for that emotion, and a picture of the emotion shown on the dwarf's face. These prompts can vary six different ways and be ordered or repeated by the parameters chosen. Also, an optional online guide can be displayed to prompt (discriminative stimuli) for child interaction, or with system verbal reinforcement (putative response) for child affirmation.

This section presents the elements of the design, shown in screen captures, to provide an inside view of the application windows. The practitioner can register a new child or select the pre-set profile for the child and then set up the child session. The session will display the presentation on the child's screen based on the practitioner's selections in the configuration window.

Figure 5: Create Profile Screen

The practitioner interface contains four main windows: SESSION PROFILE, ADD NEW PROFILE, SUCCESS HISTORY, and CONFIGURATION. A fictitious set up for demonstrating the flow of how the practitioner interacts with the following windows are presented using the name Johnny.

Figure 6: Add New Profile

The practitioner gives each child a unique profile. The ***Add New Profile*** option in the SESSION PROFILE window automatically brings up the ADD NEW PROFILE window for registering a new child into the application. The demographic data for that child includes ***Profile Name*** (child's name,) chronological ***Child's Age***, and the ***Deficit*** level of the child. The deficit level for each child is rated low, medium, or high by trained psychologists and neurologists based on the child's primary deficits related to social-emotional communication. The practitioner selects the profile name from the SESSION PROFILE and the SUCCESS HISTORY window appears. This is the main window to the application.

Figure 7: Success History Screen

SUCCESS HISTORY displays the child's success overview and sessions to date. The window presents the original interface designed in the application. The ***Emotion indices*** indicate the emotions presented to the child with the child's performance rating for each emotion. The performance rating, ***Fluency*** shows the child's percentage of correct responses to date for each emotion**.** Fluency is discussed later with the other performance measures. The child overview presentation helps the practitioner view the overall success for that child to date. Instead of averaging the overall data to date, more details were gathered trial by trial for each session. The final software version used the data differently than shown here, so the emotion indices are not updated by the system. More will be said later about these measures and the method that was used in the pilot test conducted at the Dan Marino Center.

The SUCCESS HISTORY screen is the gateway to other resources in the system. The options ***Configuration, View Statistics***, ***Different Profile, and Start Session*** allow for accessing information stored by the system. ***Different Profile*** returns to the SESSION PROFILE screen and ***Start Session*** begins a child session. ***Configuration*** and ***View Statistics*** will be illustrated and explained below. Here is the original design describing how the child's success could have been viewed.

***Configuration*** brings up a window for configuring the session interaction. The window contains two configurations that can be set up for the session: ***Interface Options*** and ***Clip Configuration. Interface Options*** list different cue options for each ***Cue*** number and clip configuration.

Many different ***Cue***s are displayed in the interface screen for the child interaction. Visual aids can be selected to display on the child screen: icons, word, dwarf, guide, and pop-up. These form the first category of selectable options. The next category is ***Doll Cues.*** Dolls can cue the child with one of the following three choices: affect sound, hatband lights, or internal vibration. Continuing to the right, the next category is ***Guide Cues*** spoken by an online guide.

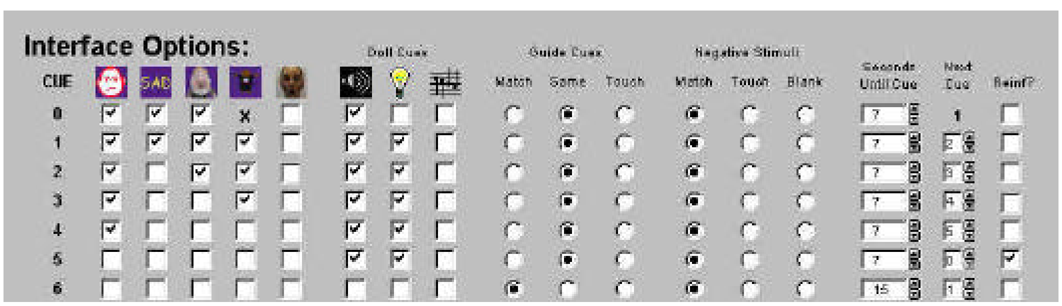


Figure 8: Interface Options section of Configuration Screen

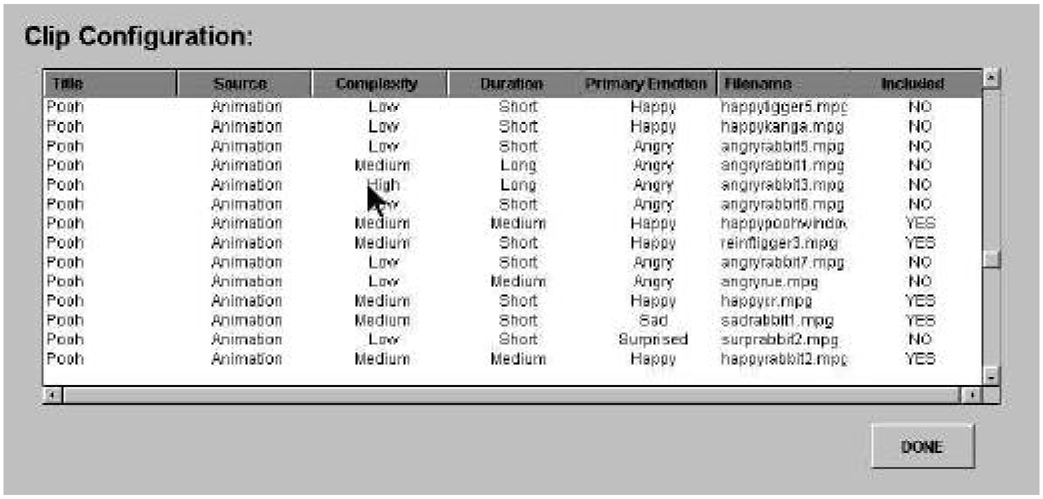
The guide audibly plays one of three different sequences to prompt the child to select a doll to match the emotion in the video clip. For instance, when a *happy* clip plays, the guide will say, "*MATCH HAPPY*" when ***Match*** is chosen, or say, "*PUT WITH SAME*" when ***Same*** is chosen, or say, "*TOUCH HAPPY*" when ***Touch*** is chosen. Likewise, reinforcements for incorrect doll selections will say, "*THAT'S SAD, MATCH HAPPY*" for ***Match***. One row of selections sets up one of seven configurable options for the interface. After each ***Cue*** has been selected for one ***Cue***, another set of hints can be selected.

Seven different cue set-ups are configurable for one session with the timing, sequence, and repeat rate tailored for each ***Cue***. The ***Seconds Until Cue*** select box allows the practitioner to set the time interval between each ***Cue*** series. The variety and flexibility of ***Cue*** options give the practitioner a tiered approach for setting up the interaction most effective for a particular child.

The order in which the ***Cues*** will occur can be set in the ***Next Cue*** selection box. The flexibility allows the practitioner to experiment with different ***Cue*** approaches to aid each child towards his best performance in emotion recognition.

The last ***Cue*** category includes the option of a reinforcement clip. When the child selects the appropriate doll, the guide reinforces that selection and says, "*THAT'S GOOD, THAT'S <emotion>*" the correct choice selected. An option to reward the child with a reinforcement clip that plays for five consecutive times can be selected by clicking that check box.

Special clips are selected and stored as reinforcement clips in the database. Reinforcement clips are not focused on emotion as much as on rewarding the child with entertainment – for example, the Winnie the Pooh Tigger Bounce song is played– and may reinforce the child's match of the correct doll and motivate the child. A reinforcement clip plays after the child touches the correct doll. After the next stimulus clip plays and the child matches that emotion, the same reinforcement clip will repeat; the clip repeats five times before a different set of the same reinforcement clips play. The reinforcement clips are selectable from the CLIP CONFIGURATION screen.




| Title | Source | Complexity | Duration | Primary Emotion | Filename | Included |
|---|---|---|---|---|---|---|
| Pooh | Animation | Low | Short | Happy | happytigger5.mpg | NO |
| Pooh | Animation | Low | Short | Happy | happykanga.mpg | NO |
| Pooh | Animation | Low | Short | Angry | angryrabbit5.mpg | NO |
| Pooh | Animation | Medium | Long | Angry | angryrabbit1.mpg | NO |
| Pooh | Animation | High | Long | Angry | angryrabbit3.mpg | NO |
| Pooh | Animation | Low | Short | Angry | angryrabbit6.mpg | NO |
| Pooh | Animation | Medium | Medium | Happy | happypoohwindo | YES |
| Pooh | Animation | Medium | Short | Happy | reintigger3.mpg | YES |
| Pooh | Animation | Low | Short | Angry | angryrabbit7.mpg | NO |
| Pooh | Animation | Low | Medium | Angry | angryrue.mpg | NO |
| Pooh | Animation | Medium | Short | Happy | happycr.mpg | YES |
| Pooh | Animation | Medium | Short | Sad | sadrabbit1.mpg | YES |
| Pooh | Animation | Low | Short | Surprised | surprabbit2.mpg | NO |
| Pooh | Animation | Medium | Medium | Happy | happyrabbit2.mpg | YES |

Figure 9: Clip Configuration section of the configuration screen

CLIP CONFIGURATION offers customization as well. Each column can be sorted by clicking on any one of the headers ***Title, Source, Complexity, Duration, Primary Emotion*** or ***Filename***. The ability to sort gives the practitioner a quick view of different aspects to choose between or to group together. Clips can be deselected by highlighting the clip or series of clips and hitting the space bar. For example, Cinderella may not be the best stimulus clip for one child because the clips may be too complex or the child has watched them many times at home. Alternatively, certain emotions can be deselected in early trials.

The design objective was to offer as much flexibility to the practitioner as possible for customizing the screen interface for a particular session or child. This is especially important because autistic children usually have unique idiosyncratic behaviors. Clicking the ***Done*** button returns the practitioner to the SUCCESS HISTORY screen. A session using the configuration just set up is started by clicking the ***Start Session*** button.

### *Child Interface*


Figure 10: Child Interface Screen

The practitioner interface sets up the child screen interface. The child screen interface provides a therapeutic environment with sub systems to create a heterogeneous way for the child to interact with the application. Following are the media elements to the child interface.

The screen interface serves as an output device for the application. This session screen was designed to allow the child to view images in a consistent location. Images of the icon, dwarf, word, and guide always appear in the same spot. The panel allows enough area for each to be displayed unequivocally and frames the video clip nicely. Initially, the idea was to have all the images appear in the bottom bar, but this crowded the screen and could distract the child by drawing unnecessary attention to that area and away from the video.

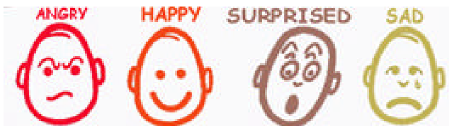


Figure 11: Icons


Figure 12: Armbands

The different cues intend to complement existing teaching materials and to reinforce the images in the system. Mayer-Johnson is the originator of Picture Communication Symbols (PCS) and has a set of 3,200 symbols used in many schools for communication by nonverbal and autistic individuals to visually aid communication (Mayer-Johnson 99). Each doll comes with its own removable icon that can be used as a matching cue or removed for advanced interaction. Incorporating these icons was to complement certain standardized teaching methods.

Words are coupled with each icon picture. Nonverbal and autistic children often learn words from pictures, such as the PCS, and will sometimes carry a book containing these images to communicate with when they are not able to articulate verbally. Speech and language pathologists help children use the pictures to learn words and to construct a story. In keeping with this model, the word appears over the icon as well as in its own screen frame.

Figure 13: Words

The guide animates to engage the child either with a positive reinforcement or a prompt to help the child make the correct selection. The guide may appear on the screen if the practitioner chose this visual aid. The guide displays no affective content to keep it separate from the other emotion labels in the application.


Figure 14: Guide

The visual guide is animated with its mouth moving. The decision to animate the guide's verbal prompts with flat affect was because the bear, the displayed guide, represents more than one emotional state while the rest of the interface is directly paired to a single emotion, the importance of consistency led to choosing no affect in the guide's speech.


Figure 15: Dwarf Faces

The dwarf faces help the child in matching the appropriate doll. The face contains the outward and visual expressive part of the doll. The visual matching helps children to match the dolls with the same emotion from the content they recognize in the video clip.

Another visual feature includes a pop-up window overlaying the video clip. The pop-up is a very short video of someone expressing one of the four emotions. This feature did not get implemented in this version of the software, but was included in the interface as a placeholder for when it would later be added.

The purple background color emphasizes the important content of the video in the center while not being too bright, which might be potentially distracting to the child, nor too dark, which might confuse the child by seeming like a negative reinforcement. The child interface was implemented after many revisions based on suggestions from professionals in the field.

*Video Clips*


Figure 16: Static Images of Video Clips (angry, happy, surprise, and sad)

Source

Collections of video clips of different styles, such as animation, drama, pop television, or documentary, were considered. However, after several video segments were gathered and reviewed, the reader team decided that animation should be used to reduce the amount of uncontrollable noise in each clip, which might distract the child from recognizing the emotion.

Animation, in general, minimizes the background in a scene and the focal point is usually on the main character. Secondly, animation exaggerates the features of emotional expression. Disney and Pixar spend great efforts in representing the quality of emotion in each pixel of an expression. Animators catalogue expression and movement for posture and facial expression, particularly for eye expression

(Thomas 95). Pixar, for example, has a room of mirrors where animators can try to mimic the postures and expressions of the emotion they are trying to depict as they animate a character.

Included with the animated expressions are realistic human expressions from television child programming, such as *Blues Clues*. Though the selection of these clips represents a small sample of the available programs, it was hard to find a variety of clips to represent each emotion, whereas the breadth for the happy emotion was abundant in both non-animated and animated footage (57% happy, 16 % angry, 15 % sad, and 12% surprise of 518 total clips (see appendix for list of sources.)

Length

The clips include short segments where most are no longer than a minute. They are rated as short (0-4 seconds), medium (5-10 seconds), or long (10 plus seconds). Emphasis was on the expression in the clip and not the context. The time it takes to express an emotion is extremely short. In many cases, the clips were lengthened to avoid chopping related audio or visual content expression.

The clips were not professionally edited. In special cases though, the clips were rendered using Media 100 or Adobe Premier. The challenge was to crop the video segment in order to capture the whole audio track for a scene while keeping the visual content focused on the salient expression. In normal interaction, words blend with other words and clipping them leaves disturbing audible sound. People previewed the clips to validate footage and commented on the audio cuts, so time was spent recapturing segments to reduce those awkward cuts as much as possible.

Emotion Labels

The system provides children with a set of visual images that they can associate with a particular emotion. A varied set of expressions for each emotion may help the child to generalize that emotion. Therefore, different scenarios of the same emotion in different settings were provided. The selected clips were rated on clip complexity. The scale for determining the clip's complexity, low, medium, or high, was based on the criteria listed in Table 1.

| **Low Complexity Criteria** | **Medium Complexity Criteria** | **High Complexity Criteria** |
|---|---|---|
| ❑ little background noise<br>❑ (multiple characters or distracting objects or movements) | ❑ some background noise<br>❑ (like multiple characters or distracting objects or movements) | ❑ background noise<br>❑ (like multiple characters or distracting objects or movements) |

| | | |
|---|---|---|
| ❑ only one character in scene<br>❑ single emotion displayed<br>❑ obvious emotion expressed | ❑ two or three characters in scene<br>❑ single emotion displayed<br>❑ clear emotion expressed | ❑ two or more characters in scene<br>❑ multiple emotions may be displayed<br>❑ complex emotions expressed |

Table 1 : Clip Criteria

Format

The video clips were collected and digitized using the Moving Picture Expert Group (MPEG) standard. MPEG is a video format standardized by the International Standards Organization (ISO) for digital video. The digitization compression stream for encoding and decoding was defined so that captured digitized footage could share this format internationally. Companies develop their own compression algorithms but follow the format set up by ISO.

MPEG-1 was the format chosen because of the compression rate and decoding compatibility across various applications, and mainly because the Java JMF version included that format in its API. The MPEG-1 code pattern uses still image data, intra frames (I frame), and bidirectional frames (B frame), then predicted frames (P frame) in its coding scheme, e.g. IBBPBBPBBPBB (MPEG 97).

### *Evaluation by Practitioners*

While designing and developing the application several professionals were consulted. Their continual guidance in the development of this project was invaluable. Boston area evaluators included professionals from some centers that treat children with autism: Cambridge Children's Hospital; The May Center; and The Occupational Therapists Association. In addition, two specialists from Miami Children's Hospital, Roberto Tuchman and David Lubin, collaborated in the application design. David Lubin participated in early stages of development when he visited Cambridge and both Tuchman and Lubin selected candidates for ASQ child testing where the pilot took place in Florida. Miami Children's Hospital has a special center for intervention programs. As stated in their brochure, "The Dan Marino Center is a comprehensive medical center for children with developmental and chronic medical needs." More information on the center can be found in the appendix.

### *Content Critique*

The first stage of evaluation focused on video content. After Media Lab ASQ team members collected footage clips from television programming, it became evident that the content could be too complex for the demographic pool of children targeted for testing. Adult programming, though containing interesting depictions of emotion, often presented complex expressions and contained a lot of distracting information in the scene. For example, footage from Sienfeld episodes contained too many scenes with background distractions, and when these were viewed frame by frame, the actors displayed mixed emotional expressions. Therefore, content shifted to focusing on animation and to keeping the clips short, without including situational content. Animation shows characters that exaggerate their emotional expression and the scenes include less background noise. Situational context for the emotion was not as important; the goal was to represent the way the emotion was expressed, not necessarily why it was expressed.

Video clips for the target audience -- children between three and five years of age -- were collected. After the animation and the children's television programming clips were digitized, professionals in the field of autism reviewed a videotape sampler with samples of these clips. The responses back from the viewers validated the decision to include animation and to keep the clips short, to less than thirty-seconds. Children's programming, from shows such as *Baby Songs* and *Blues Clues*, received positive appraisal and were added to the collection of clips to show real children expressing emotion.

What surprised most of the viewers was the way the clustered set of emotions affected them when they viewed the sampler. For instance, the cluster of happy clips elated the viewers. They commented on feeling happy after viewing only a three-minute segment with twenty different happy clips edited together. Likewise, angry and sad had the same affective sway towards them feeling those emotions. Their feedback helped identify clips that contained complex emotions and were labeled complex or eliminated from the collection because these were not illustrating basic representation of an emotional expression.

### *Interface Critique*

A prototype of the system was reviewed in a meeting to discuss the application design. In attendance were medical professionals from Boston Children's Hospital and members of ASQ's reader team. The decision to create a behavior analysis application was approved. The primary goal was to see if children would engage in the application and be able to potentially learn to recognize emotional expressions depicted in the video clips. One noticeable characteristic of PDD children is their attention span. Often they are easily distracted and their attention quickly shifts, which may contribute to their delay in learning. If a system could keep children's interest long enough they might enjoy what they learn. If engaging them is successful, the potential benefit to these children could be enormous. This application might help children learn social communication if these children could be engaged in the video clips and match them to other representations for that emotion. If they could identify emotional expressions in people while in a social situation, perhaps they could also understand the context of the situation.

In the meeting, the idea to possibly incorporate a play-mode into the application design was suggested. This was similar to the initial idea of creating a doll driven system. Those who recommended this approach were curious as to whether children preferred a play mode to the behavioral mode. From a design standpoint, to include both a video driven system and a doll driven system required the interaction in the application to be re-designed to switch back and forth between both modes. This was difficult to resolve, particularly when statistics were gathered based on the child recognizing an emotion. Capturing the interaction between the child and doll is easiest with one interaction approach. The doll driven concept has thus become part of the future work ideas.

## Operational Modes

### Plush Toy Interface

Video segments initiate ASQ interaction, but to play in this environment, plush doll dwarves are employed. ASQ uses four interactive dolls that represent the basic emotions, angry, happy, surprised and sad.

Figure 17: Dwarf Faces (angry, happy, surprise, sad)

ASQ, being an interactive system, also helps in the development of joint-attention. Joint-attention, as mentioned earlier, is a social skill for pointing, sharing, and showing. It incorporates eye-gaze and turn taking with another person. Some autistic children are just not interested in eye contact, and thus rarely initiate it.

They prefer to play by themselves, often with inanimate objects, but may not like the loneliness of playing alone. ASQ can help by having different dolls act like playmates.

The dolls may be set up to offer helpful cues during the child session. Each doll either vocalizes emotion, internally jiggles, or its hatband lights up to cue the child to make the correct selection. After the clip has played the appropriate doll will activate one of the cues set up in the configuration. Though this was implemented in the doll hardware, child responses to these were confusing and not used in the pilot at Dan Marino. The child could not easily attend to both the doll cues and the screen cues at the same time. The inclusion of the doll cues may be added in more advance levels of interaction with ASQ, after the child shows success with screen cues.

### *Interactive Modes*

The system design has two modes of interaction -- an applied behavior mode and a story-based mode. The first mode displays short clips, one at a time, from various child program sources and the second mode displays an entire movie with the story segmented by the emotions. When the video freezes, the interaction is the same for both modes until the correct doll is selected.

#### *Applied Behavior Analytic Mode*

The design targets children with prior early intervention using a discrete-trial method of instruction. To complement this approach of teaching, the system evolved to represent a stimulus reinforcement (behavioral analysis) model for interactive learning.

Applied behavior analysis (ABA) uses operant behavior to shape behavior with reinforcement and prompting methods. Given a stimulus, the respondent is to behave in a trained way. The behavior is modified by continually reinforcing the correct behavior while shaping other behaviors toward the expected result. For example, discrete-trial training procedures derived from strict principles of behavior analysis and modification typically address singular developmental skills until some mastery has been observed. This process includes repeated trials over a specific amount of time. In each trial, a practitioner presents an antecedent cue (discriminative stimulus) and, dependent on the child's ensuing response, presents the specific consequential event to either reinforce the response, or prompts the child in order to increase the probability that the targeted skill will be exhibited on subsequent trials (Lubin 89). Although highly effective when administered by humans, this method is highly expensive and labor-intensive due to low teacher-to-student ratios. ASQ attempts to offset the time demands on the practitioner with a complementary tool.

ASQ implements operant behavior in its ABA mode. A guide's verbal response or reinforcement clip rewards the child's correct behavior. The guide also provides repeat prompt responses to incorrect dolls selected by stating the doll selected and re-requesting the desired response. Additionally, different screen cues offer matching aids for shaping the behavior. The child can either directly pattern match -- the picture of the dwarf's face on the screen to the dwarf doll, a screen icon and word to the icon with same word on the doll armband -- or use standardized intervention tools. All the cues, dwarf's face, icon, and word, help the child to generalize the emotion to different representations. They assist the child in identifying one representation and associating it with the expression played in the video clip. As the child's performance increases, these shaping aids can be eliminated, leaving just the video clip stimuli alone.

*Story-Based Mode*

The story-based mode uses the same interface but instead of short random clips, a whole movie plays. This mode was added because of a suggestion made during early pilots of the system when it was in development. The story includes situational context for the emotion, whereas the mode above just presents short clips from various sources. When an emotion is represented by the system, the system freezes on that frame and goes into the operant behavior mode until the correct doll is chosen, then resumes until the next emotion displays. In this case, the clips are not disjointed but flow together. The disadvantage to this mode is the length of play. The movies often are one hour in length, and with freeze frames this mode tends to be longer than most manual intervention sessions. This mode, although implemented, was not included in any of the children's trials.

## Application Development

The software application will run on most compilers, like the Intel family CISC or Alpha family RISC processors aimed at Win32 environment. It was developed in the Win32 environment, under Windows -95 and -98 and NT, and written in the software programming language Java. The system controls all the different software modules: serial communication, application clock, Java class for database management, and Java media player. The backend uses a SQL database, Microsoft Access, and uses SQL to talk to the queried information with JDBC/ODBC. The application uses the Java Media Framework (JMF) application programming interface (API) for incorporating media data types (JPEG images for interface elements, MPEG video for video clips). JMF could be used for the animated JPEG images for the online guide and audio files for the online guide's reinforcements, but was not implemented this way in this application. Instead, the other media pieces in the interface are handled by Symantec packages, Symantec animated image player and Symantec sound player, respectively. The JMF 1.1x API architecture plays media elements (video clips) in the video frame. Video clips coded in the database are retrieved by the system based on the selection criteria chosen in the configuration screen. Media elements are part of the visual-based system and display on the child's screen (see ASQ Team).

The hardware interfaces the dolls to the system through infrared communication. Dolls are embedded with iRX 2.1 boards. The iRX is a circuit card measuring 1.25" × 3" with an RS-232 serial port, a visible light emitting diode (LED), an infrared LED, and an infrared detector. A 12-bit micro controller, PIC16F84, made by Microchip Technologies, Inc. controls the board (Poor 99). The iRX 2.1 uses five of the programmable integrated circuit (PIC) input-output (I/O) ports; the remaining eight ports are used by the applications that control doll features: toy detection switch, affective sound recorded voice box, haptic internal vibration motor, and hatband LED lights.

Each toy has a unique ID recognized by the system. The system sends codes for each session to the doll for custom responses based on condition parameters. The system continually polls the toys to identify the doll selection from the child's touch on the touch switch over a set period of time. The dolls continually request data from the system to activate their appropriate applications based on the system's configured cue features.

As stated, the system is designed with a great deal of flexibility so each session setup is customized for each child by session. Also, the system is extendable. The system can include custom clips tailored for the child. Digitized clips can be loaded into the database located on the hard drive and retrieved randomly with the others in the system.

***Software***

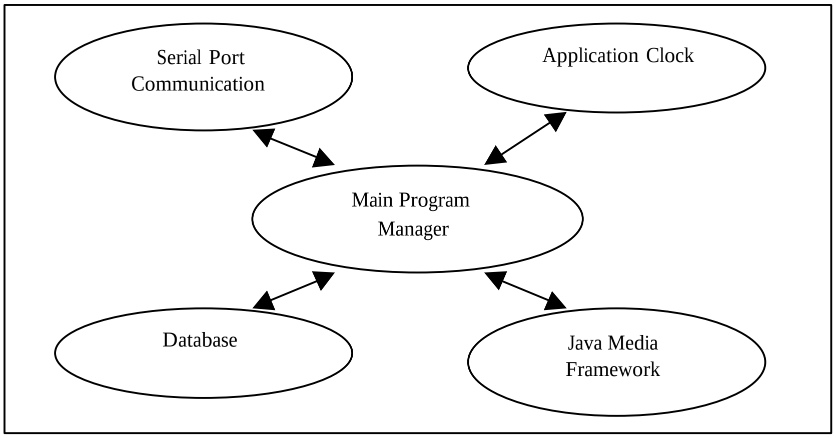



Figure 18: Application Architecture

The Java programming language was chosen to develop the application because of its system portability, rapid prototyping capability, and media rich packages. Designing the system behavior was challenging because of the desire for built-in flexibility. The application uses a multi-threaded environment with two application programming interface (API) architectures -- JDK and JMF. This coupled with the transfer of interface information synced to the system clock made debugging a complex and daunting task even for minor modifications.

The system is subdivided into five primary task functions illustrated in figure 18. The main program manager is the application puppet master. It manages the different functions in the application. Being multithreaded, it keeps track of the system interaction and associates it to the media and syncs it to the system clock while polling the serial port communication for hardware interaction. The database is the main repository for data inputted or selected for interaction.

The system continually updates its cached arrays based on the response interactions the serial communication and the cue interactions set up in the configuration. Each 250 ms of interaction time is recorded and stored in memory until the system is exited.

After the application is executed the JDBC-ODBC establishes a bridge between the database and the Java source code. This connects the front-end to the backend and manages the data passed between long term and short term memory. Using SQL select statements, the application collects data and writes it to an array or to respective database tables. At the system execution, it calls the database and requests profile names using SQL SELECT statements.

There are five database tables queried by the system. ASQ executes JDK 1.1.x. from an MS-DOS prompt window of a Win32 environment running Windows 95. The application instantiates a session frame and a Java database class. The database is queried using JDBC/ODBC, the bridge between the Java source code and the database (Microsoft Access). Names of all existing profiles are selected and their addresses are loaded into a table accessed by the application from the system's memory. When the practitioner creates new profile, a window for the NEW SESSION frame is instantiated for profile data to be inputted: ***profile name, deficit*** and ***age.*** When the ***Done*** button is clicked that new entry is added to the application table and later stored in the database for that new child profile. If the practitioner chooses an existing profile SUCCESS HISTORY is instantiated and the frame displays in the window on the screen. Originally, this frame was to include statistics on the child's performance to date. The frame still exists as part of the interface, but the fields are blank. A different method of data gathering was implemented as opposed to having the application calculate an aggregate performance rating for the child's over all sessions.

A CONFIGURATION frame is instantiated when the ***configuration*** button is clicked on. The new frame displays flexible set up options. In the clip configuration section of this frame video clips are listed and are sorted by the system through Symantec's application-programming interface (API) package. In that same frame are interface options. Clicking on radio buttons activate application interface features: guide responses and screen displays for the six cues. When that ***done*** button is selected, all the configuration parameters are written cached and dynamically accessed by the application based on the system clock associated with the selected features. After a session the parameters are saved into memory in an array string until the session application is exited. The array data is then written to a comma separated value (CSV) file with interaction responses recorded during the interaction.

Clicking on the ***statistics*** button instantiates the frame where statistics were going to be stored. The original design was going to include statistics computed by the system and presented in the SUCCESS HISTORY frame. The intention was that the application would collect data for each profile, calculate the statistical measures and keep a running sum of these measures, which were to be shown in this frame. These were aggregate statistics for the child. With the expansion of the data gathering task a different method of statistical presentation was chosen and changed the data structure. The data is now exported to a CSV file to be read into a spreadsheet program, such as Microsoft Excel. This design changed in the last stage of the system development. It was thought that each session's data should be preserved and that it would be best if more data could be collected on the child session interactions. As stated earlier, the new approach made the initial design of the data structure obsolete and these fields in the frame are blank. The screen currently displays no information based on the child performance.

Export of the data is called from the menu bar, under ***File > Export Data***, where the practitioner is prompted to give the path and file name for the two files. One filename is for interaction values and the other is for interface options set up by the practitioner in the CONFIGURATION frame. Data is written to the CSV file at the time export is selected from the menu-bar. Data is collected for all interactions from the last export data to present export data. The system array is cleared with each export and system shutdown. It is important that session data collected for each session be exported after the session to keep the data separate from session to session or from child to child. When the application is exited, then data for parameters, video frames, and interaction intervals (in milliseconds) stops streaming and is downloaded into the comma separated file.

Three threads run together and share the system processing. The main thread controls the frames (windows), a secondary thread controls the serial communication for detecting doll interaction and another controls the data passed to the application array for the CSV files and manages upcoming media elements for the interface. The two secondary threads run their own clock: the serial runs at 250ms and data runs at 150ms. These threads are handled by methods written in the main program.

The main thread controls a JMF panel that deals with the video clips played in the center of that frame. The secondary thread, managing the data, sets up the next frames and waits in the background to be called by the main program. For example, data continues to be stored in the array with addresses accessed from the database, and passed back and forth while serial communication from the doll detection and doll activation are handled by the other thread.

JMF dictates the timing of the video frame and other screen interface elements. The application interaction has to wait until that clip completely plays before the application performs another task. Garbage handling became a major problem in early development because of the rapid growth in virtual memory taken up by the interface elements. Each time a clip played, Java's garbage collector was called to clear all memory except array data and interface components. Initially, either no garbage was deleted, or no garbage was collected. With the help of developers on the JMF development team, code was re written based on their suggestions.

### *Hardware*

Each time the system receives the code of the emotion shown on the screen, a signal is sent to the corresponding doll. The doll will exhibit a specific response to represent the emotion it depicts. For the verbal doll cue, happy doll may giggle and angry doll may grunt depending on which clip is playing. The toy's purpose is to reinforce an emotion symbolically.

*Doll Switch*

Figure 19: Doll's Touch Switch

The touch switch illustrated is a copper laid tape formed into a switch separated by Velcro and cloth. When the switch is touched, the copper tape creates a contact on each side causing an interrupt to occur in the component software, signaling that that doll was chosen. The touch switch pad was made using cloth so that it was soft and could not be felt when the doll was touched or lightly squeezed. The touch pad is located in the tummy of the doll, underneath the doll's shirt clothing.

*Doll Packaging*

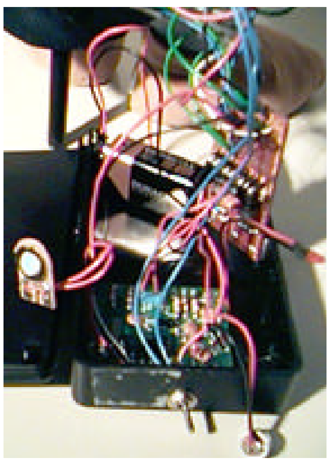


Figure 20: Doll's Hardware Box

An iRX board controls the component applications for each feature of the doll selected in the interface options. The dolls are each configured with a touch switch, speaker, pager motor, and band of four LED lights. The features of the doll are stuffed inside the doll and the wires from each component go through the doll's back and into its backpack. The black box contains wiring for each component connected to the iRX board powered by a volt battery. All the hardware fits into each dolls' backpack. The backpack provides a storage container to maintain the plush interface of the doll.

*Doll Features*

Figure 21: Dwarf Front & Back View

The hatband for each doll contains an array of LED lights, LED receivers, and black transmitters. Each is threaded on its own wire for ground and power. Each wire strand is insulated with plastic casing to shield it from other wires and hot glued for extra protection. The three threaded strand -- one for LED lights, one for transmitters and one for receivers -- are woven together, strategically separating each strand and offsetting them between each other. The strand forms a u-shape that fits on the doll's head and was sewn into place. Four emitters were selected. The goal was to extend the range of wireless communication. It was effective, though it reduced the communication distance between the system's receiving device attached and the dolls from nine feet to three feet. The change in distance did not affect the interaction because of the doll's close location to the system's receiver box.

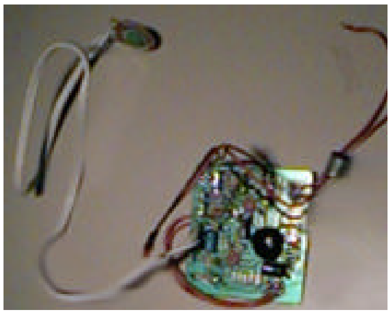


Figure 22: Doll's Recording Unit

The affective sound for each doll was recorded onto a microphone hardware chip that has a quarter watt output. A single twenty-second audio sound was recorded for each doll. The component is threaded through the back of the doll's head and the speaker is placed in the doll stuffing around the doll's mouth.

Inside each doll is a pager vibration motor. The motor is inside the doll's nose and causes the whole doll to vibrate when activated. Originally, the idea was to have the doll visibly jiggle and move on a flat surface, but the amount of power and size of the motor exceeded the system power source capabilities. This motor offers a good haptic sensation through the doll when the motor is activated and can be felt anywhere on the doll.

Figure 23: Doll's Stand

The dolls are mounted on a table with recliner boards and adhered to the table with Velcro. The Velcro prevents the recliner boards from sliding when a child pushes the selected doll. The recliner holds the dolls upright for the child to see them easily from a chair and pick them up to play with. The ease of placement on the recliner allows the dolls to be arranged differently on the table or for one or more to be removed from a session.

***Wireless Communication***

Figure 24: System Communication Box

The data communication interface between the doll and the system uses infrared to wirelessly transmit signals between the system and dolls. A doll's tetherless feature allows the dolls to be played with as well as to be arranged in various positions on the table during child sessions.

The dolls receive codes from the system and activate subprograms located in the hardware and stored on the iRX board. These programs run the different doll features. For example, codes sent to the doll could be one of the following: for happy either sound, light, or vibrate (HS, HL, or HV) ; sad to either sound, light, or vibrate (SS, SL, or SV) etc, respective of the interface option set up in the interface by the practitioner. Dolls send codes to the system to indicate whether they are present or detected from a touch on the touch switch: (happy (H), sad (S), angry (A), or surprised (Z)).

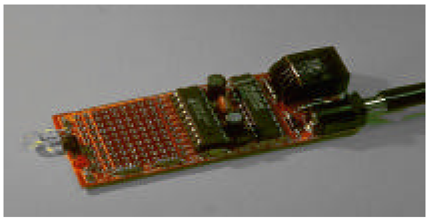


Figure 25: Doll's iRX

Doll programs run a system loop to detect whether one of two things take place: a signal has been receive, or a doll has been chosen. When the doll receives a code, it is processed by the doll's program to determine what feature was requested, and the doll performs that featured action. When a doll is touched the touch switch interrupt shifts from high-to-low and a code is sent the system, causing the interface to respond based on the code sent. This infinite loop continues until either of these code signals occur.

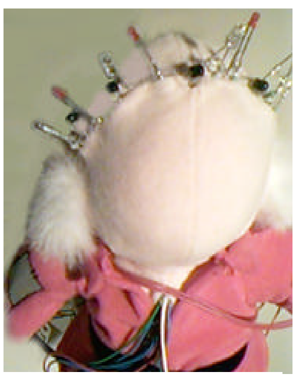


Figure 26: Doll's Communication Device

The doll program looks for the ID from the system based on the touch switch interrupt. The system continues to perform this test until either the identification signal is detected or a cue to the doll is sent, activating one of its cue indicators. The infrared receiver has an interrupt handler in the software for detecting transitions and responds accordingly.

Andrew Lippman originally suggested toys for the interface to engage the child. The use of toys as the physical interface explored research opportunities to investigate serial communication using multiple objects with one system receiver. Existing toys, such as the ActiMates dolls, can interface with the computer, but it are not capable of recognizing more than one doll at a time. The interaction through this interface as well as the communication between the multiple input devices explored a novel way of computer interaction.

### *Apparatus*

The pilot study was conducted at the Dan Marino Center in one of the therapy rooms. The room was eight by eight feet, with one outside window and one window to another office. A Toshiba Tecra

7000 laptop ran the ASQ application on a Pentium Pro(r) with 191 MB RAM in Microsoft Windows 95 4.00.950 B operating system, executed from a MS-DOS prompt window. Two screens, one for the practitioner and another for the child, were set up with a video camera angled towards the child and dolls with the practitioner's screen in the lens view to capture the screen while ASQ ran during the interaction. Speakers were attached to the system to amplify the audio of the application. Connected to the system, at the base of the child-viewing monitor, was the system communication box with four transmitters and receivers directed toward the dolls.

Figure 27: Apparatus for Study

Four toy dolls representing primary emotions were the child's input devices to the application. Each toy doll was loosely positioned on the table on a reclining board adhered to the table with Velcro pads. The dolls were mounted on reclining boards facing the wireless communication box and child-monitor. This allowed the children to see the entire doll in front of them. The dolls could be picked up easily from their stand, but were intended to remain on the stand and to be selected by the child when pressed the belt-buckle of the chosen doll.

### *General Procedures*

Figure 28: Child's Interaction

The goal was to see if children can correctly match the emotion presented on the child-screen to the emotion represented by each doll. For experimental control the same dolls were used with each child. The automated training was arranged to teach children to "match" four different emotion expressions, e.g. happy, sad, angry, and surprised. A standard discrete-trial training procedure with the automated application was used. Subjects sat facing the child-screen that exhibited specific emotional expressions under appropriate contexts within the child's immediate visual field. A video clip played for between 1 and

30 seconds. The clip displayed a scene in which an emotion was expressed by a character on the screen. The screen ‘froze’ on the emotional expression and waited for the child to touch the doll with the matching emotional expression (correct doll). After a pre-set time elapsed, a specific sequence of visual prompts displayed on the computer monitor and auditory prompts played through the computer speakers.

If the child touched the doll with the corresponding emotional expression (correct doll), then the system provided an online guide that audibly stated “Good, That’s <correct emotion selected>,” and an optional playful clip started to play on the child-screen. The application then displayed another clip depicting emotional content randomly pulled from the application.

If the child does not select a doll or if he selects the incorrect (non-matching) doll, the online guide provides a verbal prompt: “Match <correct emotion>” for no doll selection, or “That’s <incorrect emotion>, Match <correct emotion>” for incorrect doll selection. The system waits for a set time configured by the practitioner and repeats the prompts until the child selects the correct doll. An optional replay of the clip could be set up before the session, in which case the application replays that same clip and proceeds with the specified order of prompts configured in the set up. If the child still fails to select the correct doll, the practitioner assists the child and repeats the verbal prompt and provides a physical prompt, e.g., pointing to the correct doll. If the child selects the correct doll but doesn’t touch the doll after the physical prompt is provided, then physical assistance is given to insure that the child touches the correct doll.

### *Experimental Conditions*

Three different visits were scheduled for each child. During these visits, the child interacted with the application for up to one hour. All children began with the same screen interface for the first visit: all cues on the screen with a playful reinforcement clip for the correct selection. The configuration of the application varied for the children based on their level of emotion recognition and prior session performance.

### *Statistics Gathered*

Based on session data -- the child profiles, the system configuration, clip configuration, and response times for each interaction -- the system was designed to calculate performance ratings.

A decision to collect details of each child's interaction changed the data structure for the original profile statistics. The change to the data collection method changed how the system treats the data. The changed collection method monitors the child interaction in milliseconds using the system clock. The interaction parameters set up by the practitioner and the randomly retrieved video clip for one trial is written to an array stored by the system. The system collects the time, in milliseconds, that the child touches a doll. For each set of screen aids for one cue and the video clip data for that one clip shown to the child, the system records each doll the child selects and when they selected it. All these data points are written to an array table for each video clip trial. When a session is complete, all the array values, one for each trial, are exportable using an export function in the application. These values are written to a comma separated value file that lists the trial interaction values and the data can be viewed using a spreadsheet program to view the trial data in the spreadsheet rows. With these values, performance ratings can be manually computed. It was thought that the independent trial data would contain more information than a summary to date of performance ratings generated by the system. Below are the formulas used to compute the measures.

Measures of Response Rate (Ri) are used to track the number of training trials (opportunities during each session as affected by subject compliance).

Response Rate given multiple response classes (corrects/errors) is:

$$R_i = \frac{\Sigma(r_c + r_e)_i}{T_i}$$

Where:
$R_i$ = Response Rate in a specific training session
$r_c$ = Number of matching doll correct responses
$r_e$ = Number of incorrect matching doll responses
$T_i$ = Elapsed time under that specific session

Accuracy (Ai) will be used as an index of how effective the training procedures are for teaching the children to match the targeted emotion during a given trial by tracking changes in the proportion of correct responses during each session. For example, if an angry clip plays and a child picks the following dolls, happy, sad, happy, happy, and then angry, $r_c = 1$ and $r_e = 4$.

Accuracy given multiple response classes (corrects/errors) is:

$$A_i = \frac{\Sigma(r_c)_i}{\Sigma(r_c + r_e)_i}$$

Where: $A_i$ = Accuracy in a specific training session
$r_c$ = Number of matching doll correct responses
$r_e$ = Number of incorrect matching doll responses

Lastly, indices of fluency were calculated for each session. Fluency represents a performance summary of how many correct responses were made. Let Rmax be a constant indicating the perfect response rate possible. Rmax is calculated by summing the average time for the application's media to be presented and the average time for the expected flawless response. Averages for transitions in the application are used to calculate Rmax under two conditions, with reinforcement clips and without reinforcement clips: clip duration = 6 seconds, transitions for guide prompts and media frames = 1 second, and 'optional' reinforcement clip = 15 seconds. Rmax with reinforcement clip is 1/(6+1+15) = 0.045. Without reinforcement clips it is 1/(6+1) = 0.143. Excellent fluency is a result equal to 2 obtained when the correct doll is touched without any delay ($r_c$/Rmax = 1 and accuracy $A_i$ = 1).

Fluency with known physical constraints over response rate is:

$$F_i = \frac{R_i}{R_{MAX_i}} + A_i$$

Where: $R_i$ = Response Rate
$A_i$ = Accuracy
$R_{MAX_i}$ = Maximum possible response rate

## Chapter 4.
## EVALUATION & RESULTS

### Cambridge Pilot Test

Three pre-pilot cases were conducted with four children, two who were diagnosed with autism and two who were siblings of children with autism. Their parents offered thoughtful remarks during these sessions. The objective was to observe how these children responded to the application environment. The interaction with the screen interface and doll interface was observed.

*Case One*

The first subject was an eight-year-old boy and the younger brother of a ten-year-old autistic boy. He was very helpful, curious, and at times, seemingly bored. He had technical savvy and was creative with his suggestions. He appeared to be interested in the narrative and imaginative quality of an interactive system.

His interaction with the doll was interesting. He picked up on the method of interaction quickly. When a clip played, he picked up the appropriate doll and oriented it to the system receiver without much instruction. He became immediately curious about the embedded technology and his attention diverted to how the dolls did what they did. The infrared communication intrigued him and at one point he disassembled the doll to investigate the internal hardware in search of the iRX board.

Most of the surprise clips confused him, or he didn't think they matched other labels in the interface because of the additional emotions, mostly happy, that were also shown either immediately before or just after the expression of surprise. This led us to question whether to make the clip shorter or focus on the salient expression displayed.

The clip content became an interesting topic of discussion with the developer team and his mother. She was helpful in pointing out the dichotomy between the audio content and visual content. Her background in linguistics may have contributed to her observation of script development prior to the animators creating the visual content. She could understand the challenge of capturing a visual representation of the emotion, while encapsulating the audio content, without including multiple characters, secondary emotions, or adjoining scenes. Because the audio tended to merge characters and scenes, she suggested that the entire scene be included in one clip or that the audio be removed altogether.

The disjointed way different movie clips were shown one after another concerned her too. Because the clips were subsets of a whole movie, a child who may have seen that video before might be distracted by the familiarity of the footage and try to recall where that scene would appear in the original film or what should come next. Her comments motivated us to develop the story-based mode mentioned earlier. Additionally the clips were reviewed for content from both the visual and audio perspective.

Something happened during their visit that surprised me. While setting up the system, cable television was showing on the big screen used to project the application. When adult programming aired, the boy had no interest in what was playing at all and he preferred to draw on the white board in the room. However, when a child's program or animation came on the screen, his attention immediately focused on that program. This illustrated to me how child programming, with its music and color, can engage children's attention in a way that adult programming with adult dialogues might not.

*Case Two*

Next a four-year old normal developing girl and her six-year old high-functioning autistic brother were observed. She didn't show interest in the application, and deferred all interactions to her older brother. On the other hand, he displayed excitement and enthusiasm towards the gaming interaction with the doll and the video clips. He had a good grasp of emotions already and he quickly matched the emotion shown in the clips. Removing all visual cues from the screen interface (icon, word, and dwarf's face) tested this. His response slowed a little, but he was able to match the doll, with the exception of surprise. Consistently, he thought the surprise clips were displays of embarrassment.

Interaction with the doll appeared confusing to him at first, but after several illustrations, he was in total control. At first, he oriented the face of the doll towards his face, instead of pointing the head of the doll towards the system. It was surprising that he didn't focus on the doll peripherals like the boy from the previous visit.

What appeared to frustrate this boy the most was that the clips stopped playing; this was when the online guide would prompt the child to match the emotion by picking a doll. He wanted the animation to continue for longer than a few seconds and kept saying, “now, don’t stop the clip.” at the beginning of each new clip. This observation supported the engaging and motivating quality of the videos in the screen interface and the doll interaction while pointing out that the application interface might possibly be a frustrating deterrent as well.

In an effort to engage his sister, she was encouraged to play with her brother. A new game was suggested. Each child was given two dolls. They were encouraged to guess the emotion displayed on the screen together and then identify who had the matching doll representing that emotion. If he had the matching doll, she would tell him to orient his doll towards the system to indicate their selection. This engaged both of them for a short time.

Their mother commented on the content of the clips and noticed that many of them contained complex representations of the basic emotional expression. She also commented on how the Disney’s earlier produced animations displayed purer representations of emotion as compared to their current movies, such as *Little Mermaid*.

*Case Three*

The last subject was a nine-year-old boy diagnosed along the pervasive development disorder spectrum. He and his parents interacted with ASQ. As with the previous boy, he engaged in the animated footage and gaming interaction, without appearing to be distracted by the peripherals. Again, the examples of surprise created the longest delay in response. He selected the other emotions with ease. At first his interaction with the dolls started out slow, but after several illustrations he understood how to orient the dolls. The social form of interaction with ASQ was also successful with this family. He was given two dolls and his parents were given the other two. He was great at attending to the person who had the matching doll and excitedly gestured and directed the appropriate parent to match the doll selection to advance to the next clip.

While visiting the lab that day, he interacted with ‘Swamped’ (Johnson 99). His motor coordination limited the number of chicken gestures he could direct, but nevertheless, he seemed happily engaged.

At times he appeared over-aroused by the music, color, and animations on the screen and jumped up and down and shrieked without any correlated affect. Later, his parents asked him what he liked best during his visit to the Media Lab, and to both our surprise, he said he preferred ASQ; I thought he would have picked 'Swamped' by the way he enthusiastically gestured when he played with the plush toy chicken.

These few pre-pilot tests were conducted while the system was in development. Their interaction pointed out key parts of the system. The dolls and animated clip segments engaged the children. As suspected, the orientation of the doll to the system was difficult for the children to understand at first, but after a few demonstrations they understood what to do. Picking the surprise emotional expression from the total number of clips was the most difficult for these children.

What was most surprising was how ASQ naturally included a play mode for social interaction. While not part of the initial design, this serendipitous finding added a new multi-person dimension to the way the system interaction could take place. Participation by the parents and their comments were helpful and some of their suggestions were included in the application design.

## *Method*

A pilot study was conducted to determine whether an application run on a computer system is engaging to children with autism and whether this type of an application may potentially help children learn emotion recognition. The hope is that through using the system these children will learn to generalize the recognition of emotion in self and in others; however, only observations of their interaction with the application were gathered. The pilot study was approved by the Committee on The Use of Humans as Experimental Subjects (COUHES) at MIT and by the Internal Review Board (IRB) at Miami Children's Hospital. The IRB proposes a longer study, for which this serves as the initial pilot test (see appendix).

### *Subjects*

Six children diagnosed with PDD or within the autistic spectrum served as subjects. Subjects were recruited as volunteers through advertisements posted at the Dan Marino Child NETT Center.

Standardized assessment tools, as well as direct observation by trained psychologists and neurologists, were used to identify children whose primary deficits are related to social-emotional responding and appropriate affect.

To participate in the pilot study, children needed to come to the center to play with ASQ for at least three days for up to one-hour sessions. Afternoon time slots were the most convenient time for families to schedule a session, which constrained the number of participating families during the two-week time frame of this pilot. Fortunately, those families that participated represented a broad range of children along the PDD spectrum. At the beginning, eight children were part of the study, however only six continued for the three days and are included in the observational findings.

Two children who planned to be part of the three-day pilot dropped out after the first day. One child required a behavioral practitioner in the room during the session due to non-compliance. After his first visit, his mother preferred he spend his time in behavioral therapy instead. The second child selected the correct doll accurately on each clip during his first visit and his mother thought that interacting with the application was not the best use of his time and she withdrew him.

### Data Analysis

#### *Response Measures*

To objectively measure the effectiveness and efficiency of the training procedures, response measures were collected based on the child's interaction. Measures of response rate were used to track the number of training trials and response accuracy was used as an index of how effective the training procedures were for teaching the children to match the targeted emotion during a given clip by tracking changes in the proportion of correct responses. These measures were described earlier in the statistics section, which contain the formulas for the different measures: rate, accuracy, and fluency.

#### *Test Sessions*

Subjects were each tested on three different day visits. On each visit they interacted with the system for multiple sessions. Each session was approximately ten minutes long with the exact length determined by the child's interaction and enthusiasm during their session or application problems. Each session was followed by a five-minute 'play' break. Within each session the child watched clips displaying four basic emotions. Each clip represent a trial for that session, several trials represent a session, and several sessions represent the visit for one day.

*Transduction*

The software application collected data as part of the general system function. Video footage was also captured on each child's interaction. The application had difficulties detecting the different ways children touched the dolls and some of the erroneous data was not recorded by the system. Therefore, the transduction for this pilot was from the practitioner viewing the video footage captured during the child's interaction. From the video, observational data was collected and tabulated as done in manual trial intervention sessions. The data collected included the number of system and human prompts, the number of correct and incorrect doll match selections, and the session time for the three days. Individual child session results are presented in the appendix.

### Dan Marino Test


Figure 29: Child Testing Profile 1


Figure 30: Child Testing Profile 2

Nineteen different children with deficits along the pervasive development disorder (PDD) spectrum from the Dan Marino Center were exposed to ASQ. Throughout the day families stopped by to visit and spent up to twenty minutes playing with the system. For the Miami study, six of these nineteen children were observed over three days and multiple sessions were played during each visit as stated earlier.

### General Observations

The overall reaction to the environment was positive; maybe due to its novelty. The children appeared to be drawn to the system because of the toys. Initially, they appeared to be engaged and enthused by the soft plush dolls, the colorful screen interface, and the video clips; the child interface created a playful environment for the children as compared to their customary visit to behavioral therapy.

The screen interface for the child received positive appraisal by the staff and the children's parents; many families requested a copy to take home with them. The video animation clips absorbed the attention of all but four of the nineteen children, whose cases are discussed next.

One six-year-old child treated for behavioral compliance exhibited more interest in devastating the room than in interacting with the system. In contrast, another boy who was five years old (Subject 2), known to be mild mannered, cried and wanted to leave the room on his second and third day visit. Another child, seven years old, thought to be technologically savvy by his parents, displayed minimal interest in the video clips. He inspected the dolls, but he displayed more interest in a toy phone instead of in the dolls and video clips. The youngest child to play with the system was a 19-month-old boy who was recently diagnosed with autism. He did not pay much attention to the dolls, video clips, or other objects in the room. His parents tried to assist him in touching the dolls or looking at the screen, nevertheless his eye gaze never focused on any of the application elements.

Young children showed interest in the system, yet they were unable to master the interface without the help of their parents for the first session. This was expected. In fact, David Lubin thought it would take up to seven days to teach all children to use the dolls. Surprisingly, the children were able to learn to doll interaction the first day. Two low functioning autistic children, between the ages of 2 and 3, engaged in the video clips, yet displayed little interest in the doll interface without direct assistance. One boy, age 4, demonstrated an understanding of the interaction, although he struggled to match the appropriate doll. Another boy who was five years old appeared to understand the interaction, yet had such a soft touch that he required assistance in touching the doll so that the system could detect what was selected.

A three-year-old child, with Spanish as the native tongue, appeared very interested in the application regardless of the language difference. He and his family were visiting from Chili and together they played with ASQ for one hour. Two visiting neurologists from Argentina sat in on the child session.

Earlier they expressed their opinion about the interface. They were certain that the screen interface had too many images (referring to the icon, word, and dwarf's face) and cluttered the screen. They didn't believe that a child could be engaged in the application because of the noise on the screen. Also, they thought that the dolls were not a good way for the child to select the correct emotion. After they saw this boy interact with the application, both the physicians and the boy's parents were surprised at this boy's quick adaptation to the doll interface and his ability to recognize the emotions, despite the screen interface. His parents also requested to take a copy of the application home with them.

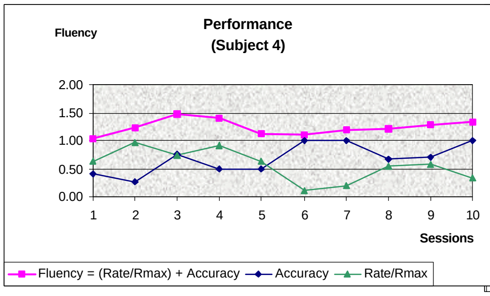
As suspected, higher functioning and older children, age 6-9, demonstrated ease with understanding the doll interaction, exhibited pleasure with the gaming aspect, and needed few of the helpful screen cues to make their selection. They were able to match emotional expressions displayed on their screen by selecting the correct doll after only a few sessions. One boy mimicked the displayed emotions on the screen (Subject 3). His mother reported that he was able to recognize other people's emotional expressions at home also.

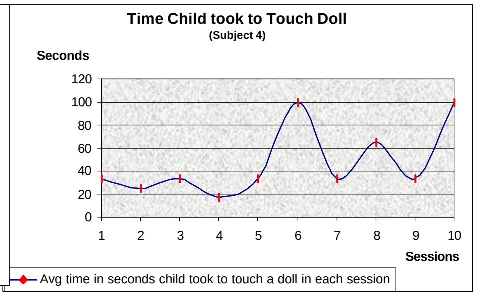
### *Dan Marino Results*

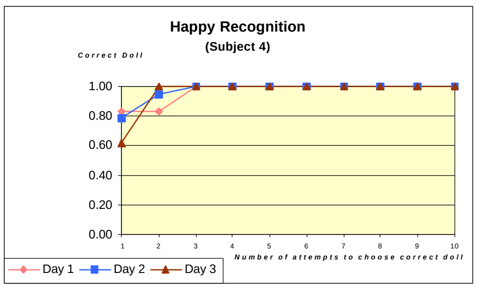
Interesting observations came from the analysis of the children who participated in the pilot provided. Presented is a sample set of graphs for one child. The individual graphs and session results for each child can be found in the appendix. Formulas used to calculate the different measures are provided in the statistics gathering section. The graphs are briefly explained. Following is a general description of each child. Lastly, a summary set of graphs for the group of children concludes this section.

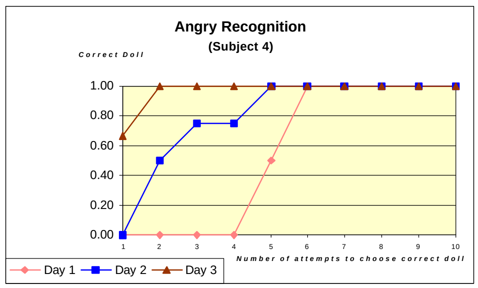
*Child Observations*

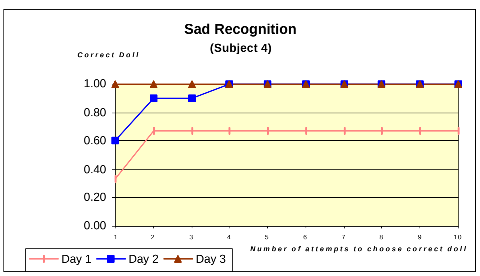
| **Subject 4** | **Table of Clips Presented for each Day** | | | | | |
|---|---|---|---|---|---|---|
| Days | Sessions | Total Trials | Happy (ΣSessions = Day) | Angry (ΣSessions = Day) | Sad (ΣSessions = Day) | Surprised (ΣSessions = Day) |
| Day 1 | 2 | 13 | 4+2=6 | 2+0=2 | 2+1=3 | 0+2=2 |
| Day 2 | 6 | 38 | 5+7+1+1+2+3=19 | 1+1+1+0+0+1=4 | 0+3+1+0+2+4=10 | 0+2+0+1+2=5 |
| Day 3 | 2 | 21 | 8+5=13 | 3+0=3 | 4+0=4 | 1+0=1 |
| Totals | 10 | 72 | 17+14+1+2+3=38 | 6+1+1+0+0+1=9 | 6+4+1+2+4=17 | 1+4+0+1+2=8 |

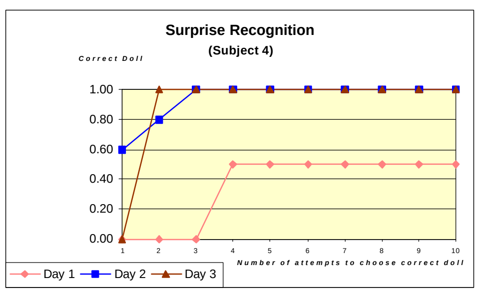


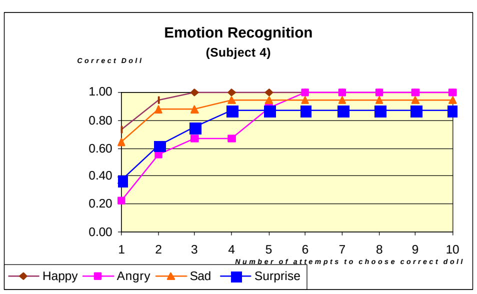




These graphs show a sample set of responses with an explanation of the graph illustrations for one child.

The first table presents the number of clips (trials) for each child. The table breaks the data into days, sessions per day, total for each day, and the breakdown of displayed emotions by session for a day. The table data is useful for understanding the relevance of the data shown in the graphs because sessions were different for each child based on the number of trials and randomly generated emotions presented.

The first *Performance* graph illustrates the success for the child's matching the four emotions based on fluency, accuracy, and rate/Rmax measures. Fluency is the uppermost line in the graph and represents the combined accuracy and rate of response for the child matching the correct doll across all emotions. Rmax is the minimum time a child could take to select the correct doll. Optimization for each measure is when the lower two lines approach 1, or the upper line approaches 2 on the y-axis. *Rate*, for the second graph, shows the average time that a child took to select a doll. To represent that number in seconds, the inverse (1/rate) was plotted for each session.

The other graphs represent the child's emotion recognition using a receiver operator characteristic – used for detecting signal hits, false hits, decoys or misses in communication and used for computer pattern matching – to convey the accuracy trend of the child 'hitting' the correct doll. These represent the child's degree of accuracy of selecting the matching emotion over the three days. For example, when Subject 4 was shown the sad clips on day 1, he picked the sad doll on the first attempt only 33% of the time. On his second attempt Subject 4 correctly picked the sad doll almost 70% of the time the first day, and around 90% of the time the second day, and 100% of the time the third day. A flat, leveled off curve indicates that the attempts to pick a new doll were not getting any more accurate. For instance, the first day, on some of the sad clips the child selected all the other dolls except the sad doll after his second attempt. When a curve lies 'above' another on this graph, the one that lies above it has a better performance.

The recognition graphs show the child's improvement over the three days, especially for angry and sad. For happy, one of the clips was not responded to on the third day, which is indicated by the flat slope at the second attempt to choose the doll. Overall, however, Subject 4 showed improvement for matching all four emotions. The *Emotion Recognition* graph combines all three days, and shows that the child recognized happy best, followed by sad, followed by surprise, and then angry.

*Child Profiles*

Subject 1 was a very gregarious and active boy. At the time of the pilot he was four years old. He visited the Dan Marino Center for behavioral therapy based on his mild to moderate autism. He had good social skills with deficits in language and social communication. He also had problems with repetitive behavior and attention span. He learned the interface of ASQ very quickly and understood that to interact with the system he had to touch a doll. Difficulties he had with the system were behavioral related; he would verbally repeat many of the prompts, but not associate the prompt with selecting a doll. The video clips engaged him, yet clips he had seen more than once would loose his interest. Sad and surprise were the most difficult. Also, he would get attached to a particular emotion and not easily transition to matching the correct emotion.

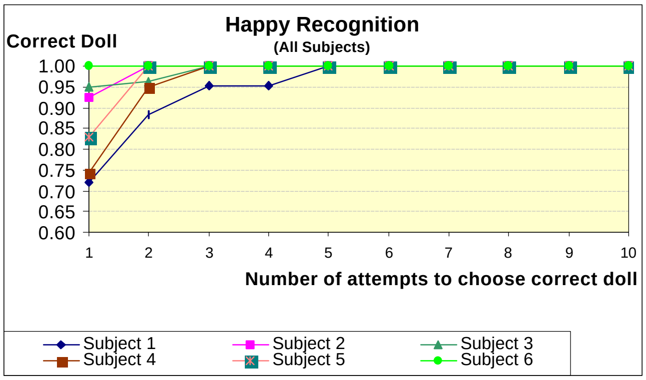
Subject 2 was diagnosed with the most severe case of autism. He was five years old at the time of the pilot. He was diagnosed with development skill and social play deficits and had developmental delays with fine motor perceptual problems, which might explain his difficulty with the doll interface. He came to Dan Marino for behavioral and language therapy. According to his parents their son's interest in televisions or computers was rare and they were curious about how he might react to this type of application. The first day he came with his mother. He calmly played with the application, however he did need his mother's help with touching the dolls, and appeared to enjoy the interaction with and video clips without being bothered by the application being run from a computer. This surprised his mother. He was described as being mild tempered and compliant, yet with ASQ he showed distress on the second and third day visit. During his second visit he started to play with the application without a problem, but after five minutes started to cry. His father thought he might be resisting 'work,' referring to behavioral therapy. His visit the last and third day started with heavy sobs and expressive offense to the environment; he lifted his shirt up and according to his parents this behavior communicates his dislike for something. It was never clear what caused his distress because we removed the dolls and turned the computer off, yet his behavior never changed. To try to understand what was troubling him, as well as to calm him, the dolls and then the computer were removed from his view, but there was no apparent change in his behavior. A child behavior specialist suggested that something might have happened to him after his visit on the first day that created a negative association, which may have caused him to have nightmares that night, possibly explaining the reason he reacted the way he did.

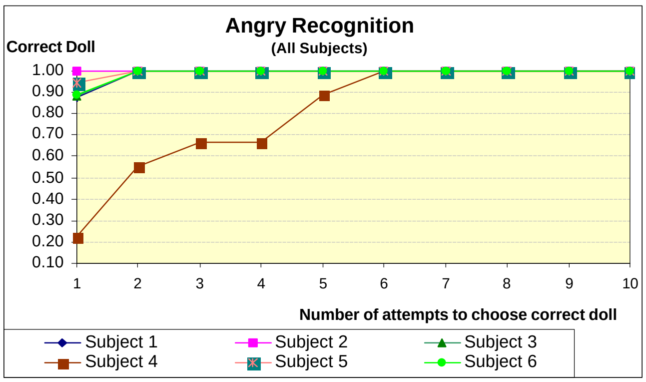
Subject 3 had a lot of personality. He was seven years old at the time of the pilot. He was diagnosed as a high-functioning autistic boy with echolia -- a tendency to repeat things with exact wording and intonation -- and attention deficit disorder. He has poor social interaction, gaze monitoring and social affect and is treated for behavior at the Dan Marino Center. He learned the interaction of the system quickly. He appeared to be intellectually bright and from the observations and could select emotions in the video clips with short latency. Clips that had been shown previously lost his attention. Overall, his performance was high and he rarely needed prompts or assistance to select the correct doll.

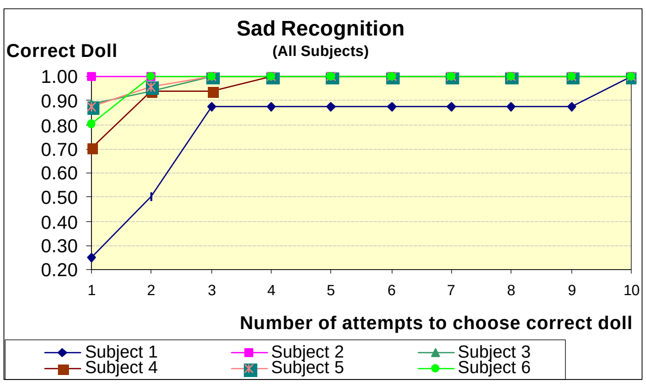
Subject 4 was the youngest subject. He was three and a half years old. He had little social affective communication, was non-verbal and had moderate autism. His play was the most promising and he was thought to benefit most from ASQ. The graphs illustrate his ability to match sad and happy within four attempts. The emotions of surprise and angry were more difficult for him to match. With angry, he had only 60% accuracy on average after picking up as many as four dolls. It is expected that a child would be close to 100 % accuracy by the fourth attempt if they tried to pick each doll once before correctly matching the appropriate doll.

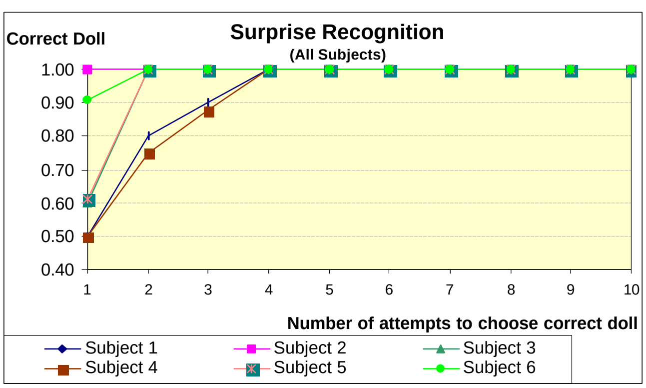
Subject 5 was diagnosed with Asperger syndrome and treated for language therapy at the Dan Marino Center. He was six years old at the time of the pilot. He learned the interaction with the dolls quickly and was social while he interacted with the system. He appeared to know most of the emotion expressions in the clips. For those that caused him confusion he was able to guess on the second attempt because of the guide's verbal prompts. More often he selected a doll before the guide or practitioner prompted him.

Subject 6 was the oldest child. He turned nine on his third day visit. He was diagnosed with autism at the age of seven. At that time he had social difficulties and deficits in language, social communication, and repetitive behavior. During the ASQ interaction, he was able to understand how to choose the matching dolls. His emotional understanding was high for three of the emotions except surprise. He enjoyed the video clips and suggested content he wanted included in the future. He had a sense of humor while he interacted with the clips and the dolls. If a delay or incorrect prompt occurred in the system, he would say, "he's just kidding," referring to the guide.




Another representation of emotion recognition is shown in the next graph. A child's ability to recognize the emotion category is shown by the curve representing that emotion. As stated with the last set of individual child graphs, a receiver operator characteristic was used to show the children's progression of selecting a particular emotion. These convey the accuracy trend of the children's matching an emotion over multiple attempts at picking dolls. As mentioned earlier, the application design requires the child to select the correct doll based on the emotion in the clip before another clip plays; however, they may attempt to select a wrong doll many times before they touch the right one. For example, when a sad clip was shown, Subject 1 had picked the sad doll only 25% of the time on his first attempt, but had picked it 50% of the time by his second attempt. By his third try, he picked the sad doll 87% of the time. When the curve levels off, it indicates that the attempts were not getting any more accurate: the child picked any doll but the correct one. When a curve lies 'above' another on this graph, the one that lies above has a better performance.

For Subject 4, the graph shows that angry and surprised were difficult emotions to match. All children eventually reached 100% indicating the child correctly picked the right doll, which was necessary before the system could advance to another clip. Because there are four dolls, three different attempts can be made at selecting and matching the emotion; by process of elimination. Not selecting the correct doll by the fourth attempt may indicate that either the child did not understand that emotion, did not interact with the application appropriately, or may have been obsessed by a prior doll choice and not been able to transition by picking a different doll.

The first graph shows the children's recognition accuracy of the happy emotion by the first attempt, second, and so fourth with most of the children getting it perfect by the third attempt. Angry was the most easily recognized by all children except for Subject 4. Sad and surprise appear to have been more difficult emotions for these children. Note that the vertical scales on the four graphs are different to help the reader view the different children's individual lines.

The higher functioning and older children (Subject 3, 5, and 6) were able to match all emotions by the second attempt, except for sad. The consistency in the correct selection on the second try is attributable to the guide prompt telling them to match the 'emotion.' Verbal children were able to use the guide prompt by either waiting for the first prompt or incorrectly selecting a doll after the first try. More often, if these children were confident in their recognition of the emotion, they would select a doll before the guide's first prompt. This can be seen in the first graph for happy. Most of the older children accurately picked happy on the first attempt and accurately picked angry by the second attempt.

# Chapter 5.
# CONCLUSION

## *Discussion*

Overall child interaction indicates that ASQ was successful at being engaging based on comments from the staff at Dan Marino as well as parent feedback and observations by the author and child study practitioner. Furthermore, the statistical findings suggest that emotion matching occurred in most child cases, with some showing some apparent learning of difficult emotional expressions. In some cases there was measurable day-to-day improvement of emotion matching with the system.

One mother said that her son said, "I'm happy" with a smile on his face at the dinner table with the family. She doesn't remember him expressing himself like that before. Also, she said that when he was picked up from school he asked if he could go play with the dwarves. Roberto Tuchman commented on the benefit of this application for older children. Their correctly matching the emotion may positively affect them because they experience what it is like to be good at something, which is a positive aspect of this system. Generalization and spontaneous use of knowledge are the two most challenging educational goals for autistic children. The observations above are especially exciting given that they demonstrate these aspects.

The thesis question was “can we observe benefits of an automated system for engaging autistic children while trying to teach them emotion recognition?” The answer to this question, from general observations of child engagement, is yes. Most children showed interest in the screen interface design displaying multimedia elements. Nineteen children interacting with ASQ at least once were engaged in the application and seemingly enjoyed their interaction. The doll interface required an initial training and often needed human assistance because of the doll touch switch not detecting heterogeneous touching even after several different implementations of doll-touching methods. Once the child learned the method they were able to interact with the application.

The answer to the question of actual emotion recognition learning 'appears' to be salient. The anecdote above demonstrates that for at least one child it did. The individual child results graph the tendency toward emotion recognition when using the system. The graphs show that at least one child improved after using the system over three days. Similarly, the other children showed improvement as well, however all but one (Subject 2 who was upset by the interaction) were able to match many of the emotions on the first day. Clearly, the three-year-old child (Subject 4) results show that this child was able to recognize more samples of an emotion with each additional session of interaction. This suggests the target age for a follow-up study, which includes pre and post testing, could benefit children around this age and deficit level. Some who had a prior knowledge of emotions demonstrated learning of surprise and one showed generalization as reported by the mother. It may be helpful in scaffolding those with little recognition through the matching of word, dwarf, and icon pictures to video and later fading those cue prompts over time to just the video.

By describing ASQ as an application to test the demonstrable potential for an automated emotion recognition system for children with autism the results offer the preliminary findings for recommending further work. The evaluation was not designed to show conclusive evidence that ASQ taught emotion recognition. A study where base line tests before and after using the system over a longer duration would present more conclusive results to validate the initial pilot results. The purpose of the work was to see if this technology was interesting and proposed opportunities of future exploration by professionals in the area of autism, which it does.

## Problems and Challenges

The pilot revealed ways the ASQ design could be modified in future work. The work has shown that the application can be modified in two specific ways: input device and system data gathering.

### Doll Interface

The application design may benefit by incorporating a different input interface for the children to interact with the clip segments, or at least for our audience. They need a robust touch detection system. It was not apparent that the wireless free moving toy interface was as important a feature as originally thought. This could be because the wireless detection system for the dolls was not robust enough because some attempts by the child's touching method went undetected by the system. The children touched the doll in different ways: some touched it ever so lightly and sometimes only on the feet, more often they pressed hard on the doll or hit it, and then others just leaned on it.

The touch switch was a deliberate choice as was the infrared wireless communication. The thought was that these features were important for detecting child intention; doll intention was to be detected by the line of position between the doll and the system receiver, then further constrained by the location of touch to the doll torso.

Detection of unintended touches by the child playing with a doll while watching the clip creates another problem with this type interface. The original idea was to provide an engaging way for the child to interact with the system. The main challenge was how to control the system's recognition of doll selection. The system should detect any doll touch and interpret that touch to mean something by the system if used for behavior analysis. Doll play needs to be recognized so that the child be behaviorally modified by the system. Dolls touched during the interaction, as well as during the clip playing on the screen, needs to be noticed by the system in order to provide a consistent behavior response to help the child understand that the doll is the input device used to select the doll. In other words, if any doll is touched at any time, the system response needs to be controlled so that the child understands that the system interprets the touch to be a selected choice, particularly for the autistic child that already has difficulty communicating their intentions with abstract objects. Further testing of different input detection systems in the dolls needs to be explored.

In fact, it may be better if the interface objects are not moveable by the child and fixed or tethered to the system. Yet, a flexible and interchangeable interface is recommended to keep the heterogeneity of the application design. This poses a challenge of human communication interface (HCI) design. How can the interface to the system be flexible with both number and type of input devices and still be clearly defined to the child? The dolls added mechanism for alternative input and feedback. Possibly the most valuable of these are the prospects for supporting generalization. They offered a novel way for the different choices to vary for each subject; dolls could be included or omitted as needed. Additionally, the arrangement of the child interface options could be changed. These features allowed for different looking systems to be implemented within a child case study.

### *Practitioner Interface*

The idea to create a flexible application environment for the practitioner made multiple configuration set-ups for the child possible, yet in the pilot few of these settings were actually utilized. Including this interface delayed the session start time because of the time for each set-up; this allows the child to become distracted between sessions.

The configuration for the child session included the same time between cues, six seconds, and the same order of cues, one through six, with a replay at the sixth cue. Most children didn't go beyond the fourth cue because they either selected the correct doll or were prompted by the practitioner or mother to choose the correct doll before the fifth and sixth cue executed.

The configuration for option interfaces could have been a simple single cue set-up for the session and then changed for each following session as opposed to the possible six different interface cue selections. The set up interface options were the same for each child's first session, and then the cues appearing on the screen were faded in future sessions by reducing the number of cue prompts visible on the child screen, based on the child's prior performance. For longer child testing studies, the opportunity to use the flexibility of the interface options may help in the interaction, though for this pilot they were not necessary.

### *Statistics*

Analysis in this thesis is based on information viewed from videotapes. The analysis is described in the data analysis section of chapter 4. As mentioned earlier, the original method of gathering data by the system changed from a simplistic overview of the child data to a more detailed collection of data. The new method collected child interaction data and it was written to a comma separated value file that could be viewed from spreadsheet applications. In analyzing the data, at first it was not correctly timed with the system clock, and second the values were not associated to the session identification or the clip identification presented in the interaction. After debugging, the associations were fixed, yet the presentation of the data was clumsy and not easily decodable.

To account for the multiple doll selections possible the data in the fields had expanding columns that grew by the number of dolls selected or by the different cue in the interface for that selection. Because the columns expanded differently for each trial, one clip, an easier method of reviewing the total data needs to be addressed in the next version. The varying columns did not allow for the data to be easily referenced or calculated. Each row required close attention and important information manually re-coded into another data sheet. Sometimes less is more. The data may be best summarized on a per session bases with the accuracy, rate and latency calculated and the fluency derived from those figures and presented, as proposed initially in the statistics section.

To calculate rate and accuracy, and then fluency, the time codes for each interaction are required. To calculate the rate of the child's interaction the system must take the summation of the following: (duration of the clip )+ (the duration of the time delay between the clip and all possible prompts before the child selects the correct doll) + (the duration for the guide prompt) + (the duration of the guide's positive response) + (the duration of the reinforcement clip.) All these values need to be handled by the system because each of the above values vary for each variable. The system could easily keep the running total and store the figures in a table until the session is complete and then calculate the rate based on the responses from the child. However, because doll selections were not always accurately recognized by the system, the timing was not accurately determined in an automatic way, and the main statistics were gathered manually by re-viewing the video sessions recorded.

### *Intentionality*

An important feature of the interface is that it should make a direct association to the child's selected intention. The system needs to respond within a rate of human response based on the selection detected by the child. With the doll interface this was not always achieved. Several options for fixing this are possible. Some recommended that big buttons replace each of the dolls, and that the buttons be tethered to the system. To label the button, a representation of the emotional expression, like the Mayer-Johnson icon (PICS), or a picture of someone displaying that emotion, or the word, could be placed in front of the button. Each of these could be tested individually to test for equivalence matching (Sidman, M, Tailby, W. 1982).

Equivalence matching is testing the subjects' performance under conditional-discrimination procedures that define conditional relations between stimuli. For example, If A, then B; if A2 then B2, may be used to help generate matching to sample under different pictorial conditions. In this example, A could be a PICS and A2 could be a picture of a person displaying that same emotion shown in the icon representation, and later extendable to the word representation expressing that emotion. With these pictures the different representations could be paired and used for a separate match testing to identify generalization of the different representations.

Additionally, I would design the media elements to be divided into database tables that are cued individually based on emotion and then on subtlety of emotion. The emotion clips should be analyzed and chosen based on a preliminary evaluation by normally developed adults and children. This is recommended as a preliminary development to the application to ensure that the content in the clips evaluated between a set of viewers validates the content to the emotion and the level of complexity in the emotion category. The range of emotion clips should extend beyond animation and child programming for more advanced child performance. This would include clips that are captured from documentary, game shows, and popular television programming for child, adolescent and adult programming. These would be labeled more complex expression of emotion but be important to the generalization of the clip viewed by a heterogeneous audience.

# Chapter 6.
# FUTURE WORK

## *Version 2.0*

An upgraded version of the current software might benefit from an alternative input device as suggested in the conclusion, with the importance placed on its detection and system response timing. The upgraded version might include a touch screen, big buttons, or a special keyboard. A touch screen would allow children to match the emotion by touching one of the featured emotions in the application. These could be placed in the same region as the guide, right panel, if they are different from the interface cues. Otherwise, the interface cues could be used and then positioned in their present location. Alternatively, big buttons with labels either adhered to the button or mounted in a removable holder would provide an easy way for the child to select the matching emotion. Specialty keyboards are available for children with disabilities and could be customized for the application. The ease with which children could select the correct match and the reliability of the input device's detection must be kept in mind when choosing a mode for the child to communication with the system.

The interface layout was positively reviewed. The only modification might be to simplify the method by which the subtlety of emotion is accessed by the application. The database tables could be structured by emotion type and then by complexity of emotion. From the interface options, the clip type could still be accessed the same way, except the backend would treat retrieval of the clips differently. More diverse source clips in the application would increase the level of difficulty for each emotion. More clips with people in other social situations might help the children generalize emotions.

The clips that were deselected in the configuration appeared in the presentation, although rare nevertheless randomly were included in the pool of selected clips. The software requires more debugging for its future release to create a robust way for the children to interact with the application in a heterogeneous way. Including only two emotions during the first session reduces the stimulation and allows the practitioner and child to focus on learning the emotions for one set and then to add more emotions as the child successfully matches the first pair. Additionally, the success rate will be higher and the positive reinforcement greater for each child by constraining the number of presented emotions in early sessions.

### *Other ideas*

While the application was created, several interesting ideas were suggested and deserve recognition. Adapting the software to the initial design of a play environment for children to initiate the interaction through selecting a doll to display clips for an emotion could provide the child freedom to explore emotions based on their viewing interest. Another idea that was deferred to future work includes emotions being represented by more than one doll, simultaneously. In this idea, dolls would respond to the emotions displayed in the clip. Multiple dolls react to the character's emotional displays on the screen; a clip with two different emotions activates two different dolls and their vocal and light-up features come on when that emotion occurs on the screen. Through this type of interaction, a meta-level of watching the application occurs. A child could see the dolls watch and react to the screen.

Providing a safe place for autistic children to experience situations in a virtual environment extends this work. The Interactive Characters group in the Media Lab develops systems where the user can interact with the application and view that interaction on a big screen. A system developed to present special situations choreographed for autistic children to teach behavioral methods of socially interacting could provide a safe place for the child to explore. Vision recognition systems detect the gesture and facial expression of the child and display that in the viewing screen. Children could virtually react to these situations and see that interaction and be instructed on social behavior skills.

Children solving 'what if' scenarios may help them decide what the next action in a sequence could be. Sequencing is difficult for PDD children. They might be helped with an automated system that includes rich media elements that encourages them to choose between different outcomes to learn appropriate behavior. Laurette designs such software for autistic children; however, it lacks video and entertaining media. Knowledge Adventure and Broderbund are two companies that develop educational software that use animation and bold color to engage children. An autistic child could be educated and entertained if Laurette's approach to teaching was combined with the aesthetic quality of software like JumpStart by Knowledge Adventure.

Embedded technologies in objects offer diverse opportunities. Moveable parts that represent facial expressions could be manipulated to create an expression. A child makes a face using the moving objects when prompted to show happy. Moving point ends of a line upward to create a semicircle forms a smiling face. The system detects if the expression matches the prompt. If incorrect, the system could draw the expression for the child and repeat the prompt.

Many pedagogical ways of teaching affect are possible with technology. Automated stimulus to get a response with consequential feedback is a simplistic model of behavior analysis. Technology offers many different ways to provide this method of instruction.

We all exist on the spectrum of autistic behavior when in certain situations we feel inhibited and that affects our social interaction. All people can benefit from learning systems that enrich emotional understanding and potentially affects our social quotient.

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## APPENDICES

## *ASQ Team*

### *The Advisors*

*Andy Lippman*

Andrew Lippman has spent the past 27 years at MIT in capacities ranging from undergraduate to associate professor. He is currently Associate Director of the Media Laboratory and lecturer. Lippman is co-principal practitioner of the Television of Tomorrow research program, and principal practitioner of the Media Bank Program. He has participated in congressional and international meetings on communications, American competitiveness and the future of television. In the past, he directed the Architecture Machine Group and gained some notoriety for the development of an early interactive videodisc system, the Movie-Map, which enabled viewers to literally pre-experience a trip to Aspen, Colorado via a video personal computer. Later work included the Movie-Manual an electronic book written individually for each reader as it was being read, and research programs in teleconferencing, news information, and personalized publishing. He has published widely and made over one hundred presentations, for technical and lay audiences, on interactivity, high definition television, personal communications, and making the information highway entertaining.

*Roz Picard*

Rosalind W. Picard earned a Bachelors in Electrical Engineering with highest honors from the Georgia Institute of Technology in 1984, and was named a National Science Foundation Graduate Fellow. She worked as a Member of the Technical Staff at AT&T Bell Laboratories from 1984-1987, where she designed VLSI DSP chips and developed new methods of image compression and analysis. Picard earned the Masters and Subject 6torate, both in Electrical Engineering and Computer Science, from the Massachusetts Institute of Technology (MIT) in 1986 and 1991, respectively. In 1991 she joined the MIT Media Laboratory as an Assistant Professor, and in 1992 was appointed to the NEC Development Chair in Computers and Communications. She was promoted to Associate Professor in 1995, and awarded tenure at MIT in 1998. The author of over 60 peer-reviewed scientific publications in pattern recognition, multidimensional signal modeling, and computer vision, Picard is known internationally for pioneering research into digital libraries and content-based video retrieval. She is co-recipient with Tom Minka of a "best paper" prize (1998) from the Pattern Recognition Society for their work on interactive machine learning with multiple models. Dr. Picard guest edited the IEEE Transactions on Pattern Analysis and Machine Intelligence special issue on Digital Libraries: Representation and Retrieval, and edited the proceedings of the first IEEE Workshop on Content-Based Access of Image and Video Libraries, for which she served as Chair. She presently serves as an Associate Editor of IEEE Trans. on Pattern Analysis and Machine Intelligence, as well as on several scientific program committees and review boards. Her recent book, Affective Computing, (MIT Press, 1997) lays the groundwork for a new area of research: giving machines the skills of emotional intelligence.

### *The Readers*

*Roberto Tuchman*

Dr. Tuchman is the Executive Medical Director of the Miami Children's Hospital Dan Marino Center. He earned his BA from Hampshire College and his M.D. from the New York University School of Medicine. Dr. Tuchman completed an internship and residency at Boston City Hospital. He completed a fellowship in pediatric neurology, clinical neurophysiology and epilepsy at Albert Einstein College of Medicine and Montefiore Medical Center in New York. Dr. Tuchman is certified by the American Board of Pediatrics and the American Board of Psychiatry and Neurology with Special Qualification in Child Neurology. He has held Assistant Professorships at Columbia University (Babies and Children's Hospital) and the Albert Einstein College of Medicine. He is a

Clinical Assistant Professor of Neurology at the University of Miami School of Medicine and is Clinical Associate Professor of Pediatrics at Nova Southeastern University. Dr. Tuchman was recently honored as a Distinguished Professor in Communication Sciences and Disorders at Nova Southeastern University. He and has written and co-authored over 40 articles and book chapters and has lectured nationally and internationally on the topic of developmental disorders.

*Ted Selker*

Dr. Ted Selker is an IBM Fellow and Stanford University Consulting Professor. He runs the User Systems Ergonomics Research Laboratory at IBM. Ted works on cognitive, graphical and physical interface. Ted is known for the design of the TrackPoint in-keyboard pointing device with performance advantages derived from a special behavioral/motor-match algorithm, for creating the "COACH" adaptive agent that improves user performance, and for the design of a notebook computer that doubles as an LCD projector. IBM is shipping new USER technology this year in Thinkpads, mice, keyboards and agent intermediaries that improve navigation. Some of the research labs he worked in before joining IBM in 1985, include Xerox PARC, Atari Research Labs, and Stanford University. Ted is also the father of a young boy with autism.

*David Lubin*

Dr. David Lubin graduated with a Ph.D. in psychology from Auburn University. Major areas of study included behavior analytical training technology and clinical neuropsychology. After graduating from Auburn, he took a position with McDonnell Douglas space systems to lead a team of engineers on the design of user interface technology and robotic training simulators. He returned to South Florida in 1991 to take the position as clinical director of an agency that served children with autism and severe behavioral disorders. Since that time, he has established a private practice and has become an in-house associate of the Miami Children's Hospital's Dan Marino Center.

### The Developers

*Katharine Blocher*

Kathi is author of this thesis and graduate candidate for Media Arts and Sciences, June 1999. She created the research concept, designed the system, selected and managed ASQ team, helped with software interface components, supervised software development, chose video footage content, designed hardware construction for dolls, constructed dolls, conducted interviews with peer researchers, recruited professionals for internal system evaluation, and administered pilot and subject study.

*Steven Shapiro*

Steven is an undergraduate candidate in electrical engineering and computer science, June 1999. Steven was the main programmer for the project. He developed the front-end, including all interfaces for the system screen, back-end, bridge to database and serial communication protocol.

*Dave Mcloda*

David is an undergraduate candidate in electrical engineering and computer science, June 1999. His contribution to the project was coding the hardware for the wireless two-way communication protocol and doll interaction.

*Richard Li*

Richard is an undergraduate candidate in computer science, June 2000. His work on the project focused on the database, Microsoft Access, and Java JDBC to ODBC query for SQL. He also helped with the serial communication coding.

*Luke Phelan*

Luke is a undergraduate freshman. He digitized and edited the video clip footage.

*Frank Lieu*

Frank is an undergraduate candidate in electrical engineering and computer science, June 2000. Frank helped with the hardware construction of the dolls.

## Video Clips

### Sources

| Video Source | Title | Source Type |
|---|---|---|
| MGM/UA Home Video | Pee-Wee's Playhouse, Vol.15, 1987 | Child programming |
| MGM/UA Home Video | Pee-Wee's Playhouse, Vol.10, 1990 | Child programming |
| Walt Disney Home Video | Winnie the Pooh and a Day for Eeyore | G Movie |
| Walt Disney Home Video | Winnie the Pooh and The Blustery Day | G Movie |
| Walt Disney Home Video | Winnie the Pooh and the Honey Tree | G Movie |
| Walt Disney Home Video | Winnie the Pooh and Tigger Too | G Movie |
| Walt Disney Home Video | Cinderella | G Movie |
| Walt Disney Home Video | Snow White and the Seven Dwarfs | G Movie |
| Walt Disney Home Video | Beauty and the Beast | G Movie |
| Walt Disney Home Video | The Little Mermaid | G Movie |
| Walt Disney Home Video | Lady and the Tramp | G Movie |
| Paramount Pictures | Blue's Clues Arts and Crafts | Child programming |
| Paramount Pictures | Blue's Clues Story Time | Child programming |
| Paramount Pictures | Blue's Clues Blue's Birthday | Child programming |
| Baby Songs | Baby Songs Vol.1 | Child programming |
| Baby Songs | Baby Songs Vol.2 | Child programming |
| Baby Songs | Baby Songs Vol.3 | Child programming |
| Baby Songs | Baby Songs Vol.4 | Child programming |
| Walt Disney Home Video | Movie Trailers | Child program advertising |
| Paramount Pictures | Movie Trailers | Child program advertising |

### *Questionnaire*

Please evaluate the following clips:

Low Complexity Criteria

- little background noise
- (multiple characters or distracting objects or movements)
- only one character in scene
- single emotion displayed
- obvious emotion expressed

Medium Complexity Criteria

- some background noise
- (like multiple characters or distracting objects or movements)
- two or three characters in scene
- single emotion displayed
- clear emotion expressed

High Complexity Criteria

- background noise
- (like multiple characters or distracting objects or movements)
- two or more characters in scene
- multiple emotions may be displayed
- complex emotions expressed

| | | | |
|---|---|---|---|
| Clip ID: | Select Emotion :<br>Happy<br>Sad<br>Angry<br>Surprised<br>Other<br>____________ | Indicate Complexity:<br>Low<br>Medium<br>High | Comment: |
| Clip ID: | Select Emotion :<br>Happy<br>Sad<br>Angry<br>Surprised<br>Other<br>____________ | Indicate Complexity:<br>Low<br>Medium<br>High | Comment: |
| Clip ID: | Select Emotion :<br>Happy<br>Sad<br>Angry<br>Surprised<br>Other<br>____________ | Indicate Complexity:<br>Low<br>Medium<br>High | Comment: |
| Clip ID: | Select Emotion :<br>Happy<br>Sad<br>Angry<br>Surprised<br>Other<br>____________ | Indicate Complexity:<br>Low<br>Medium<br>High | Comment: |
| Clip ID: | Select Emotion :<br>Happy<br>Sad<br>Angry<br>Surprised<br>Other<br>____________ | Indicate Complexity:<br>Low<br>Medium<br>High | Comment: |

## *Subject Testing*

## *COUHES*

Application # 2498

MASSACHSETTS INSTITUTE OF TECHNOLGY
Committee on The Use of Humans as Experimental Subjects
Application for Approval to Use Humans as Experimental Subjects

PART I: November 30, 1998
Title of Study: Affective Computing: Affective Social Quest
Principal Practitioner: Dr. Roz Picard (Professor, MIT Media Laboratory)
Department: Vision and Modeling
Room No.: E15-392
Telephone No.: 253-0611
Associated Practitioners: Kathi Blocher (M.S. student, Media Laboratory)
blocher@media.mit.edu (253-4551)
Undergraduate Assistants (rotating)

Collaborating Institutions: Roberto Tuchman M.D., (Director, Dan Marino Center, Miami Children's Hospital)
David Lubin PhD. (Behaviorist, Dan Marino Center, Miami Children's Hospital)

Financial Support: Sponsored by Digital Life Consortium
Anticipated Dates of Research: Start Date 1/99 Estimated Date of Completion 6/99
Amendment Attached.

Purpose of Study:

Researchers have gained substantive knowledge about the nature of autism and its disorder associated with human emotional response. Presently, response patterns can be observed using stimuli and response of appropriate selection. While many of the mechanisms which mediate these responses are not yet understood, we are presently able to acquire response times on the recognition and distinction of emotions with the aid of recording and measuring devices. The purpose of this research is to understand how those with autism can learn to recognize displays of emotion.

However, present analysis systems include as a necessary step the observation of trained psychologists in order for interpretation to occur. The purpose of the described set of studies is to mimic, in a laboratory setting, the kind of human interactions experienced on an everyday basis by individuals. The goal is to help the autistic user learn how to better distinguish affective cues in social situations. The affective computing system, as presently conceptualized, would take easily obtainable visual data and present it in a form to help the user distinguish affect in the individual's environment.

There are several benefits to this study. One is to gain empirical information regarding the measurement of emotional differentiation. This is of interest to the field of psychology in general, as it adds in a unique manner to knowledge about how autistic children recognize displays emotion and possibly express emotion. Additionally, this project is designed to provide information to aid in the development of computer monitoring devices which has far reaching implications for psychology professionals, educators and many other disciplines.

PART II: EXPERIMENTAL PROTOCOL:

Data collection will take place during an experimental study at Dan Marino Center. Subjects may be asked to engage in any of the following tasks:

Film Viewing Task (A task in which subjects are asked to view a series of short film clips, from both commercial and non-commercial sources, which have been shown to reliably display particular basic emotions and selected as "G" rated content.)

Matching Task (A task in which subjects are asked to select a toy that represents the emotion displayed in the film.)

Toys use sensors to communicate with the system. All sensors are completely non-invasive because subjects do not come in contact with the sensors at all since they are embedded in the toys. Employment of this equipment presents no threat of either physical or psychological discomfort to subjects. Investigation in the current experiment includes utilization of sensors specialized for:

· Wireless communication between system and toy
· Toy sensors to detect child touching toy

In addition to these objective measures, subjects may be asked to answer one or more questions to determine subjective labeling of their base understanding, baseline levels, of subjects' present emotional differentiation abilities. Subject's staff at Dan Marino will also be asked to answer a basic inventory of demographic items (including such items as sex, chronological age, developmental age, skill deficits, familiarity with computers, ways of communicating emotion, and other pertinent information based on child's development of emotion, etc.) Subjects may also be asked to complete post-test questions to assess difference from baseline. While subjects are engaged in any of the above tasks, they may be videotaped.

PART III:
Subjects will be recruited through Dan Marino Center. This study will entail the recruitment of 3+ subjects who may have had prior intervention training and are chronologically aged 3-6.

- Girls and minorities will be encouraged to participate.
- Subjects or Parents of subjects will not receive any monetary compensation for their child's participation in this study.
- Subjects will be studied at the Dan Marino Center at Miami Children's Hospital.
- NA. The Clinical Research Center facilities will not be used.
- NA. No drugs will be used.
- NA. No radiation or radioactive materials will be employed.
- NA. No special diets will be used.
- NA. Subjects will not experience any physical pain or stress.
- Questions may be asked (see above).
- No personal interviews will take place with subject, but we may ask the subjects parents and teachers to comment on child's development of emotion (see above.)
- Subjects may incur mild stress, or learning frustration, during their participation as they attempt selection of the appropriate doll to continue the interaction. However, the level of this stress should not exceed anything that they would encounter during an everyday frustrative experience.
- NA. Subjects will not be encouraged to understand deceptive messages.
- NA. No information acquired through this investigation should adversely affect a subject's relationships with other individuals.

All subjects will be assured of their anonymity in the experiment. Consent forms will be immediately separated from answer sheets. After the experiment is completed, each subject's answer sheets will be assigned an ID number, and from that point, they will be referred to only by that number.

PART IV:

The only risks to the subject anticipated are the stress effects described above -- as stated, these are well within the normal range of everyday stressors and should not cause any harm to subjects – and may be minimized by "G " rated movie segments from these experiments including the film stimuli. It is not anticipated that subjects will encounter any privacy risks, and any information regarding subjects' baseline emotional state will be referred to completely anonymously. There is no possibility that anyone could have access to such information.

No ill effects are anticipated. However, all parents of subjects will be given, as part of their debriefing, a Subject 6ument which includes the name and number of the experimenters. If subjects experience any ill effects (either mentally or physically) post-experimentation, they will be instructed to inform the experimental personnel, who will subsequently refer them to medical assistance. Any events of this kind will be immediately reported to the Committee.

Signature of Principal Practitioner:________________________ Date:____________

Print Full Name:___________________________

Signature of Department Head:____________________________ Date:____________

Print Full Name:___________________________

PART V: CONSENT FORMS

**Consent Declaration for Parent**

Researchers from Massachusetts Institute of Technology, in the group of Affective Computing, together with the Dan Marino Center at Miami Children's Hospital are collaborating in a study to help autistic children predict displays of emotion in different settings.

Your child's participation in the following experiment is completely voluntary. Participation in this study requests your child to be available one hour a day, each week day, for up to six weeks. You are free to withdraw this consent at any time, for any reason, and to request that any data collected be destroyed. If at any time you feel uncomfortable, or unsure that you wish your results to be part of the experiment, you may discontinue your child's participation with no repercussions.

By participating in this study your child may acquire new functional socialization skills. Although you will not receive monetary compensation for your child's participation, you will be provided a certificate of your child's participation at the conclusion of their participation. The results of this study may result in a better understanding of new procedures for establishing socialization skills in children who exhibit autistic behavior.

In each session of the study your child will be participating in a series of tasks, which may include any of the following:

- Relaxing while watching a tape recording of emotional displays.
- To continue viewing segments similar to the one viewed, select the appropriate doll that matches that emotion, e.g.; the happy doll for the happy actor.
- Participate in a computer game or learning task that is potentially difficult.

Participation in this study presents minimal risk to your child. Your child may incur mild stress or learning frustration during their participation as they attempt selection of the appropriate doll to continue the interaction. However, the level of this stress should not exceed anything that they would encounter during an everyday frustrating experience.

These tasks are expected to help your child predict displays of emotion in different settings. Any and all responses are normal. Also, you together with them may be asked one or more questions about what you observed. If at any time you are uncomfortable, either physically, or with what your child is being asked to do, you are free to ask that the experiment be suspended.

Any responses that are collected during the experiment will be completely anonymous. From this point forward, your child will be referred to only as the ID number, which appears on the upper right corner of this packet.

If you have any questions, at any point during the experiment, the experimenter will gladly answer them.

Please read the following and sign on the lines below:

"I, the undersigned, have read and understood the explanations of the following research project and voluntarily consent to have my child participate in it. I understand that all responses will remain confidential and that I may terminate participation at any time.

In the unlikely event of physical injury resulting from participation in this research, I understand that medical treatment will be available from the Dan Marino Center, including first aid emergency treatment and follow-up care as needed, and that my insurance carrier may be billed for the cost of such treatment. However, no compensation can be provided for medical care apart from the foregoing. I further understand that making such medical treatment available; or providing it, does not imply that such injury is the Practitioner's fault. I also understand that by my participation in this study I am not waiving any of my legal rights.

I understand that I may also contact the Chairman of the Committee on the Use of Humans of Experimental Subjects, MIT 617-253-6787, if I feel I have been treated unfairly.

Name:_______________________________________________

Date:________________

Location:____________________

Additionally, please read the following paragraph:

Videotapes may be collected of my child's participation. This data will be used for experimental purposes only, and after the data collection is over, they will be permanently stored in a private archive. In the future, they will only be viewed/used for experimental purposes. At any time during or after the experiment you may request that the tapes of your child be destroyed.

Please sign on the lines below to give special permission for the videotaping my child's participation.

Name:_______________________________________________

Date:________________

Location:____________________

## *Dan Marino IRB*

Miami Children's Hospital/Dan Marino Child NETT Center
Massachusetts Institute of Technology

Abstract
Whereas a number of very effective behavior-analytic treatments addressing developmental skill deficits in children diagnosed within the autistic spectrum have been Subject 6umented, most are labor intensive and inefficient. A potential resolution to this inefficiency is to design an automated system for implementation of traditional procedures. This study will compare the effectiveness and efficiency of an automated system for implementation of behavior-analytic training procedures to the traditional manual approach. Since one of the more significant deficits associate with autism is the lack of appropriate affective/emotional expression and recognition, the system will be designed to teach children to match correct emotional expressions on dolls to specific emotional contexts displayed in animated video clips. Identical target behavior will be addressed by the manual training procedures. If the automated system does provide a more efficient approach to addressing such skill deficits than the manual training procedures and is at least equally as effective, then this and similar system could become notably useful tools in actual clinical settings.

Introduction
Pervasive Developmental Disorder (PDD), Autism and related disorders are marked by notable deficits across a number of developmental domains including language, motor coordination and cognitive abilities (abstraction skills) [Autism Society of America, Diagnostic Statistic Manual (DSM-IV]. One of the significant deficits associated with these disorders is the weak or inappropriate expression of affect and social-emotional behavior [Maurice, Siegel, Baron-Cohen, Sigman]. This is of concern to the clinical behavioral and neuro-psychiatric community since inappropriate emotion can interfere with assimilation into typical social contexts.

In order to address this issue, as well as other deficits that create a barrier to typical assimilation, a number of standard behavioral therapeutic procedures have been developed and successfully implemented [Lovaas, Greenspan & Weider, Maurice, Green & Luce]. Most of these procedures required very small ratios of teachers/trainers to students, most often one to one or one to three. For example, discrete-trial training procedures derived from strict principles of behavior analysis and modification, typically address singular developmental skills until some mastery has been observed. This process includes repeated trial on training instances over a specific amount of time. In each trail, a therapist presents an antecedent cue (discriminative stimulus) and depending on the child's ensuing response, presents the specific consequential event to either reinforce the response, prompt or assist the child in order to increase the probability that the targeted skill will be exhibited on subsequent trials. Although highly effective [Lovaas], it is highly expensive and inefficient labor-intensive due to low teacher-to-student ratios, daily manual data collection, data analysis and procedural updates/modifications.

One solution to the problems of inefficiency associated with effective behavioral treatment for social-emotional skill deficits is to develop an automated approach to accomplish the same objective as human intervention methods. The system would have to meet most of the requirements used in the manual intervention including antecedent and consequential stimuli/events, data collection, data analysis and online adjustment of the procedures based on analysis. Hence, this study is designed to examine such a system and compare measures of its effectiveness to similar measures obtained through traditional manual intervention. Both training modes (automated and manual) will utilize toy dolls that exhibit distinct emotions: *happy, sad, angry, and surprised*. The child will be prompted to select the appropriate doll following the presentation of pictures depicting matching affective or emotional contexts under the manual training mode and video clips depicting the matching emotional/affective contexts with online cues during the automated training.

Manual support for the automated system will be limited to set-up for the training session, monitoring the interaction, and minor maintenance. As such, the required man-hours could be notably reduced. Additionally, the system will not be hindered by human traits such as fatigue, frustration and or distraction. The interface will use wireless toys and minimize potential difficulty that may arise from use of computer keyboards. While the automated system will implements a discrete-trail approach, it will be coupled with coupled with animation and will provide a more game-like environment that could also enhance the child's motivation to interact with the system and learn. If effective, the system will be designed to augment manual intervention in future therapeutic settings.

Method

Subjects:
16 children diagnosed with PDD, Autism or Within the Autistic Spectrum will serve as subjects. Subjects will be recruited as volunteers through advertisements posted at the Dan Marino Child NETT Center. Standardized assessment tools, as well as direct observation by trained psychologists and neurologists will be used to identify children whose primary deficits are related to social-emotional responding and appropriate affect.

Apparatus:
Manual Condition – LDA Photo emotion cards (ref 06006) will be used as antecedent discriminative stimuli, other age appropriate toys, candy and snacks will be used as reinforcing consequential events.

Automated Condition – A desktop IBM computer (advanced Pentium processor) will serve as the system platform. The application has been developed on NT systems. Four separate areas are integrated together. The backend is combined with an SQL database using JDBC/ODBC for connecting to the Java system architecture. Java uses JMF to control the media and the system interface components. The hardware communication protocol is programmed in C and bridged to the Java main program interfaces the system to the toys through infrared. Equipped with IRX boards powered with a 9-volt battery the doll hardware is controlled: toy detection switch, affective sound recorded voice box, haptic internal vibration motor, and hatband LED lights.

Each toy has a unique ID recognized by the system, which sends pre-set configuration codes for each session to the doll for custom responses based on condition parameters. The system continually polls the toys to identify the toy doll selected in time. Based on the time codes accuracy, rate and latency are recorded by the system. Based on the session data: the child profiles, the system configuration, clip configuration, and response times for each interaction the system calculates the fluency during the session and writes the data to the database.

The system is designed with a great deal of flexibility so each session setup is customized for each child. Also, the system is extendable. The system can include custom clips tailored for the child. Digitized clips can be loaded into the system database and retrieved randomly with the others in the system.

General Procedures:
The goal is to compare the effectiveness of manual to automated procedures. For experimental control the same dolls will be used across conditions. Both the automated and manual training modes will be arranged to teach children to “match” (selection of dolls to visual pictures/animations) four different emotion expressions, e.g., happy, sad, angry and surprised. Both modes will also use pre-arranged training as follows:

Manual Training Mode – A standard discrete-trial training procedure will be used. Subjects will be seated facing a therapist, which will hold a LDA photo emotion card with people (children/adults) exhibiting specific emotional expressions under appropriate contexts within the child’s immediate visual field for 30 seconds or until the child responds (whichever occurs first). If the child touches or displaces the doll with the corresponding or matching emotional expression (correct doll), then the therapist will immediately provide enthusiastic social praise and occasionally access a preferred edible (candy, snack, etc.) or 10 seconds access to a preferred toy/activity. The therapist will then display another picture card depicting the same emotional content.

If the child does not select a doll or selects the incorrect (non-matching) doll, the therapist will display the picture card again and provide a verbal ‘prompt’ e.g., “touch happy” or a similar verbal expression corresponding to the correct emotion. If the child still fails to select the correct doll, the therapist will display the picture card, repeat the verbal prompt and provide a physical prompt, e.g., pointing to the correct doll. If the child does select the correct doll after the physical prompt is provided, then physical assistance will be given to assure the child touches the correct doll. Enthusiastic social praise and occasional access to a preferred edible (candy, snack etc.) or 10 second access to a preferred toy/activity will follow all correct responses regardless of whether or not prompts/assistance was provided.

Automated Training Mode – Subjects will be seated facing a computer monitor and two dolls each displaying a different emotional expression. A video clip will be displayed for thirty seconds. The clip will display a scene where an emotion is expressed by a character on the screen. The system will halt after the emotion is displayed. The screen will ‘freeze’ on the emotional expression waiting for the child to touch/displace the corresponding doll with the corresponding or matching emotional expression (correct doll). After the pre-set time elapses, a specific sequence of visual and auditory prompts will be provided (as in the manual training mode) on the computer monitor and through the computer audio system (audio software/hardware).

If the correct doll is selected, the doll will emit an affective sound and action, for example the *happy* doll giggles. At this point a feedback loop occurs between the doll and the video. When it is set down before the screen, the system recognizes the correct selection of the doll and the system guide says, “good, that’s happy” and the next video clip plays. Each time the correct doll is chosen, a new scene will be displayed on the screen depicting the same emotional content.

Experimental Conditions:
Eight experimental conditions will be arranged as listed in the following table XXX, two subjects will serve in each condition (for a total of 16 subjects). Each condition will be comprised of six sequential phases in which the training mode and the target emotion (the emotion to be matched) will be systematically varied. The first four phases will be arranged to compare manual versus automated procedures for teaching subjects to identify each of the four targeted emotion expressions (match-to-sample, as described above). Two phases will utilize automated training procedures to address two of the four emotional states, and the other two will utilize the manual procedures to address the other two. The fifth and sixth phases will be arranged to compare manual versus automated procedures for teaching discrimination between two of the four emotional states presented at random, e.g., happy versus sad in phase 5 and angry versus surprised in phase 6.

Also, as shown in the table XXX, the eight experimental conditions will be arranged to create a balanced cross-variable design. In other words, the order I which the training modes (automated versus manual), the four target emotions and the mode per target emotion will e presented in each of the six experimental phases, are varied across the eight experimental conditions to identify any potential sequence effects.

Data Analysis:
Response Measures – To objectively compare the effectiveness and efficiency of the training procedures, response measures will be identical under both training modes. Measures of response rate as described in equation Response Rate (Ri) will be used to track the number of training trials (opportunities during each session as affected by subject compliance, latency to respond, etc.. Response accuracy, as described in equation Accuracy (Ai) will be used as an index of how effective the training procedures are for teaching the children to match the targeted emotion during a given phase by tracking changes in the proportion of correct responses to the total responding during each session. Lastly, while accuracy is an index of showing proportion of corrects out of total responding it does not proves a summary of how many correct responses were recorded. Hence, a child may have identical

accuracy in two different sessions, e.g. 0.9 the child could have completely different response rate is in those sessions e.g. 9 of 10 versus 900 of 1000. Therefore, indices of fluency will also be calculated for each session. Under the automated training condition in which the system itself will only detect a given maximum response rate, fluency type—1 will be calculated. Under the manual training conditions in which the maximum detectable response rate can change across sessions, fluency type—2 will be calculated.

Test Sessions – Each phase will be comprised of eight ten-minute sessions implemented in blocks of four per day. Each ten-minute session will be followed by a five-minute 'play' break. Hence, each subject will undergo twelve one-hour test sessions (six phases per condition) implemented across consecutive week days.

Transduction – Under the automated training mode, software will collect data as part of the general system function. Under the manual training mode, data will be collected by the therapist and a separate independent observer (either via video or direct observation). Inter-observer agreement will be identified as the proportion of consistent data (between the two observers) out of the total number of trials.

Equations:

Accuracy given multiple response classes (corrects / errors)

$$A_i = \frac{\Sigma(r_c)_i}{\Sigma(r_c + r_e)_i}$$

Where: $A_i$ = Response Rate in a specific training session / segment
$r_c$ = Number functionally defined correct responses
$r_e$ = Number of functionally defined error responses

Response Rate given multiple response classes (corrects / errors)

$$R_i = \frac{\Sigma(r_c + r_e)_i}{T_i}$$

Where: $R_i$ = Response Rate in a specific training session / segment
$r_c$ = Number functionally defined correct responses
$r_e$ = Number of functionally defined error responses
$T_i$ = Elapsed time under that specific session / segment

Fluency type–1 When physical constraints over response rate is known

$$F_i = \frac{R_i}{R\,MAX_i} + A_i$$

Where: $R_i$ = Response Rate
$A_i$ = Accuracy
$R\,MAX_i$ = Maximum possible response rate under given training conditions

Fluency type–2 performance in one session / observation in reference to a set of training sessions / observations

$$F_{i\text{-}2} = \frac{R_i}{R\,MAX_i - R\,MIN_i} + A_i$$

Where: $R_i$ = Response Rate
$A_i$ = Accuracy
$R\,MAX_i$ = Maximum possible response rate under given training conditions
$R\,MIN_i$ = Minimum response rate across a set of sessions / observations

Table-XXX Research Design Includes Eight Conditions (2 subjects per condition) to Assess Training Sequence Across Four Emotions (Happy, Sad, Angry, Surprised) and Two Modalities (Automated and Manual).

Condition: I

| Emotion | Happy | Sad | Angry | Surprised | Random Happy-Sad | Random Angry-Surprised |
|---|---|---|---|---|---|---|
| Training Sequence | Manual | Automated | Manual | Automated | Manual | Automated |

Condition: II

| Emotion | Surprised | Angry | Sad | Happy | Random Angry-Surprised | Random Happy-Sad |
|---|---|---|---|---|---|---|
| Training Sequence | Manual | Automated | Manual | Automated | Manual | Automated |

Condition: III

| Emotion | Angry | Surprised | Happy | Sad | Random Happy-Sad | Random Angry-Surprised |
|---|---|---|---|---|---|---|
| Training Sequence | Manual | Automated | Manual | Automated | Manual | Automated |

Condition: IV

| Emotion | Sad | Happy | Surprised | Angry | Random Angry-Surprised | Random Happy-Sad |
|---|---|---|---|---|---|---|
| Training Sequence | Manual | Automated | Manual | Automated | Manual | Automated |

Condition: V

| Emotion | Happy | Sad | Angry | Surprised | Random Happy-Sad | Random Angry-Surprised |
|---|---|---|---|---|---|---|
| Training Sequence | Automated | Manual | Automated | Manual | Automated | Manual |

Condition: VI

| Emotion | Surprised | Angry | Sad | Happy | Random Angry-Surprised | Random Happy-Sad |
|---|---|---|---|---|---|---|
| Training Sequence | Automated | Manual | Automated | Manual | Automated | Manual |

Condition: VII

| Emotion | Angry | Surprised | Happy | Sad | Random Happy-Sad | Random Angry-Surprised |
|---|---|---|---|---|---|---|
| Training Sequence | Automated | Manual | Automated | Manual | Automated | Manual |

Condition: VIII

| Emotion | Sad | Happy | Surprised | Angry | Random Angry-Surprised | Random Happy-Sad |
|---|---|---|---|---|---|---|
| Training Sequence | Automated | Manual | Automated | Manual | Automated | Manual |

## *Miami Children's Hospital Dan Marino Center*

What is Miami Children's Hospital Dan Marino Center?

Miami Children's Hospital Dan Marino Center is a comprehensive medical center for children with developmental and chronic medical needs. The center houses the Dan Marino Child NETT (Neurodevelopmental Evaluation and Treatment Teams) as well as a variety of pediatric subspecialists from Miami Children's Hospital. The goal of the center is to provide an integrated healthcare delivery system to treat both the physical and emotional needs of the child and family to help them better cope with the illness.

What services are provided at Miami Children's Hospital Dan Marino Center?

Dan Marino Child NETT helps children with special needs including attention deficit disorder (ADD), autism and related disorders, cerebral palsy, epilepsy, learning disabilities, mental retardation and developmental and behavioral disorders. Services provided by Dan Marino Child NETT include:

- Comprehensive neurological assessment and treatment.
- Psychological services.
- Speech and language intervention.
- Physical and occupational therapy.

Education intervention through a nationally renowned tutoring program on the premises. Miami Children's Hospital's pediatric subspecialists are available on-site at the center to provide state-of-the-art outpatient care and easier access to patients in Broward and Palm Beach counties.

Initially, subspecialties include:

- Cardiology
- EnSubject 6rinology
- Gastroenterology
- Genetics
- Hematology Oncology
- Infectious Diseases
- Neonatology
- Nephrology
- Neurology
- Ophthalmology
- Otolaryngology
- Pharmacology
- Physical Therapy
- Psychiatry
- Pulmonology
- Radiology
- Rheumatology
- Speech and Language Pathology

An integrated approach to treatment will include massage and touch therapy, yoga, relaxation classes, and a variety of special programs which will be incorporated into a total wellness program for the child.

What makes Miami Children's Hospital Dan Marino Center special?

A comprehensive team of physicians, allied healthcare professionals, and educational experts will follow children from diagnosis to treatment. This team of professionals will allow families accessible, comprehensive treatment for their child under one roof.

Where is Miami Children's Hospital Dan Marino Center located?

The $3 million, 20,000-square-foot outpatient center is located at 2900 South Commerce Parkway in Weston, Florida.

Who was involved in making Miami Children's Hospital Dan Marino Center a reality?

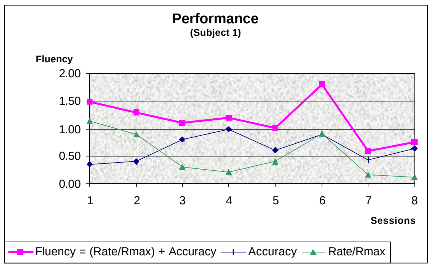
Miami Children's Hospital Dan Marino Center is a partnership between Dan and Claire Marino, Miami Children's Hospital, The Dan Marino Foundation, and Miami Children's Hospital Foundation.

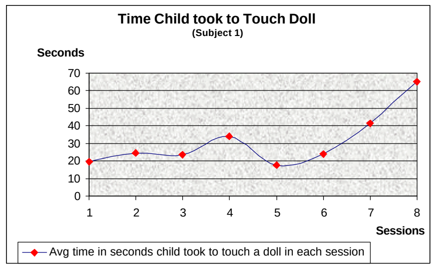
For more information:
Please call (954) 385-MARINO.
Questions and comments to neuro@mch.com

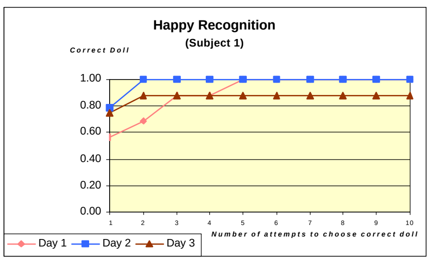

Dan Marino Center http://www.mch.com/dnnc3.html

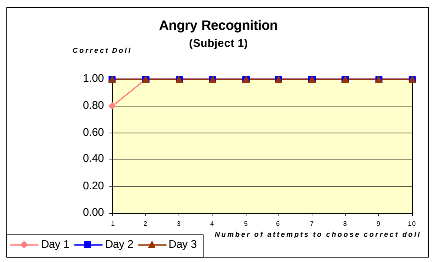
### *Child Observations*

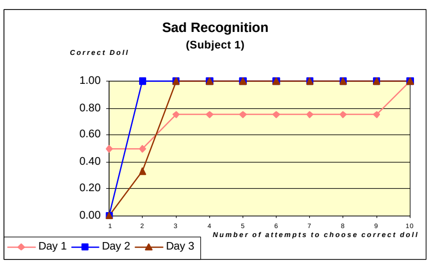
| Subject 1 | Table of Clips Presented for each Day | | | | | |
|---|---|---|---|---|---|---|
| Days | Sessions | Total Trials | Happy (ΣSessions = Day) | Angry (ΣSessions = Day) | Sad (ΣSessions = Day) | Surprised (ΣSessions = Day) |
| Day 1 | 3 | 30 | 7+3+ 6=16 | 4+0+1=5 | 2+1+1=4 | 4+0+1=5 |
| Day 2 | 3 | 22 | 1+10+8=19 | 0+1+0=1 | 0+1+1=1 | 0+1+0=1 |
| Day 3 | 2 | 17 | 5+3=8 | 1+1=2 | 1+2=3 | 2+2=4 |
| Totals | 8 | 69 | 13+16+14=43 | 5+2+1=8 | 3+4+1=8 | 6+3+1=10 |

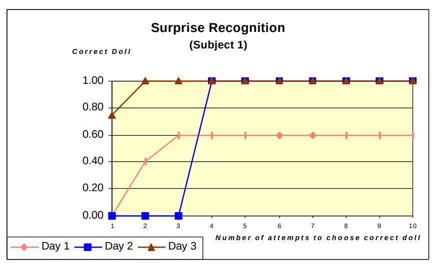


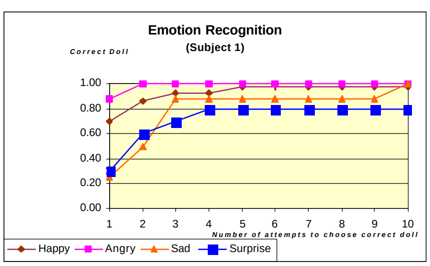




Subject 1 was a very gregarious and active boy. At the time of the pilot he was four years old. He visited the Dan Marino Center for behavioral therapy based on his mild to moderate autism. He had good social skills with deficits in language and social communication. He also had problems with repetitive behavior and attention span. He learned the interface of ASQ very quickly. He understood that to interact with the system he had to touch a doll. Difficulties he had with the system were behavioral related; he would repeat many of the prompts but not necessarily associate the prompt with the selection of the doll. The video clips engaged his attention, yet clips he had seen more than once would loose his interest. Sad and surprise presented the most difficulty with recognition. He had no problems with recognizing and matching angry emotion. Often he would request to see angry clips. Also, he would get attached to a particular emotion and not easily transition to matching the correct emotion.

His performance increased between the first and third day, yet on his third visit he was distracted easily and lost focus in the application.

As shown in the emotion recognition graph, the subject showed ability to recognize all the emotions by the slope of the curve up to the fourth attempt. After this the slopes flatten and rise slowly for the emotions which were difficult.

**Subject: Subject 1**

| | | |
|---|---|---|
| Key: | G = guide prompt | Accuracy: correct responses / total responses = percentage correct |
| | H = human prompt | Rate: total responses / session time = seconds per response time |
| | I = incorrect attempts | Fluency: (Rate / Rmax) + Accuracy |
| | C = correct attempts | Rmax is a constant dependent on the inclusion of a reinforcement clip (with reinforcement = 0.045, without reinforcement = 0.143) |
| | | Derived by the sum of the following averages: (clip time + transition time) + (reinforcement clip time) |

**Session Information**
Session Date: 19-Apr
Session Number: 1
Number of Trials: 17
Total Time of Session: 14m 34s
Cues Present on Child Screen: Icon, Word, Dwarf, and Guide; 6 seconds between Cues; Guide Prompt: Match; Consequence Reinforcement Clip: Yes

**Results**

| | |
|---|---|
| Rate | 0.05 |
| Accuracy | 0.36 |
| Fluency | 1.49 |

**Session Data**

| Emotion | G | H | I | C | Comments Subject 1 |
|---|---|---|---|---|---|
| Happy | 1 | 2 | | 1 | Introduced subject to the dolls and how to interact with them. Subject fully engaged in the clip, he said, "hey that's Tigger, that's rabbit," and the practitioner helped him match the doll face to the doll on the screen, he correctly touched the doll. He also touched the happy doll during the reinforcement Tigger clip. |
| Angry | | 3 | 1 | 1 | Showed subject the dolls and had him pick whichever doll he wanted. He picked the sad doll first. His father told him to pick angry, and then he correctly selected angry. |
| Angry | | 3 | | 1 | Practitioner asked, "who's angry," and subject touched the surprise doll, and then kept saying, "that's angry." |
| Sad | 6 | 5 | 9 | 1 | Subject attempted to make a selection but with the surprised doll only. With assistance finally chose the sad doll. |
| Happy | 3 | 8 | 2 | 1 | Subject first picked the angry doll, then he picked the sad doll. After the correct doll was pointed to, he selected the happy doll. |
| Surprised | 1 | 3 | 1 | 1 | Subject picked the angry doll. He needed the practitioner's help in to touch the surprised doll. He chose the surprised doll when the Tigger reinforcement played too. |
| Happy | 5 | 2 | 4 | 1 | Subject picked surprised doll first; he picked it before the clip stopped. He commented on how the doll was stuck and didn't hear the guide say, "that's surprised, pick happy." He continued to pick surprised doll. After some time he picked happy doll on his own. |
| Surprised | 3 | 5 | 2 | 1 | Subject touched surprise doll while the clip played. When the clip was over, his dad said surprised, but the subject first picked angry doll, then he picked sad doll. After the correct doll was pointed to, he picked surprised doll. |
| Happy | | | | 1 | Subject picked happy doll without any assistance. |
| Sad | 3 | 3 | 2 | 1 | Subject was prompted by his father and the practitioner to pick sad doll. He picked happy doll. He echoed the guide's prompt by saying, "sad." The correct doll was pointed to and then he picked sad doll. When the Tigger clip played he smiled and said "Tigger," while he gestured his hands to the tune of the Tigger song. |
| Angry | | 1 | | 1 | With human prompts the subject picked the angry doll. At the end of the Tigger clip, he picked the happy doll. |
| Angry | | 1 | | 1 | Subject leaned on happy doll while the clip played. His parents prompted him to pick angry doll. He went directly to the angry doll and touched it. |

| Emotion | G | H | I | C | Comments Subject 1 |
|---|---|---|---|---|---|
| Happy | | 2 | | 1 | Subject tends to touch the dolls hard and then to push on them for a long time when selecting a doll. He first looked like he was going to pick the sad doll, but verbally said "happy," and picked the happy doll. At the end of the Tigger clip, he picked the happy doll too. |
| Surprised | 1 | 4 | 1 | 1 | Subject picked the happy doll twice, but when told to pick surprised doll, he went to the surprised doll and selected it and echoed "surprised." He picked the happy doll at the end of the Tigger clip. |
| Surprised | 5 | 3 | 5 | | Subject echoed all the human prompts, though he picked the wrong dolls in the following order: angry, sad, happy, sad, and sad. When he touched the dolls he said, "stuck." He echoed the guide's prompt, "surprised." When Tigger played he started to wonder through the room without much interest in either the clip or dolls. |
| Happy | 3 | 4 | 1 | 1 | Subject touched sad doll and echoed the guide by saying "sad," then "happy," to the guide's "that's sad, match happy." When the practitioner asked, "What emotion is in the clip?" the subject said angry. After re-introducing the dolls he touched happy doll. He also touched happy doll after the Tigger clip. |
| Happy | 2 | 1 | 1 | 1 | Subject echoed the guide prompt and chose the sad doll for the happy clip. Then he picked happy doll. He touched the happy doll before the Tigger clip played and then touched the happy doll afterwards as well. |

**Session Information**
Session Date: 19-Apr
Session Number: 2
Number of Trials: 4
Total Time of Session: 4m 7s
Cues Present on Child Screen: Icon, Word, Dwarf, and Guide; 6 seconds between Cues; Guide Prompt: Match;
Consequence Reinforcement Clip: No

**Results**

| | |
|---|---|
| Rate | 0.04 |
| Accuracy | 0.90 |
| Fluency | 1.30 |

**Session Data**

| Emotion | G | H | I | C | Comments Subject 1 |
|---|---|---|---|---|---|
| Happy | 1 | 1 | | 1 | David Lubin entered the room at the beginning of the clip and distracted the subject's attention. Subject correctly selected the happy doll after a human and guide prompt. Subject touched the happy doll after the Tigger clip also. |
| Happy | 3 | 4 | 4 | 1 | Subject echoed the guide prompts for the emotions: sad, happy, and happy. After the practitioner and parents prompted the subject, he selected the happy doll by leaning on it |
| Sad | | | | 1 | Subject pointed to the correct doll and said "that one," and the practitioner helped him touch it. |
| Happy | 1 | 3 | 2 | 1 | Subject selected the surprised doll by leaning on it several times. After the guide prompt and practitioner prompt he touched the happy doll. |

**Session Information**
Session Date: 19-Apr
Session Number: 3
Number of Trials: 9
Total Time of Session: 3m 55s
Cues Present on Child Screen: Icon, Word, Dwarf, and Guide; 6 seconds between Cues; Guide Prompt: Match;
Consequence Reinforcement Clip: No

**Results**

| | |
|---|---|
| Rate | 0.04 |

Accuracy 0.80
Fluency 1.10

**Session Data**

| Emotion | G | H | I | C | Comments Subject 1 |
|---|---|---|---|---|---|
| Happy | 3 | 4 | 2 | 1 | The long stimulus clip lost the subject's attention. He covered his ears with his hands. After the clip, he touched the sad doll twice. The practitioner and his parents prompted him to pick the happy doll. He then touched the happy doll. |
| Happy | | | | 1 | Subject immediately elbowed the happy doll and said, “that's Tigger,” for the character in the stimulus clip, and continued to lean on the happy doll. He then said, “stuck,” about the happy doll. He echoed the guide by saying, “that’s happy.” |
| Happy | | | | 1 | Subject leaned on the happy doll immediately. When the practitioner asked him what he was feeling, he responded “happy” and leaned on happy doll again. |
| Happy | | 3 | | 1 | Subject was prompted by practitioner and his parents to pick the happy doll. He touched the happy doll. |
| Happy | | | | 1 | Subject picked the happy doll during the clip. |
| Happy | | | | 1 | Subject picked happy doll before clip completed. |
| Surprised | 2 | 3 | | | Subject verbally responded to the practitioner and his parent’s request to touch the surprised doll and echoed the guide by saying, “surprised,” and then distractedly walked around room. |
| Angry | | 2 | | 1 | Subject responded verbally by saying “sad.” He responded to the practitioner’s prompt, and said “Subject 2” and touched angry doll. The stimulus clip was long and kept his attention. |
| Sad | 2 | 1 | | 1 | Subject responded to character being sad and then leaned on the sad doll. His father offered the suggestion to position the dolls on a keyboard. He requested a version of ASQ to take home. |

**Session Information**
Session Date: 26-Apr
Session Number: 1
Number of Trials: 1
Total Time of Session: 34s
Cues Present on Child Screen: Icon, Word, Dwarf, and Guide; 6 seconds between Cues; Guide Prompt: Match; Consequence Reinforcement Clip: Yes

**Results**
Rate 0.03
Accuracy 1.00
Fluency 1.21

**Session Data**

| Emotion | G | H | I | C | Comments Subject 1 |
|---|---|---|---|---|---|
| Happy | 1 | 1 | | 1 | Subject did not pay attention to the stimulus clip playing and randomly touched all the dolls. After the clip finished playing, he looked at the frame on the screen and said “that’s happy,” and made an effort to touch the happy doll. The practitioner assisted him with touching the happy doll so it was detected by the application. He touched the happy doll after the practitioner and asked, “Where is Tigger?” The application froze and needed to be restarted. |

**Session Information**
Session Date: 26-Apr
Session Number: 2
Number of Trials: 13
Total Time of Session: 5m 11s

Cues Present on Child Screen: Icon, Word, Dwarf, and Guide; 6 seconds between Cues; Guide Prompt: Match; Consequence Reinforcement Clip: Yes

**Results**

| | |
|---|---|
| Rate | 0.06 |
| Accuracy | 0.61 |
| Fluency | 1.02 |

**Session Data**

| Emotion | G | H | I | C | Comments Subject 1 |
|---|---|---|---|---|---|
| Happy | 2 | 3 | | 1 | Subject played on the floor and seemed uninterested in the clip playing on the screen. Subject was prompted to sit in his chair and his mother asked him, “Where is happy?” |
| Happy | 1 | 6 | | 1 | Subject looked at the screen and was engaged again through most of the clip. Mother prompted him a lot with “touch happy,” and he was verbally praised on his correct selection. Subject said, “more Tigger,” and continued to ask about Tigger. |
| Happy | | 5 | 1 | 1 | Mother prompted him to pick happy doll, but he said, “that’s angry” and touched the angry doll. His mother said to “touch happy,” and “where is happy?” and he touched the happy doll. |
| Happy | | 2 | | 1 | Mom prompted subject to look at the screen when he tried to hug her neck while looking at the screen. The practitioner prompted him. The subject touched the happy doll. Subject kept saying, “I got it” and repeated “I got it” through the Tigger clip. |
| Angry | | 4 | | 1 | Subject said the character rabbit in the stimulus clip was happy. After four verbal prompts he touched the angry doll. He then touched the happy doll at the end of the Tigger reinforcement clip. |
| Happy | | 2 | | 1 | Mother prompted subject twice and the subject touched the happy doll on her first prompt. Subject starting to get restless and moved about the room. The practitioner said that after five more clips, he could play. |
| Sad | 2 | 6 | 1 | 1 | Subject picked happy doll on his first attempt. His mother said, “that wasn’t happy,” and asked what the character was feeling. Subject said, “happy,” echoing the guide and said, “sad,” then said, “surprised,” while his attention was away from the screen. He got up and started moving about the room. His Mom kept prompting him to look at the faces on the screen and to pick the sad doll. He looked around the room. He went over to the sad doll and touched it. Subject showed real joy when the Tigger clip played. He bounced up and down. Everyone praised his correct doll selection. During the Tigger clip, the subject touched the feet of the happy doll and sad doll to the rhythm of the song. |
| Happy | | 4 | 1 | 1 | Subject said, “Cinderella” at the beginning of the stimulus clip. His mother asked if the character on the screen was happy or sad, and the subject touched the happy doll and started to undress the happy doll. He repeatedly says “Cinderella” four times. His Mother said not to take the doll apart and to touch the belly button of the doll. She asked if the “character is happy or sad” again. The subject hit the angry doll. The subject said, “happy.” His mother asked, “where is the happy doll.” He touched the happy doll. He then snuggled into his mother’s lap by leaning into her on the chair beside him and laughed as he watched the Tigger clip. He diverted his attention to the video camera and smiled a big smile into the camera as he watched himself. The subject looked at the screen and sang the last of the Tigger song, “I’m the only one,” and then said cho-cho train. His parents explained that he had a fixation with trains. |
| Happy | | | | 1 | The subject said happy after the Blues Clues clip and echoed “happy paw print.” His mother asked if that was a happy or sad clip. He said “yeah,” and said “happy” and she prompted him to touch the happy doll by pointing to the doll. He touched the happy doll and kissed his mom when the Tigger clip played and then started to make fart sounds with his mouth and gestured with quick rapid fist punches back and forth towards his mother. |
| Happy | 1 | 5 | | 1 | Subject continued to do the fist gesture towards his mother. He looked at dolls and while the clip played moved his hands toward the happy doll and stopped. His mom asked if the character was sad. He repeated the word “sad” after guide prompt. His mother said |

| Emotion | G | H | I | C | Comments Subject 1 |
|---|---|---|---|---|---|
| | | | | | which one is happy. He did the fist thing again and his mom asked him to touch the happy doll twice. He said "no," and did the fist thing again and laughed. He reached for the cho-cho train and his mother told him that he doesn't want the train and to touch happy doll. He touched happy doll. She said "you did it" and he started to push hard on the happy doll. He proceeded to hit happy doll during the Tigger clip. |
| Happy | 1 | 3 | 1 | 1 | Mom described the activity in the clip by saying, "he has a green face and he is laughing," as she caressed her son who leans from his chair into her lap. She asked what that is and he said "sad." She asked, "are you sure?" and he played with his teeth and said, "teeth." The character in the clip giggled and he copied her. His mother said "happy" and he went to touch the angry doll and she asked if he was sure. He then touched the surprise doll. Then he touched the forehead of happy doll and said "happy" and touched the right side of the doll's torso and pressed hard in the belly. He is prompted to play one more time and then he could play with the train. He did the fist thing with his mother, and gave her a kiss. |
| Surprised | 6 | 6 | 3 | 1 | Mom prompted him to pick surprised and asked him to touch the surprise doll and he touched the happy doll. His mother said, "I know that's happy, touch surprise," and he said, "surprise." He touched sad doll, and then his mother pointed to the surprised doll. He lunged toward the happy doll and his mother prompted him to pick surprised several times. He said "no, happy," and pointed to the happy doll. The practitioner pointed to screen and asked what is the character feeling. The subject said scared (which in the frame may look like a scared face) and he hit happy doll again and said, "that's happy" several times. When his mother pointed to the surprise doll he said no and pointed to the happy doll and said "no, that one." The practitioner picked up the dolls and matched their faces to the dwarf face on the screen. |
| Happy | 1 | 6 | | 1 | Subject fixated on a paper clip while his mother prompted him to pick happy doll. He said happy. She pointed to the dolls and said, "he is happy," and the subject repeatedly said "happy." His mother she said to touch happy doll. He finally touched the happy doll. |

**Session Information**
Session Date: 26-Apr
Session Number: 2
Number of Trials: 8
Total Time of Session: 3m 38s
Cues Present on Child Screen: Icon, Word, Dwarf, and Guide; 6 seconds between Cues; Guide Prompt: Match; Consequence Reinforcement Clip: Yes

**Results**

| | |
|---|---|
| Rate | 0.04 |
| Accuracy | 0.89 |
| Fluency | 1.81 |

**Session Data**

| Emotion | G | H | I | C | Comments Subject 1 |
|---|---|---|---|---|---|
| Happy | 4 | 7 | | 1 | Subject kept saying, "it's finished," five times. His mother said for him to sit down as he wondered around the room and she prompted him to pick the happy doll. The practitioner prompted him also and he said, "no more" four times. |
| Happy | 1 | 5 | | 1 | He watched the clip intensely and laughed during the clip. His mom prompted and kidded around with him and said that she thought the character was sad. He tried to touch the doll with his foot, then he said, "1-2-3" three times. |
| Happy | | 1 | | 1 | After prompted the subject said, "happy" and then delayed touching happy doll by touching it with his foot and laying down in his chair. |
| Happy | 3 | 4 | | 1 | Subject started the clip with saying, "no more." He sat in his seat until his mother |

| Emotion | G | H | I | C | Comments Subject 1 |
|---|---|---|---|---|---|
| | | | | | prompted him to match happy and said she was getting angry because he was stretching his shirt over his knees and not picking a doll. Finally, he touched the happy doll. |
| Happy | 2 | 6 | | 1 | Subject echoed the clip audio, played with his head and said, "pick up" twice. After a prompt he touched the doll's nose and said, "nose." He was asked to touch the doll's belly and he said, "no," and touched the nose of the doll again. With the practitioner's assistance he touched the doll correctly. He said "Tigger" to the Tigger bounce clip. |
| Happy | 1 | 3 | | 1 | He laughed during the stimulus antecedent clip and said, "Tigger going down" twice. His mother prompted him to answer what Tigger was feeling, sad or happy. He said "happy" and touched the happy doll. |
| Happy | | 2 | 1 | 1 | Subject picked the angry doll first and then picked the happy doll after being prompted. |
| Happy | 3 | 9 | | 1 | Subject played with the doll's feet, watched himself in the camera, and kicked the selected doll instead of touching it. |

**Session Information**
Session Date: 27-Apr
Session Number: 1
Number of Trials: 9
Total Time of Session: 14m 35s
Cues Present on Child Screen: Icon, Word, Dwarf, and Guide; 6 seconds between Cues; Guide Prompt: Match; Consequence Reinforcement Clip: No

**Results**

| | |
|---|---|
| Rate | 0.02 |
| Accuracy | 0.43 |
| Fluency | 0.60 |

**Session Data**

| Emotion | G | H | I | C | Comments Subject 1 |
|---|---|---|---|---|---|
| Happy | | | | 1 | Subject came in with his mother and father. Subject immediately touched the happy doll, but the doll didn't detect his touch at first. He tried two more times and the practitioner assisted. |
| Happy | 1 | 2 | | 1 | Subject said "reward" twice, then when he tried to touch the happy doll, he said, "stuck" and the practitioner assisted him. |
| Happy | 5 | 12 | 9 | 1 | Subject laughed at the beginning of the clip and then said "that the doll is sad" and touched surprised. Practitioner introduced him to all the dolls and directed his focus to the face on the screen to match the correct doll. He echoed surprise after the guide said, "that's surprised" but then the subject said the doll was sad. His mom re-introduced the dolls; he looked confused by the dolls. The practitioner assisted him with his correct selection of the happy doll. |
| Surprised | 4 | 4 | | 1 | Subject liked the word *despicable* and often stated it randomly. He echoed his parents when they prompted him with the emotion of the doll. He said he thought the clip was angry (actually the freeze frame may look to be angry) and his mother helped him match the dwarf faces. Instead of the Tigger clip, skittle candy was used as reinforcement. |
| Happy | 1 | 10 | | 1 | His dad started with the prompt "who's that," "which one," "match" and so on. The practitioner said that if he touched the correct doll he would get a skittle candy. He touched the happy doll right away. |
| Surprised | 1 | 2 | | 1 | He said the character was angry at first, then when asked what the emotion was in the clip, he said, "surprised" and touched the surprised doll. He walked around during the clip play. |
| Sad | 10 | 14 | 2 | 1 | Subject said to his mother, "touch angry." He then counted from one to four. He echoed the guide by saying sad. He touched surprise doll and echoed the guide saying sad again. He played with the angry doll and said despicable. When shown the sad doll he said it was surprised and with assistance picked sad doll. |

| Emotion | G | H | I | C | Comments Subject 1 |
|---|---|---|---|---|---|
| Happy | 4 | 7 | 1 | 1 | His father told the subject to wait for the guide to appear on the screen before selecting a doll. Subject touched the angry doll. He said he wanted to touch the angry doll, and when prompted he touched happy doll and then he said no. His father said, “you run into the problem of how to have children, like his son, do something if they don’t want to.” His mother helped him match the dolls’ faces with those on the screen again. When prompted to touch the happy doll he said no. He looked into camera. With assistance he touched the happy doll and was given a skittle candy. |
| Angry | | | | 1 | The subject laughed at the clip and quickly touched the correct doll and laughed again. He was given a skittle candy and had a session break. |

**Session Information**
Session Date: 27-Apr
Session Number: 2
Number of Trials: 8
Total Time of Session: 11m 54s
Cues Present on Child Screen: Icon, Word, Dwarf, and Guide; 6 seconds between Cues; Guide Prompt: Match; Consequence Reinforcement Clip: No

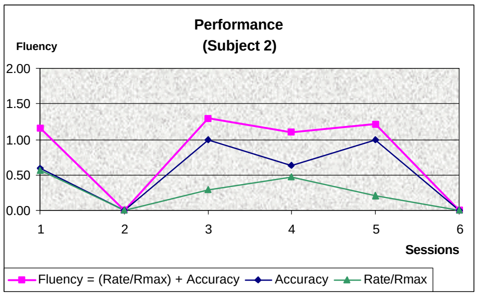
**Results**

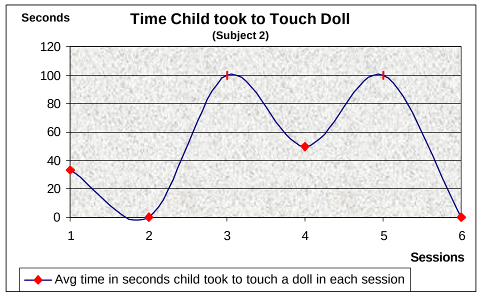
| | |
|---|---|
| Rate | 0.02 |
| Accuracy | 0.64 |
| Fluency | 0.74 |

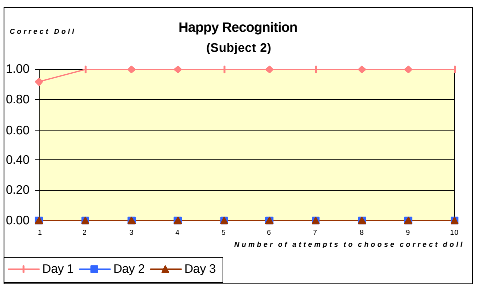
**Session Data**

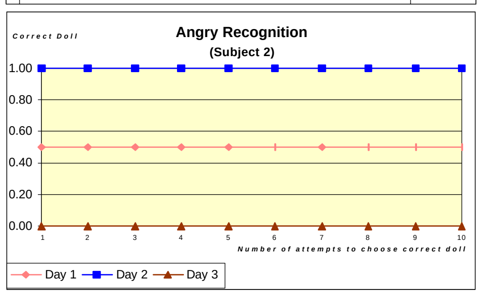
| Emotion | G | H | I | C | Comments Subject 1 |
|---|---|---|---|---|---|
| Surprised | 2 | 7 | 1 | 1 | Subject rocked in his chair. His mother prompted him. She tried to get him to sit in his chair. With additional prompts he touched the correct doll. |
| Surprised | | 4 | | 1 | Subject correctly touched the doll with an initial prompt from his mother and sang da-da-da-da when he got it correct. |
| Sad | 2 | 3 | 2 | 1 | Subject continually picked surprise doll and then picked the sad doll. |
| Sad | 2 | 5 | 1 | 1 | Subject played around the room and when asked what the character was feeling, he said sad, but made no effort to touch the sad doll. After additional prompts he picked the happy doll and then the sad doll. |
| Happy | 2 | 9 | | 1 | his parents told him to stand up by when he slid to the floor. He was told to sit in the chair by his father. His father prompted him to touch the correct doll if he wanted another skittle. Subject made kitty sounds and played in his chair. He then touched the happy doll. |
| Happy | 3 | 12 | | 1 | Subject played on the floor and rolled around in the big chair. His father asked in a frustrated voice, “if he was going to play or not.” Subject asked for a Scooby snack and his father said he would get a skittle if he touched the correct doll. Subject used his foot and kicked it, then sat up and touched it after further prompts from his parents. |
| Happy | 2 | 6 | | 1 | His mom asked, “who is that, is that sad.” He pointed to Tigger on the laptop screen and then on his screen. He was asked what the character was feeling and he said, “boing-boing-boing” many times and started bouncing. His mother said she was getting tired of this. The practitioner sat the subject up in his chair and directed his face toward the screen. He was told to point to the happy doll and he did. |
| Angry | 1 | 4 | | 1 | |

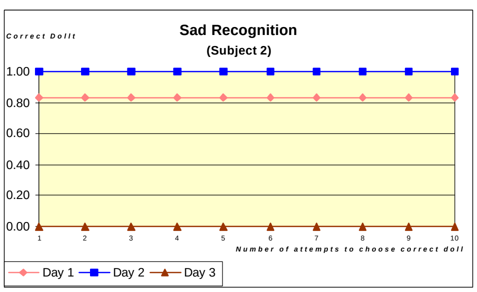
| Subject 2 | Table of Clips Presented for each Day | | | | | |
|---|---|---|---|---|---|---|
| Days | Sessions | Total Trials | Happy (ΣSessions = Day) | Angry (ΣSessions = Day) | Sad (ΣSessions = Day) | Surprised (ΣSessions = Day) |
| Day 1 | 4 | 24 | 1+0+6+6=13 | 0+0+0+2=2 | 1+1+2+3=6 | 2+0+0+1=3 |
| Day 2 | 1 | 4 | 0+0+0+0=0 | 1+0+0+0=1 | 2+0+0+0=2 | 1+0+0+0=1 |
| Day 3 | 1 | 4 | 1+0+0+0=1 | 1+0+0+0=1 | 1+0+0+0=1 | 1+0+0+0=1 |
| Totals | 6 | 32 | 2+0+6+6=14 | 2+0+0+2=4 | 4+1+2+3=9 | 4+0+0+1=5 |

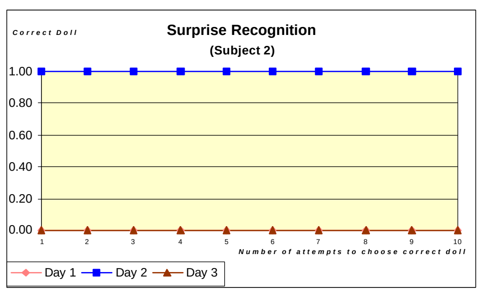


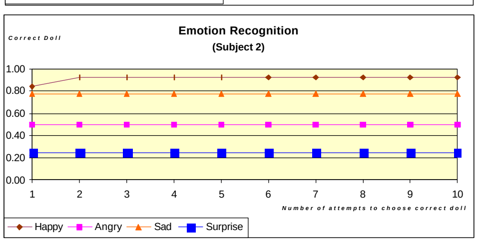




Subject 2 had the most severe case of autism. He was five years old at the time of the pilot. He had developmental delays with fine motor perceptual problems. This may account for his difficulty with the doll interface. Additionally, he was diagnosed with development skill and social play deficits. He came to Dan Marino for behavioral and language therapy. His parents said that he does not like computers and will turn a computer off when around one. The first day he came with his mother and appeared to enjoy the interaction with the dolls and video clips and did not seem to mind the computer. This surprised his mother. He always needed assistance with touching the dolls because of his soft touch. He was mild tempered and compliant, yet with ASQ he showed distress on the second and third day visit. He indicated discomfort by crying when approaching the ASQ room and resisted interaction after the first session the second day. It was thought that he could be resisting 'work' and returned the third day. His visit the last and third day started with heavy sobs and expressive dislike for the environment; he lifted his shirt up and according to his parents this behavior communicates his dislike for something. It was never clear what caused his distress because we removed the dolls and turned the computer off, yet his behavior did not change. The emotion recognition graph shows his low comprehension of the emotions by his no response during several emotion clip trials. These explain why there is a flat slope for all but the happy emotion. Though accuracy is high, this is due to assistance from his mother or the practitioner in touching the correct doll.

**Subject: Subject 2**

| | | |
|---|---|---|
| Key: | G = guide prompt | Accuracy: correct responses / total responses = percentage correct |
| | H = human prompt | Rate: total responses / session time = seconds per response time |
| | I = incorrect attempts | Fluency: (Rate / Rmax) + Accuracy |
| | C = correct attempts | Rmax is a constant dependent on the inclusion of a reinforcement clip (with reinforcement = 0.045, without reinforcement = 0.143) |
| | | Derived by the sum of the following averages: (clip time + transition time) + (reinforcement clip time) |

**Session Information**
Session Date: 14-Apr
Session Number: 1
Number of Trials: 4
Total Time of Session: 3m 20s
Cues Present on Child Screen: Icon, Word, Dwarf, and Guide; 6 seconds between Cues; Guide Prompt: Match; Consequence Reinforcement Clip: Yes

**Results**
Rate 0.03
Accuracy 0.60
Fluency 1.16

**Session Data**

| Emotion | G | H | I | C | Comments Subject 2 |
|---|---|---|---|---|---|
| Sad | | 2 | | 1 | Subject pointed to the doll. He would check all the dolls first before indicating a selected choice. He looked at the camera. His mother assisted him in touching the sad doll. |
| Surprised | 3 | | 1 | 1 | Needed assistance in touching the surprised doll. |
| Surprised | 9 | 15 | 1 | | Pushed green armband patch instead of the doll's belt buckle. He didn't understand where to touch the doll, on the belt buckle. Mother tried to help him pick the surprise doll. He spent lots of time inspecting the dolls. Mother prompted him to select the surprise doll. She said he had to work. He never touched the doll. |
| Happy | 4 | 6 | | 1 | Practitioner removed two dolls to help him. With assistance, he touched the happy doll. He pointed to screen and waited for the next clip. |

**Session Information**
Session Date: 14-Apr
Session Number: 2
Number of Trials: 4
Total Time of Session: 2m 46s
Cues Present on Child Screen: Icon, Word, Dwarf, and Guide; 6 seconds between Cues; Guide Prompt: Match; Consequence Reinforcement Clip: Yes

**Results**
Rate ---
Accuracy ---
Fluency ---

**Session Data**

| Emotion | G | H | I | C | Comments Subject 2 |
|---|---|---|---|---|---|
| Sad | | | | | He mimicked the dolls crying in the video clip, but didn't select a doll. He gave his mom kisses. She said that whenever she cried he gave her kisses. She said that he had a difficult time understanding things and it may be hard to get him to respond as expected. The practitioner had him distinguish between two dolls, happy and sad, to reduce the possible stimulation. His mother said that he normally didn't like computers and will turn them off |

| Emotion | G | H | I | C | Comments Subject 2 |
|---|---|---|---|---|---|
| | | | | | when they are on in the house. He did not respond to the reduction in dolls or to the system regardless of prompts and assistance. |

**Session Information**
Session Date: 14-Apr
Session Number: 3
Number of Trials: 8
Total Time of Session: 10m 22s
Cues Present on Child Screen: Icon, Word, Dwarf, and Guide; 6 seconds between Cues; Guide Prompt: Match; Consequence Reinforcement Clip: Yes

**Results**
Rate 0.01
Accuracy 1.00
Fluency 1.29

**Session Data**

| Emotion | G | H | I | C | Comments Subject 2 |
|---|---|---|---|---|---|
| Happy | | 5 | | 1 | |
| Happy | | 4 | | 1 | Practitioner helped him touch the doll. |
| Happy | | 6 | | 1 | He pointed to the doll. His mother touched the doll. Subject said happy in his own language. |
| Happy | | 5 | | 1 | He verbalized happy after his mother said happy. He didn't appear engaged like the other children. The Tigger clip did get his attention. |
| Sad | | 8 | | 1 | His mother displayed sad and provided verbal prompts. She helped him touch the sad doll. |
| Happy | | 5 | | 1 | Mother said he had a Barney doll at home and that she thought this was similar. Practitioner touched the happy doll. |
| Sad | 3 | 7 | | 1 | His soft touch was not detected and he needed help to touch the sad doll. |
| Happy | 1 | 5 | | 1 | His mother recommended he continue being part of the study because she thought he was interested in the application. With assistance he touched the happy doll. |

**Session Information**
Session Date: 14-Apr
Session Number: 4
Number of Trials: 12
Total Time of Session: 12m 30s
Cues Present on Child Screen: Icon, Word, Dwarf, and Guide; 6 seconds between Cues; Guide Prompt: Match; Consequence Reinforcement Clip: Yes

**Results**
Rate 0.02
Accuracy 0.63
Fluency 1.10

**Session Data**

| Emotion | G | H | I | C | Comments Subject 2 |
|---|---|---|---|---|---|
| Happy | | 4 | | 1 | He touched the happy doll with assistance. |
| Angry | | | | | No response even after he was prompted. |
| Happy | | 3 | | 1 | |
| Angry | | 3 | | 1 | He started to make unhappy sounds when he had to re-touch the doll after he already had tried to touch it. |
| Sad | | 3 | | 1 | He needed assistance with touching the sad doll. |

| Emotion | G | H | I | C | Comments Subject 2 |
|---|---|---|---|---|---|
| Surprised | | | | | No response even after prompted. |
| Sad | | 2 | | 1 | |
| Happy | 1 | 4 | | 1 | |
| Happy | | 2 | | 1 | He touched the green armband patch on the foot of the happy doll. |
| Sad | 2 | 8 | | 1 | His mom switched the dolls around. He looked to feet to find the sad doll from the armband. He touched his stomach when his mom kept saying to touch stomach of doll. |
| Happy | | 3 | 1 | 1 | He touched the doll on his own. |
| Happy | 2 | 7 | 5 | 1 | He had difficulty choosing the happy doll. After the clip replayed he touched sad doll until he was assisted. He didn't understand that the dolls were rearranged. |

**Session Information**
Session Date: 16-Apr
Session Number: 1
Number of Trials: 4
Total Time of Session: 7m 09s
Cues Present on Child Screen: Icon, Word, Dwarf, and Guide; 6 seconds between Cues; Guide Prompt: Match; Consequence Reinforcement Clip: Yes

**Results**

| | |
|---|---|
| Rate | 0.01 |
| Accuracy | 1.00 |
| Fluency | 1.21 |

**Session Data**

| Emotion | G | H | I | C | Comments Subject 2 |
|---|---|---|---|---|---|
| Surprised | 1 | 3 | | 1 | Father brought son. Subject yawned a lot. He started to show frustration at the beginning of this session. His father touched the surprised doll. |
| Sad | 2 | 4 | | 1 | He cried and his father asked what was wrong. When the Tigger clip played, he stopped crying. |
| Angry | 1 | | | 1 | Subject cried a lot when clip played. He was touched the angry doll. He looked to his dad like he wanted something. |
| Sad | 1 | 4 | | 1 | He turned his head away when his dad picked up the sad doll. When he pulled up his shirt, his father said that when he didn't want something he would pull his shirt up. |

**Session Information**
Session Date: 16-Apr
Session Number: 2
Number of Trials: 0
Total Time of Session: ---
Cues Present on Child Screen: ---
Consequence Reinforcement Clip: ---

**Results**

| | |
|---|---|
| Rate | --- |
| Accuracy | --- |
| Fluency | --- |

**Session Data**

| Emotion | G | H | I | C | Comments Subject 2 |
|---|---|---|---|---|---|
| | | | | | He pointed to the screen and held hands with palms up gesturing that he didn't know and had a grimace on his face. His father thought he was communicating that he didn't like this. The screen was turned off. He stopped displaying his uneasiness. Practitioner and his |

| Emotion | G | H | I | C | Comments Subject 2 |
|---|---|---|---|---|---|
| | | | | | father played with the dolls and subject lifted his shirt up. He pushed sad doll away when he was given the doll to play with. He said, "blue" when asked what he wanted. He pushed practitioner away. |

**Session Information**
Session Date: 19-Apr
Session Number: 1
Number of Trials: 4
Total Time of Session: 4m 39s
Cues Present on Child Screen: Icon, Word, Dwarf, and Guide; 6 seconds between Cues; Guide Prompt: Match;
Consequence Reinforcement Clip: Yes

**Results**
Rate ---
Accuracy ---
Fluency ---

**Session Data**

| Emotion | G | H | I | C | Comments Subject 2 |
|---|---|---|---|---|---|
| Sad | | | | | He came in with his mother. He was crying and did not want to play. The clip did not engage him. He kept looking at his mother. If the clip shown was fast paced, he would be quiet and watch it. |
| Surprised | | | | | Mother said he had a tummy ache. She didn't understand why he was upset because on the first day he was okay. He looked at the clip but didn't want to play. When assisted with the dolls he would pull back away from the table. |
| Happy | | | | | |
| Happy | | | | | |

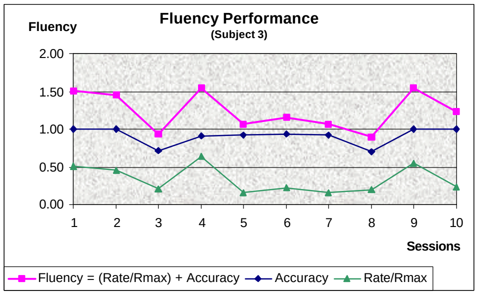
**Session Information**
Session Date: 19-Apr
Session Number: 2
Number of Trials: 0
Total Time of Session: ---
Cues Present on Child Screen: ---
Consequence Reinforcement Clip: ---

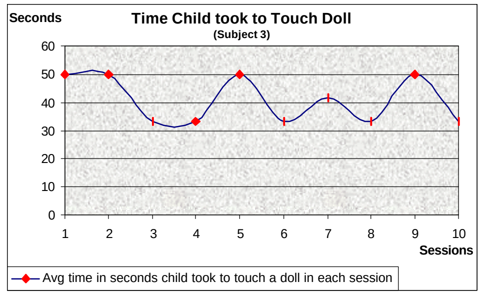
**Results**
Rate ---
Accuracy ---
Fluency ---

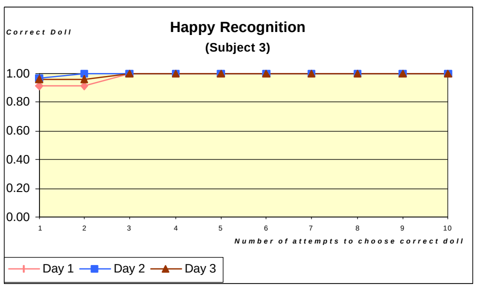
**Session Data**

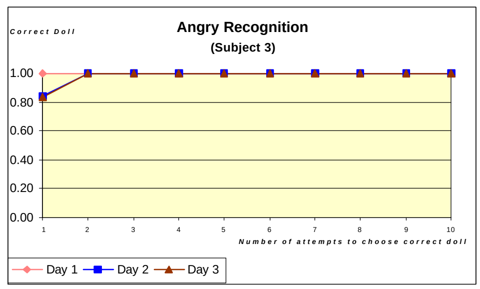
| Emotion | G | H | I | C | Comments Subject 2 |
|---|---|---|---|---|---|
| | | | | | David Lubin joined the session. He removed all the dolls to look for a change in subject's behavior, but subject still cried. David said that he was typically mild mannered and that he had never seen the subject behave like this before. David and subject's mother tried to get subject to look at the video clip on the screen. David said he never saw subject cry. The practitioner and his mother commented on how he was fine the first day. Subject didn't watch the clip and began to cry and made hand gestures toward the screen. Practitioner decided that subject was not benefiting from this and this should be his last day visit. Mother reported that when the computer is turned off, he is okay because he doesn't like computers. |

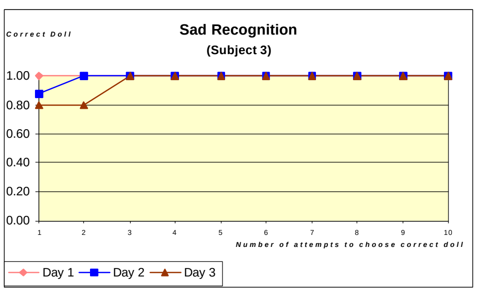
| Subject 3 | Table of Clips Presented for each Day | | | | | |
|---|---|---|---|---|---|---|
| Days | Sessions | Total Trials | Happy (ΣSessions = Day) | Angry (ΣSessions = Day) | Sad (ΣSessions = Day) | Surprised (ΣSessions = Day) |
| Day 1 | 3 | 39 | 6+8+10=24 | 0+4+3=7 | 3+1+0=4 | 1+2+1=4 |
| Day 2 | 4 | 53 | 6+6+13+5=30 | 3+4+3+3=13 | 1+1+2+4=8 | 1+1+0+0=2 |
| Day 3 | 3 | 39 | 7+13+4=24 | 1+3+2=6 | 3+0+2=5 | 3+1+0=4 |
| Totals | 10 | 131 | 19+27+27+5=78 | 4+11+8+3=26 | 7+2+4+4=17 | 5+4+1+0=10 |

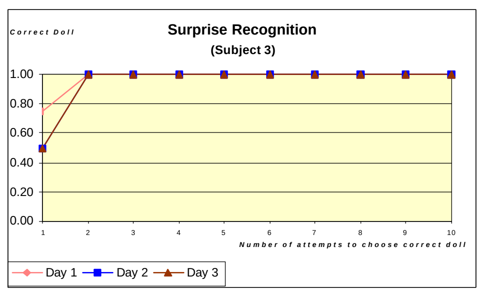


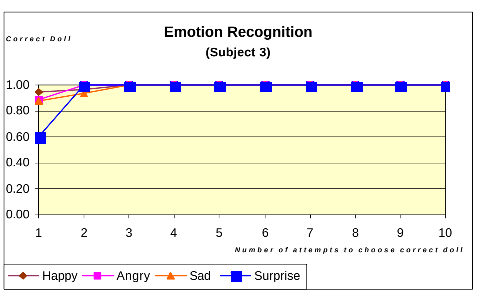




Subject 3 had personality. He was seven years old at the time of the pilot. He was diagnosed as a high-functioning autistic boy with echolia and attention deficit disorder. He has poor social interaction, gaze monitoring and social affect. He is treated for behavioral therapy at the Dan Marino Center. He learned the interaction of the system rapidly. He appeared to be intellectually bright and could select emotions in the video clips with short latency. Clips that had been shown previously lost his attention. Overall, his performance was high and he rarely needed prompts or assistance with selecting the correct doll.

**Subject: Subject 3**

| | |
|---|---|
| Key: G = guide prompt<br>H = human prompt<br>I = incorrect attempts<br>C = correct attempts | Accuracy: correct responses / total responses = percentage correct<br>Rate: total responses / session time = seconds per response time<br>Fluency: (Rate / Rmax) + Accuracy<br>Rmax is a constant dependent on the inclusion of a reinforcement clip<br>(with reinforcement = 0.045, without reinforcement = 0.143)<br>Derived by the sum of the following averages:<br>(clip time + transition time) + (reinforcement clip time) |

**Session Information**
Session Date: 14-Apr
Session Number: 1
Number of Trials: 10
Total Time of Session: 7m 19s
Cues Present on Child Screen: Icon, Word, Dwarf, and Guide; 6 seconds between Cues; Guide Prompt: Match; Consequence Reinforcement Clip: Yes

**Results**

| | |
|---|---|
| Rate | 0.02 |
| Accuracy | 1.00 |
| Fluency | 1.51 |

**Session Data**

| Emotion | G | H | I | C | Comments Subject 3 |
|---|---|---|---|---|---|
| Happy | | 1 | | 1 | Previous day subject helped test during the system. At that time, doll selection for system detection was by the child directing the head of the doll to the system receiver box and squeezing the doll. After viewing the subject's difficult time with this form of interaction, the method changed. The dolls were mounted on toy blocks and the child was instructed to touch the doll's belt buckle. Subject's first session after previous day trial set up, the practitioner asked subject, "What is that character feeling?" and he said, "happy" and picked up the happy doll like he was instructed the day before. |
| Happy | | | | 1 | Verbally, he said, "happy," and practitioner assisted him with touching the happy doll's belt buckle to indicate his correct doll selection. |
| Sad | | 1 | | 1 | He held the nose of the sad doll and tried to pick it up, as he was taught the first day. The practitioner asked, "what emotion is the doll," and he said, "sad." |
| Sad | | | | 1 | He went to touch the nose of the sad doll and the practitioner helped him touch it correctly. He responded to the practitioner's request to touch the belt buckle by saying, "belt buckle" and then said "sad" several times. |
| Happy | | | | 1 | He was asked, "who the character on the screen is," and he said "happy." His mother and practitioner ask, " who is happy?" and he said "happy" again and then said "Tigger." The practitioner helped him to push the belt buckle of the happy doll. |
| Happy | | 1 | | 1 | He said McJunior. His mother asked, "who is that?" and he said "happy" and correctly touched the belt buckle on the happy doll and sang the Tigger song. |
| Surprised | 1 | | | 1 | Subject waited for guide prompt before he selected the surprised doll, and echoed surprised. |
| Sad | | | | 1 | Subject said "sad" and picked the sad doll after looking at all the dolls before selecting one. He looked for the belt buckle and touched it. He bounced with the Tigger song after his mom said, "Your awesome." |
| Happy | | | | 1 | He said, "that's happy" and correctly selected the happy doll. He said, "Winnie the Pooh" after the Tigger song started. |
| Happy | | | | 1 | He said, "happy" when the clip played and correctly selected the happy doll. |

**Session Information**
Session Date: 14-Apr
Session Number: 2
Number of Trials: 15
Total Time of Session: 12m 16s
Cues Present on Child Screen: Dwarf, and Guide; 6 seconds between Cues; Guide Prompt: Match;
Consequence Reinforcement Clip: Yes

**Results**

| | |
|---|---|
| Rate | 0.02 |
| Accuracy | 1.00 |
| Fluency | 1.45 |

**Session Data**

| Emotion | G | H | I | C | Comments Subject 3 |
|---|---|---|---|---|---|
| Happy | | | | 1 | He smiled a real big smile at the camera. He said "happy" as he touched the happy doll. The practitioner tried to move his chair to position it better for him, but he said "no, me." |
| Happy | | | | 1 | He said, "Winnie the Pooh" whenever the Tigger reinforcement clip played. |
| Happy | | | | 1 | He bounced to the Tigger song. |
| Angry | | | | 1 | He said, "angry" and touched the angry doll. |
| Happy | | | | 1 | He contemplated his decision and then touched the happy doll. |
| Angry | | | | 1 | |
| Angry | | | | 1 | He said, "angry" several times. His mom said, "Aerial's dad is angry" and he echoed his mom, "Aerial's dad is angry," with the same prosody. He danced to the honey reinforcement clip and asked the practitioner to dance with him. |
| Happy | | | | 1 | He said happy and the touched happy doll. |
| Sad | | | | 1 | The clip stopped on a different still image than the emotion displayed on the screen, but he still picked the sad doll. |
| Happy | | | | 1 | He said, "happy" and touched happy. He went to look at the practitioner's laptop screen when the clip played and then he played with the recording video camera and moved it around. |
| Happy | | | | 1 | He said, "happy" and touched the happy doll's belt buckle however he needed the practitioner to help. He repeated what the guide would say when the system detected the correct doll being touched, "Good, that's happy." |
| Happy | | | | 1 | He said, "happy." He said that the clip was too long. His mother asked if he wanted a shorter clip. He said, "shorter." His mother told the practitioner that at the dinner table the previous night he smiled and said he was happy. She thought that was the first time he expressed his emotion in that way. She wondered if it was due to his interaction with ASQ. |
| Angry | | | | 1 | He said, "angry" and then touched the angry doll. |
| Surprised | | | | 1 | He said, "surprise" before touching the surprise doll. |
| Surprised | | | | 1 | He said, "surprise" and his mother told him that he was so cool. |

**Session Information**
Session Date: 14-Apr
Session Number: 3
Number of Trials: 14
Total Time of Session: 10m 9s
Cues Present on Child Screen: Guide; 6 seconds between Cues; Guide Prompt: Match;
Consequence Reinforcement Clip: No

**Results**

| | |
|---|---|
| Rate | 0.03 |
| Accuracy | 0.72 |

Fluency 0.93

**Session Data**

| Emotion | G | H | I | C | Comments Subject 3 |
|---|---|---|---|---|---|
| Happy | | | | 1 | |
| Happy | | | | 1 | He moved around the room when the clip played and looked at it on the laptop screen. His mom explained to him that Pooh is stuck in Rabbit's hole because he is so chubby. The practitioner asked what the emotion was in the clip and he said, "happy" and touched the happy doll. His mother thought it was a difficult clip for deciding the correct emotion. |
| Happy | 2 | 2 | 2 | 1 | He picked the sad doll (the frame expression is confusing and could be sad if the clip was not watched), he then touched the angry doll, and the practitioner asked him what the boy looked like and what the boy was feeling. He said, "angry," and repeated it several times. The practitioner described what had happened in the clip to explain why the boy was laughing so hard. The boy was having fun with the bubbles in the tub and that the boy was feeling happy and not angry. The practitioner helped the subject touch the happy doll. |
| Angry | | 1 | | 1 | His mother said that he had to settle down and to watch the clip. She asked what that emotion was and he said, "angry" and touched the angry doll. |
| Happy | | | | 1 | He said happy and touched the happy doll. |
| Happy | | 1 | | 1 | The practitioner asked about the emotion and he said, "happy" and punched the happy doll. |
| Happy | | 1 | | 1 | |
| Happy | 3 | 1 | 2 | 1 | The practitioner asked what the emotion was and he said, "angry," touched the angry doll. Then he said, "sad" and picked the sad doll and listened to the guide prompt. He said "happy" and touched the happy doll. |
| Angry | | | | 1 | The practitioner suggested that he touch the belt buckle on the doll softly. |
| Angry | | | | 1 | He said "angry" and touched angry doll. |
| Surprised | 3 | 2 | 1 | 1 | He said sad and touched the sad doll. He didn't watch the clip and chose the emotion based on the image frame on the screen and said "surprised." |
| Happy | | | | 1 | He said "happy" and touched the happy doll. |
| Happy | | | | 1 | He said "happy" and touched the happy doll. Then he said, "Good, that's happy" with the guide prompt. |
| Happy | | 2 | | 1 | He said "happy" and picked the happy doll. |

**Session Information**
Session Date: 15-Apr
Session Number: 1
Number of Trials: 11
Total Time of Session: 6m 24s
Cues Present on Child Screen: Icon, Word, Dwarf, and Guide; 6 seconds between Cues; Guide Prompt: Match; Consequence Reinforcement Clip: Yes

**Results**
Rate 0.03
Accuracy 0.91
Fluency 1.55

**Session Data**

| Emotion | G | H | I | C | Comments Subject 3 |
|---|---|---|---|---|---|
| Surprised | | | | 1 | He said surprised and touched the surprised doll. |
| Happy | | | | 1 | He said happy and touched the happy doll. |
| Happy | | | | 1 | He said happy and touched the happy doll. |
| Sad | | | | 1 | He said sad and touched the sad doll. |

| Emotion | G | H | I | C | Comments Subject 3 |
|---|---|---|---|---|---|
| Happy | | | | 1 | He said happy and touched the happy doll. |
| Angry | | | | 1 | He said angry and touched the angry doll. |
| Angry | | | | 1 | He said angry and touched the angry doll. |
| Angry | | | | 1 | He smiled at the clip and laughed and said “angry” and touched the angry doll and giggled some more. |
| Happy | | | | 1 | He said happy and touched the happy doll and looked at the practitioner when the doll didn’t respond. |
| Happy | | | | 1 | |
| Happy | | | 1 | 1 | He said happy and touched the happy doll, then said what the guide would say “Good, that’s happy,” A plumber was working on the toilet in the next room with the rotor rooter and making an awful racket. |

**Session Information**
Session Date: 15-Apr
Session Number: 2
Number of Trials: 12
Total Time of Session: 9m 3s
Cues Present on Child Screen: Guide; 6 seconds between Cues; Guide Prompt: Match;
Consequence Reinforcement Clip: No

**Results**

| | |
|---|---|
| Rate | 0.02 |
| Accuracy | 0.92 |
| Fluency | 1.07 |

**Session Data**

| Emotion | G | H | I | C | Comments Subject 3 |
|---|---|---|---|---|---|
| Angry | | 1 | | 1 | His mother suggested that because she thought the dolls were a confusing input device that children would be better off using a mouse like those they use at school. She described that the word on the screen could be clicked on to help them with their reading and to learn the word. |
| Angry | | | | 1 | He said “angry” and picked the angry doll. |
| Angry | | | | 1 | He said “angry” and picked the angry doll. |
| Happy | | | | 1 | He said “happy” and touched the happy doll, then said the guide prompt. |
| Happy | | | | 1 | He said “happy” and touched the happy doll, then said the guide prompt. |
| Sad | | | | 1 | He said “sad” and touched the sad doll. |
| Angry | | | | 1 | He said “angry” and touched the angry doll. |
| Happy | | | | 1 | He said “happy” and touched the happy doll, then he said the guide prompt. |
| Happy | | | | 1 | He said “happy” and touched the happy doll. |
| Happy | 3 | 1 | | 1 | He said he is done and stopped playing. He waited and finally picked the happy doll. |
| Happy | | | | 1 | He said “happy” and touched the happy doll, then said the guide prompt. |
| Surprised | 1 | | 1 | 1 | He said “surprise” and touched the surprise doll. |

**Session Information**
Session Date: 15-Apr
Session Number: 3
Number of Trials: 18
Total Time of Session: 9m 40s
Cues Present on Child Screen: Guide; 6 seconds between Cues; Guide Prompt: Match;
Consequence Reinforcement Clip: No

**Results**

| | |
|---|---|
| Rate | 0.03 |
| Accuracy | 0.94 |
| Fluency | 1.16 |

**Session Data**

| Emotion | G | H | I | C | Comments Subject 3 |
|---|---|---|---|---|---|
| Angry | 2 | | 1 | 1 | He said "sad" and touched sad doll. He played with dolls since the doll didn't respond. The practitioner asked him what the emotion was and he said "happy" and touched the happy doll. The practitioner helped him put the dolls back on their blocks. The guide prompted him to pick angry so he touched the angry doll. |
| Angry | | | | 1 | He said "angry' and touched angry doll. |
| Happy | | | | 1 | He started laughing and then he touched happy doll. |
| Happy | | | | 1 | He said "Blues Clues" and after a few seconds said "happy" and touched the happy doll. |
| Sad | 1 | | 1 | 1 | He said "happy" and touched the happy doll and echoed with guide prompt. He said "sad" touched sad doll. |
| Happy | | | | 1 | He got up and wanted to dance to the honey stimulus clip and said "Winnie the Pooh." He had excellent rhythm and drummed his hands to the beat. The practitioner prompted him to pick an emotion and said "happy" and he touched the happy doll. |
| Happy | | | | 1 | He said "happy" and picked happy doll. |
| Happy | | | | 1 | He "paramount," said happy and picked happy doll. |
| Happy | | | | 1 | He said "happy" and picked the happy doll. |
| Happy | | | | 1 | He said "happy" and picked the happy doll. |
| Angry | | | | 1 | He said "angry" twice and touched the angry doll then he said the guide prompt before it occurred. |
| Happy | | | | 1 | He said "happy" and picked the happy doll. The practitioner asked him to show her what a happy person looked like and he smiled real big smile. |
| Happy | | | | 1 | He said "happy" and picked happy doll. |
| Sad | | | | 1 | He said "sad" with a sad voice and touched the sad doll. The practitioner asked him to show her a sad look and he gestured the Tigger quivering sad lower lip facial expression. |
| Happy | | | | 1 | He said "happy" and touched the happy doll. |
| Happy | | | | 1 | The practitioner asked him what Tigger did best, he said "Winnie the Pooh" three times. The practitioner asked him what the character was feeling. He said "happy" and touched the happy doll. |
| Happy | | | | 1 | He marched to the song playing in the clip and played the drum on his tummy and additional rhythms to the beat. He mimicked the scene in the clip. The practitioner asked him what the emotion was and he said "happy," and touched the happy doll. |
| Happy | | | | 1 | He said "happy" and touched the happy doll and repeated the guide prompt. |

**Session Information**

Session Date: 15-Apr
Session Number: 4
Number of Trials: 12
Total Time of Session: 9m 23s
Cues Present on Child Screen: Guide; 6 seconds between Cues; Guide Prompt: Match;
Consequence Reinforcement Clip: No

**Results**

| | |
|---|---|
| Rate | 0.02 |
| Accuracy | 0.92 |
| Fluency | 1.07 |

**Session Data**

| Emotion | G | H | I | C | Comments Subject 3 |
|---|---|---|---|---|---|
| Sad | | | | 1 | He said "sad" and his mother gestured a high ten toward him and she said great job. |
| Sad | | | | 1 | Subject started to take apart the doll's switch by mimicking what the practitioner does when fixing the dolls if they are not detected. |
| Angry | | | | 1 | He touched the angry doll. |
| Happy | | | | 1 | He said "paramount," "activities," the said "happy" and touched the happy doll. |
| Happy | | | | 1 | He said "happy" as he touched the happy doll. |
| Sad | | | | 1 | He said "sad" as he touched the sad doll and said "good that's sad" with the guide prompt. |
| Angry | | | 1 | 1 | He said "that's happy" and touched the happy doll. He needed the practitioner's assistance. The practitioner restated the system. The practitioner asked him to demonstrate the four emotions and he made facial expressions for each emotion. |
| Angry | | | | 1 | |
| Happy | | | | 1 | |
| Sad | | | | 1 | When the guide prompt started he said the guide prompt too. |
| Happy | | | | 1 | |
| Happy | | | | 1 | He said "we're going home." He echoed his mother words, "okay, let's go home." |

**Session Information**
Session Date: 20-Apr
Session Number: 1
Number of Trials: 14
Total Time of Session: 12m 12s
Cues Present on Child Screen: Guide; 6 seconds between Cues; Guide Prompt: Match;
Consequence Reinforcement Clip: No

**Results**

| | |
|---|---|
| Rate | 0.03 |
| Accuracy | 0.70 |
| Fluency | 0.89 |

**Session Data**

| Emotion | G | H | I | C | Comments Subject 3 |
|---|---|---|---|---|---|
| Happy | | | | 1 | He said, "happy" and touched the happy doll. |
| Happy | | | | 1 | He said, "Mc junior," and "happy" and touched the happy doll. |
| Surprised | | 1 | | 1 | The practitioner asked what he the character was expressing and he said "surprised" and touched the surprise doll. |
| Happy | | | | 1 | He said, "happy" and touched the happy doll. |
| Angry | | | | 1 | He said, "angry" and touched the angry doll and echoed guide, "Good, that's angry." |
| Happy | | | | 1 | He said, "happy" and touched the happy doll. |
| Happy | | | | 1 | He said, "Tigger" and "happy" and touched the happy doll. He echoed the guide prompt, "Good, that's happy." |
| Sad | | | | 1 | He said, "sad" in a sad voice and touched the sad doll and echoed guide prompt, "that's sad." |
| Surprised | 2 | | 1 | 1 | He touched happy and then looked at all the dolls, then touched the sad doll. He echoed the guide prompt "Match surprise" and he touched the surprise doll. He echoed "Good, that's surprised," twice. |
| Happy | | | | 1 | He said, "happy" and touched the happy doll. He echoed "Good, that's happy." |
| Sad | 3 | 1 | 2 | 1 | He said, "happy" and touched the angry doll. He touched the angry doll and looked at the practitioner and touched the angry doll again. The practitioner asked if he was angry or sad and he said "angry." The practitioner suggested sad so he touched the sad doll and echoed "Good, that's sad" (the clip is similar to another clip with the same character and the same scene, but in this scene the character is displaying a different expression.) He echoed |

| Emotion | G | H | I | C | Comments Subject 3 |
|---|---|---|---|---|---|
| | | | | | "That's sad" while waiting for next clip. |
| Surprised | 2 | | 1 | 1 | He said, "angry" and touched the angry doll. He looked at the practitioner and said to "match angry." The practitioner asked him who was angry in the clip and he said the horse was angry (the horse does look angry though the clip both a horse and a cat are surprised to see each other.) The practitioner points out that the cat looks surprised like the horse does. The guide prompt said match surprised, he touched the surprise doll and echoed "Good, that's surprised." |
| Happy | 2 | 1 | 2 | 1 | He touched the sad doll said, "sad," then said "angry" and touched the angry doll. The guide said match happy. The practitioner explains that the character is happy when he plays with the bubbles in the tub, which is why the boy is laughing hard. He said "happy" and touched the happy doll and mimicked the guide saying "Good, that's happy." |
| Sad | | | | 1 | He said, "sad" and touched the sad doll. The doll was not detected and the practitioner checked all the dolls and had to restart the system. The subject played with on laptop keyboard before the practitioner gave him a puzzle to solve. |

**Session Information**
Session Date: 20-Apr
Session Number: 2
Number of Trials: 17
Total Time of Session: 10m 42s
Cues Present on Child Screen: Guide; 6 seconds between Cues; Guide Prompt: Match;
Consequence Reinforcement Clip: No

**Results**

| | |
|---|---|
| Rate | 0.02 |
| Accuracy | 1.00 |
| Fluency | 1.55 |

**Session Data**

| Emotion | G | H | I | C | Comments Subject 3 |
|---|---|---|---|---|---|
| Angry | 2 | 1 | 1 | 1 | Subject said "surprised" and touched the surprised doll, then he said "angry" and touched the angry doll. |
| Happy | | 1 | | 1 | Subject moved around the room. He needed help focusing on the screen. The practitioner asked what Tigger feels and he said "happy" and touched the happy doll. |
| Angry | | | | 1 | He said "angry" twice. The practitioner had to ask him to touch the angry doll before he touched the angry doll and he said "angry" twice. |
| Happy | | | | 1 | He approached the table and contemplated his choice before he said "happy" and touched the happy doll. |
| Happy | | | | 1 | He said "happy" and touched the happy doll. |

Multi-person way of playing the game with interaction between subject and practitioner.

| | | | | | |
|---|---|---|---|---|---|
| Surprised | | 1 | | 1 | The practitioner introduced the subject to a variation of the game. The practitioner assigned him two dolls, the surprised and the angry doll, and assigned her two dolls, the happy and the sad doll. He was told to tell the practitioner to touch the matching doll for emotions that were sad or happy in the clip. The practitioner told him that he could touch the surprised or the angry doll. The practitioner asked him what the emotion was and he said "surprised" and touched the surprise doll and echoed the guide prompt. He got up and moved around the room. |
| Happy | | 1 | | 1 | The practitioner asked him what the emotion was and he said "happy" and went to touch the happy doll before the practitioner said wait, who has the happy doll, and asked him to tell her to touch the happy doll. He tried to touch the happy doll twice and the practitioner intervened and asked him to tell her to pick the happy doll. He then said "pick happy," and |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | echoed the guide prompt “Good, that’s happy” and he walked around the room when the Tigger played. |
| Angry | | 1 | | 1 | He said “its angry” and went to touch the angry doll. The practitioner said wait, tell me which doll to pick. He said “Kathi, pick angry,” and said “Good, that’s angry.” He said “Little Mermaid” and walked around the room and said “computer” when he sat down to play with the laptop. |
| Happy | | 1 | | 1 | The Pooh honey reinforcement clip played and he said “dance Kathi” and the practitioner and the subject danced around the room. When the clip stopped, the practitioner directed him back to his chair. He said “happy” and the practitioner asked him what he had to say and he said “Kathi, pick up happy,” and he mimicked the guide prompt “Good, that’s happy” and then he bounced around the room to the Tigger clip. |
| Happy | | 1 | | 1 | The practitioner asked him what the emotion was and he said “Kathi pick up happy.” The practitioner said good and touched the happy doll. He got up and played with the video camera. |
| Happy | | 1 | | 1 | He said “happy” and touched the happy doll. He bounced to the Tigger song. |
| Happy | | 1 | | 1 | The practitioner asked what the clip was and he said “Kathi pick up happy” and mimicked guide prompt “Good, that’s happy.” |
| Happy | | 1 | | 1 | The practitioner asked him about the clip and he said “Kathi pick up happy.” |
| Happy | | | | 1 | He said “Kathi pick up happy” and echoed the guide prompt, “Good, that’s happy.” |
| Happy | | | | 1 | He watches from the laptop screen and moves the screen cursor on the screen. The practitioner asked him to sit at the table. He hit the laptop table and came to sit at the child table. He said “happy” and then looked at me and said “Kathi pick up happy” and mimicked the guide prompt “Good, that’s happy.” The practitioner switched the dolls around so he had the happy doll and the surprise doll. He said “bee bumble” before the reinforcement clip played. |
| Happy | | | | 1 | He said happy and touched the happy doll and quickly looked at the laptop screen again. |
| Happy | | 1 | | 1 | The practitioner asked what the emotion was and he said “happy.” The practitioner said that he had the happy doll and to touch the happy doll. He walked around to the table and said “Kathi pick up happy” and echoed “that’s happy.” The practitioner asked what he thought the next clip would be, and he said “happy” and then said “Kathi pick up happy.” He mimicked the guide prompt “Good that’s happy” and mumbled “Good that’s sad,” “Good that’s angry.” The practitioner restarted the system and he read from the screen and said “interface options” and “configuration.” |

| | |
|---|---|
| Different Game | The practitioner showed him emotion learning cards used in manual intervention. He was asked to pick the emotion displayed on the card and then touch the doll that matched that emotion. The practitioner showed him all four cards. The sad card was first, he said “sad.” The practitioner asked him to touch the sad doll. He started to move around the room. The practitioner showed him a different picture and he was distracted and played with the some dried flowers decorating the room and moved toward the laptop screen. The practitioner showed him the same picture again and he said “working.” The practitioner asked him what they are feeling in the picture and the prompted him with angry pointed to the boy in the picture. In the next picture the practitioner showed him a child sitting next to his bike crying. The practitioner asked what the boy was feeling and he said “sad” and he touched the sad doll. When shown the next picture, and he said “crying” and he touched the sad doll. The practitioner asked him to touch the sad doll and he said “crying.” The next picture was a happy girl clapping her hands. He said “sad.” The practitioner pointed out that she was happy and he said “the machine turning on” and rummaged through a bag in the room. The practitioner presented him another picture. He moved the camera, and made a crying noise. The practitioner said one more picture and then we’ll play with the computer. |

**Session Information**
Session Date: 20-Apr

Session Number: 3
Number of Trials: 8
Total Time of Session: 4m 2s
Cues Present on Child Screen: Guide; 6 seconds between Cues; Guide Prompt: Match;
Consequence Reinforcement Clip: Yes

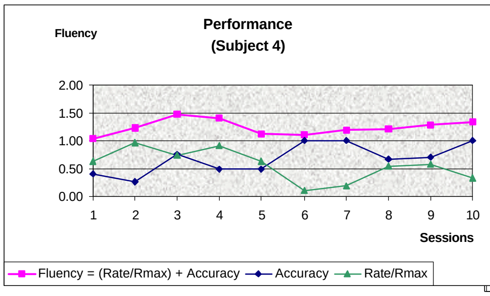
**Results**

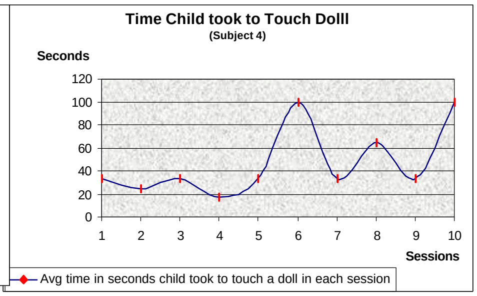
| | |
|---|---|
| Rate | 0.03 |
| Accuracy | 1.00 |
| Fluency | 1.23 |

**Session Data**

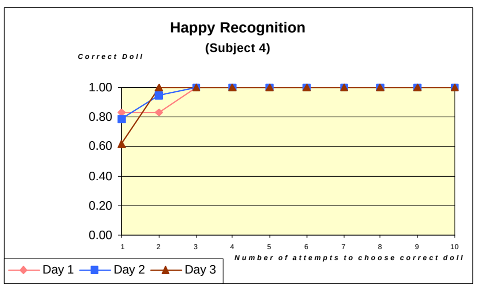
| Emotion | G | H | I | C | Comments Subject 3 |
|---|---|---|---|---|---|
| Happy | | | | 1 | He said "happy" and touched the happy doll. |
| Angry | | | | 1 | He handed the practitioner her sunglasses and said "angry" and touched the angry doll. |
| Happy | 1 | | | 1 | He said "happy" and touched the happy doll and mimicked the guide "Good, that's happy." |
| Sad | | | | 1 | He said "sad" and touched the sad doll. The practitioner suggested they play the game together. He sat at the laptop desk. |
| Sad | | | | 1 | The practitioner tried to get him to sit in his chair. The practitioner asked him what the clip was and he said "sad," The practitioner pointed to the dolls and said she had the sad doll and the angry doll and he had the happy doll and the surprise doll. The practitioner touched sad to start the game. |
| Angry | 2 | 4 | | 1 | He looked at the recording video camera as the clip played. He was asked what the emotion was and he said "angry" and went to touch the angry doll when the practitioner intervened and said who has the angry doll. He said "sad" then "angry" as he pointed to the dolls. The practitioner said she had the angry doll and asked what he needed to do. He said "angry" and he walked away from the table. The practitioner asked him to tell her to pick the angry doll, and he reached across the table to touch the angry doll. He said "angry" three times and the practitioner asked him to tell her to touch the angry doll. He then touched the angry doll. |
| Happy | | 1 | | 1 | The practitioner said to play two more times. He said "one more." The practitioner said two. The practitioner asked him to say what the character in the clip was feeling and he said "happy" and touched the happy doll. The practitioner told the subject to touch the happy doll. |
| Happy | | 1 | | 1 | He said "happy birthday," with the clip. The practitioner asked what they were feeling and he touched the happy doll. The practitioner said he did great. |

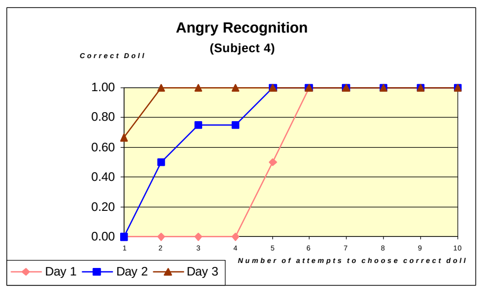
| Subject 4 | Table of Clips Presented for each Day | | | | | |
|---|---|---|---|---|---|---|
| Days | Sessions | Total Trials | Happy (ΣSessions = Day) | Angry (ΣSessions = Day) | Sad (ΣSessions = Day) | Surprised (ΣSessions = Day) |
| Day 1 | 2 | 13 | 4+2=6 | 2+0=2 | 2+1=3 | 0+2=2 |
| Day 2 | 6 | 38 | 5+7+1+1+2+3=19 | 1+1+1+0+0+1=4 | 0+3+1+0+2+4=10 | 0+2+0+1+2=5 |
| Day 3 | 2 | 21 | 8+5=13 | 3+0=3 | 4+0=4 | 1+0=1 |
| Totals | 10 | 72 | 17+14+1+2+3=38 | 6+1+1+0+0+1=9 | 6+4+1+2+4=17 | 1+4+0+1+2=8 |

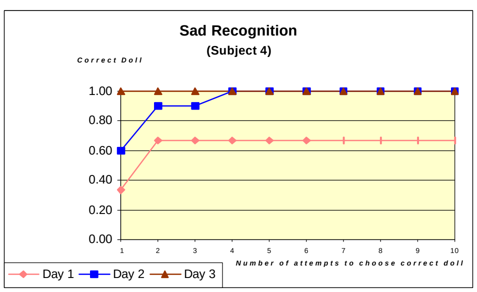


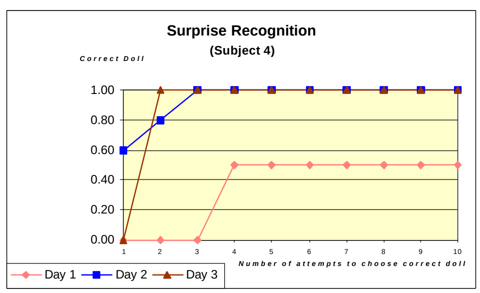



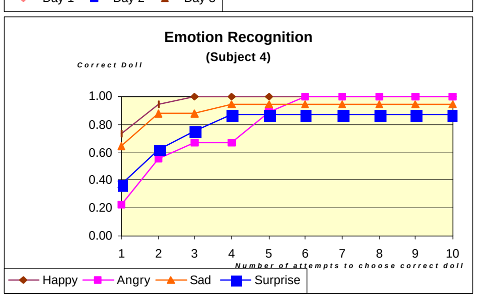

Subject 4 was the youngest subject. He was three and half years old. He had little social affective communication, non-verbal and moderate autism. His play was the most promising and thought that he would benefit most from ASQ.



**Subject: Subject 4**

| | | |
|---|---|---|
| Key: | G = guide prompt | Accuracy: correct responses / total responses = percentage correct |
| | H = human prompt | Rate: total responses / session time = seconds per response time |
| | I = incorrect attempts | Fluency: (Rate / Rmax) + Accuracy |
| | C = correct attempts | Rmax is a constant dependent on the inclusion of a reinforcement clip (with reinforcement = 0.045, without reinforcement = 0.143) |
| | | Derived by the sum of the following averages: (clip time + transition time) + (reinforcement clip time) |

**Session Information**
Session Date: 16-Apr
Session Number: 1
Number of Trials: 8
Total Time of Session: 11m 40s
Cues Present on Child Screen: Icon, Word, Dwarf, and Guide; 6 seconds between Cues; Guide Prompt: Put with Same; Consequence Reinforcement Clip: Yes

**Results**

| | |
|---|---|
| Rate | 0.03 |
| Accuracy | 0.40 |
| Fluency | 1.03 |

**Session Data**

| Emotion | G | H | I | C | Comments Subject 4 |
|---|---|---|---|---|---|
| Sad | 5 | 3 | | 1 | The subject's parents said that he had been ill, but was feeling better. He came before behavior modification therapy. Visiting behaviorist helped the subject in this session. Practitioner prompted him and he touched the sad doll. |
| Happy | 1 | 1 | | 1 | Subject leaned his right ear toward the screen and may have been turning his ear away from her voice in that ear. He touched the happy doll. |
| Happy | 1 | 1 | | 1 | He was prompted to touch the doll's belt buckle because he was touching the feet of the doll. |
| Angry | 3 | | 4 | 1 | Subject touched the doll in front of him without regard to matching the emotion. After three guide prompts and three incorrect selections of the happy doll, subject started to make sounds of frustration and moved his arms up and down. Behaviorist assisted him with touching a different doll. He didn't understand how to match the doll to the clip. Finally, after shown how to do it, he pushed the belt buckle of the angry doll. |
| Happy | | | 2 | 1 | Subject went to touch the same doll as before. With assistance touched the happy doll. |
| Happy | | | | 1 | Subject smiled at the kids on the screen laughing together. He touched the happy doll. |
| Angry | 4 | 3 | 5 | 1 | Subject picked doll in front of him, the happy doll instead of the angry doll. He liked touching and playing with that doll. After touching happy five times and with the guide prompt, "that's happy pick angry," four times, the correct doll was pointed to and he touched the angry doll. |
| Sad | 1 | | 1 | 1 | Subject continued to play with doll in front of him. Before prompted by the guide, he pushed the tummy of the sad doll. |

**Session Information**
Session Date: 16-Apr
Session Number: 2
Number of Trials: 5
Total Time of Session: 4m 15s
Cues Present on Child Screen: Icon, Word, Dwarf, and Guide; 6 seconds between Cues; Guide Prompt: Put with Same; Consequence Reinforcement Clip: Yes

**Results**

Rate 0.04
Accuracy 0.27
Fluency 1.23

**Session Data**

| Emotion | G | H | I | C | Comments Subject 4 |
|---|---|---|---|---|---|
| Sad | | | 2 | | Subject started to cry after a minute and a half passed while the system was being set up with the new configuration. He started to move the dolls around on the table. |
| Surprised | | | 3 | | Subject played with the doll in front of him. |
| Surprised | | | 3 | 1 | He touched the surprise doll. |
| Happy | | | | 1 | He touched the happy doll. |
| Happy | | | | 1 | He touched the happy doll. |

**Session Information**
Session Date: 21-Apr
Session Number: 1
Number of Trials: 6
Total Time of Session: 4m 5s
Cues Present on Child Screen: Icon, Word, Dwarf, and Guide; 6 seconds between Cues; Guide Prompt: Match; Consequence Reinforcement Clip: Yes

**Results**
Rate 0.03
Accuracy 0.75
Fluency 1.48

**Session Data**

| Emotion | G | H | I | C | Comments Subject 4 |
|---|---|---|---|---|---|
| Happy | 3 | 1 | | 1 | His dad brought in the subject. Subject touched the happy doll after several prompts. |
| Happy | 1 | 2 | | 1 | Subject touched the happy doll after the guide prompt, and he giggled during the reinforcement clip. |
| Happy | | | | 1 | Subject touched doll during the clip and his father helped him when the clip stopped. |
| Angry | 3 | | 2 | 1 | After prompting, he touched the angry doll. |
| Happy | 2 | 5 | | 1 | Subject giggled at beginning of clip and tried to select happy but needed help, that erased his smile. |
| Happy | | 4 | | 1 | Subject giggled through the clip, selected happy's nose when asked to touch the happy doll, he started to cry and hit the happy doll. |

**Session Information**
Session Date: 21-Apr
Session Number: 2
Number of Trials: 13
Total Time of Session: 6m 50s
Cues Present on Child Screen: Icon, Word, Dwarf, and Guide; 6 seconds between Cues; Guide Prompt: Match; Consequence Reinforcement Clip: Yes

**Results**
Rate 0.06
Accuracy 0.50
Fluency 1.41

**Session Data**

| Emotion | G | H | I | C | Comments Subject 4 |
|---|---|---|---|---|---|
| Sad | | 2 | | 1 | He stopped crying and watched screen once the next clip played. After prompted, he touched the sad doll. |
| Happy | 1 | 2 | 1 | 1 | Subject touched the sad doll and then prompted to pick happy. Happy doll did not detect his touch and he started to make sad sounds. |
| Happy | | 2 | | 1 | When the happy doll detected his touch he smiled a real big smile. |
| Surprised | 2 | 1 | 2 | 1 | Subject touched the sad doll when prompted. The practitioner helped him with touching the surprise doll. |
| Sad | | | | 1 | He touched the sad doll. |
| Happy | 2 | 2 | 2 | 1 | Subject giggled with the children in the clip and played with feet of the sad doll while the clip played.  When it was over he excitedly flapped his arms up and down, and after the doll was pointed to he touched the happy doll. Subject flapped his arms after Tigger clip |
| Happy | | | | 1 | Without prompting he selected the correct doll. |
| Sad | 3 | 5 | 3 | 1 | Subject played with the sad doll's feet and when the clip was over he needed prompting to select a doll. He picked the happy doll twice and the surprise doll once. Then he touched the sad doll. |
| Happy | | | | 1 | Subject touched correct doll without prompts. |
| Happy | | 1 | | 1 | Subject touched the happy doll after one prompt. During the reinforcement clip he looked at the practitioner twice. |
| Happy | | 1 | | 1 | Subject correctly selected the happy doll after the practitioner prompted him. |
| Surprised | 2 | 3 | 1 | 1 | Subject selected the happy doll first, then the surprise doll. |
| Angry | 4 | 4 | 4 | 1 | Subject attempted to match the emotion, but incorrectly chose the happy doll three times, then the sad doll, before touching the angry doll. |

**Session Information**
Session Date: 21-Apr
Session Number: 3
Number of Trials: 3
Total Time of Session: 3m 30s
Cues Present on Child Screen: Icon, Word, Dwarf, and Guide; 6 seconds between Cues; Guide Prompt: Match; Consequence Reinforcement Clip: Yes

**Results**

| | |
|---|---|
| Rate | 0.03 |
| Accuracy | 0.50 |
| Fluency | 1.13 |

**Session Data**

| Emotion | G | H | I | C | Comments Subject 4 |
|---|---|---|---|---|---|
| Sad | 2 | 5 | 1 | 1 | Subject showed frustration in the transition back to the system after being read a book. He needed prompts to select a doll. He first chose the doll in front of him, then picked surprised before touching the sad doll. |
| Angry | 1 | 3 | 1 | 1 | The dolls were rearranged. Subject picked the surprise doll, now the doll in front of him. His dad pointed to the angry doll and he touched the angry doll. |
| Happy | | 3 | 1 | 1 | He selected surprised and needed help with touching the happy doll. He started to get agitated while waiting for another clip. |

**Session Information**
Session Date:  21-Apr
Session Number: 4
Number of Trials: 2
Total Time of Session: 2m 20s
Cues Present on Child Screen: Icon, Word, Dwarf, and Guide; 6 seconds between Cues; Guide Prompt: Match;

Consequence Reinforcement Clip: No

**Results**

| | |
|---|---|
| Rate | 0.01 |
| Accuracy | 1.00 |
| Fluency | 1.10 |

**Session Data**

| Emotion | G | H | I | C | Comments Subject 4 |
|---|---|---|---|---|---|
| Happy | | 2 | | 1 | Subject got upset after waiting for the system to restart. He showed no interest in reading a book and began to cry. His dad tried to encourage him to say what he wanted. The room was warm and the door was opened. He was given some milk to drink and something to eat as well. He picked the happy doll. |
| Surprised | | 3 | | 1 | After prompted, he touched the surprise doll. |

**Session Information**
Session Date: 21-Apr
Session Number: 5
Number of Trials: 6
Total Time of Session: 3m 30s
Cues Present on Child Screen: Icon, Word, Dwarf, and Guide; 6 seconds between Cues; Guide Prompt: Match; Consequence Reinforcement Clip: No

**Results**

| | |
|---|---|
| Rate | 0.03 |
| Accuracy | 1.00 |
| Fluency | 1.20 |

Session Data

| Emotion | G | H | I | C | Comments Subject 4 |
|---|---|---|---|---|---|
| Happy | | 2 | | 1 | Subject cried because his milk was taken away from him. He touched the happy doll. |
| Sad | | 3 | | 1 | Subject cried when his milk was taken away from him to motivate him to touch the correct doll. |
| Surprised | | 2 | | 1 | He touched the surprise doll. |
| Surprised | | 2 | | 1 | He touched the surprise doll. |
| Sad | | 5 | | 1 | Subject needed a prompt. The milk became the reinforcer. His father said to touch sad and he touched sad after several prompts. |
| Happy | | 2 | | 1 | Subject said happy three times and when prompted to touch the happy doll, he touched it. |

**Session Information**
Session Date: 21-Apr
Session Number: 6
Number of Trials: 8
Total Time of Session: 8m 07s
Cues Present on Child Screen: Icon, Word, Dwarf, and Guide; 6 seconds between Cues; Guide Prompt: Match; Consequence Reinforcement Clip: Yes

**Results**

| | |
|---|---|
| Rate | 0.02 |
| Accuracy | 0.67 |
| Fluency | 1.21 |

**Session Data**

| Emotion | G | H | I | C | Comments Subject 4 |
|---|---|---|---|---|---|
| Sad | | 2 | | 1 | Subject started to wonder around the room. |
| Sad | | 2 | 1 | 1 | Subject picked happy and his father prompted him to pick sad. |
| Sad | | 3 | 1 | 1 | Subject picked up happy and father asked where sad was and he touched the sad doll. |
| Sad | | 2 | | 1 | He touched the sad doll after being prompted. |
| Happy | | 3 | | 1 | Subject was upset when he was told to sit down. He correctly selected happy after told to pick the happy doll. |
| Happy | 1 | 6 | 1 | 1 | Subject touched the surprise doll first. |
| Angry | 1 | 6 | 1 | 1 | He touched the sad doll first and then said "angry" and touched the angry doll. |
| Happy | | 2 | | 1 | He touched the happy doll. |

**Session Information**
Session Date:  23-Apr
Session Number: 1
Number of Trials: 16
Total Time of Session: 14m 41s
Cues Present on Child Screen: Icon, Word, Dwarf, and Guide; 6 seconds between Cues; Guide Prompt: Match; Consequence Reinforcement Clip: Yes

**Results**

| | |
|---|---|
| Rate | 0.03 |
| Accuracy | 0.70 |
| Fluency | 1.28 |

**Session Data**

| Emotion | G | H | I | C | Comments Subject 4 |
|---|---|---|---|---|---|
| Happy | | 2 | 1 | 1 | Subject's behaviorist is in the room with him today. His mother came in and out. Subject touched doll in front of him, the sad doll.  He was prompted to pick the correct doll. The practitioner pointed the to the correct doll and he touched it. |
| Angry | | | | 1 | He touched the angry doll. |
| Happy | | 2 | 1 | 1 | Subject leaned on the sad doll in front of him. |
| Surprised | 1 | 2 | 1 | 1 | He touched the sad doll first. |
| Happy | | 2 | | 1 | The practitioner helped him select the happy doll. |
| Happy | | 3 | 1 | 1 | He selected the doll in front of him. After assistance he selected the correct doll. |
| Sad | | 2 | | 1 | With prompts, he touched the sad doll. |
| Happy | | 2 | | 1 | He touched the sad doll. |
| Happy | | 2 | 1 | 1 | He picked the sad doll, then with a prompt picked the happy doll. |
| Angry | | 3 | 1 | 1 | Subject focused on the clip didn't respond to the prompt to pick the matching doll. He picked the sad doll, the one in front of him first.  He was moved to a bigger chair. |
| Sad | | 3 | | 1 | He touched the sad doll after prompts. |
| Happy | 2 | 4 | | 1 | He played with dolls' noses. He touched the happy doll. |
| Angry | 2 | | | 1 | He touched the angry doll. |
| Sad | | 2 | | 1 | After prompted, he touched the sad doll. |
| Sad | | 1 | | 1 | He touched the sad doll. |
| Happy | 1 | 3 | 1 | 1 | He took the green fabric off the screen that was covering the computer buttons. He touched the undetected sad doll, before prompted to pick happy and touched the happy doll. |

**Session Information**
Session Date: 23-Apr

Session Number: 2
Number of Trials: 5
Total Time of Session: 5m 36s
Cues Present on Child Screen: Icon, Word, Dwarf, and Guide; 6 seconds between Cues; Guide Prompt: Match; Consequence Reinforcement Clip: Yes

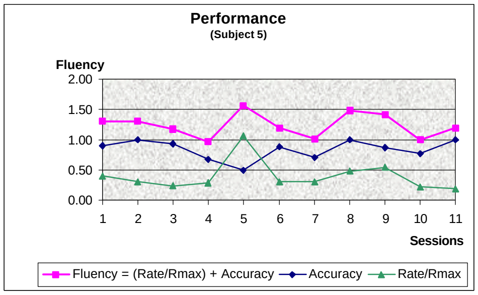
**Results**

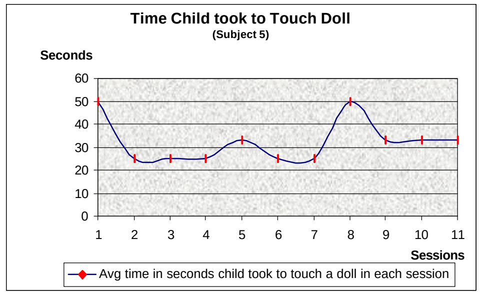
Rate 0.01
Accuracy 1.00
Fluency 1.33

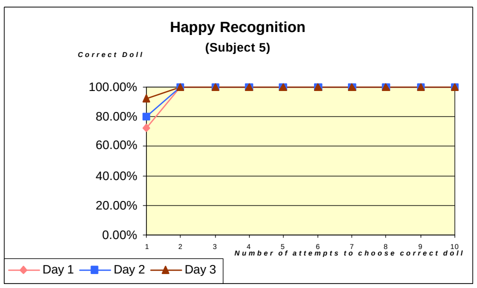
**Session Data**

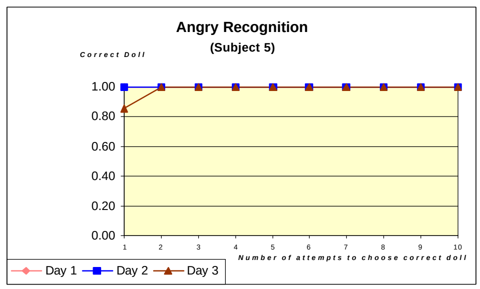
| Emotion | G | H | I | C | Comments Subject 4 |
|---|---|---|---|---|---|
| Happy | | | | 1 | He selected the happy doll. |
| Happy | | 3 | | 1 | He said happy when told to touch happy. Then he touched the happy doll. |
| Happy | | 2 | | 1 | He touched the happy doll. |
| Happy | | 1 | | 1 | Spoke first and then picked the happy doll. |
| Happy | | 1 | | 1 | Subject slouched in his seat and needed a verbal prompt to select doll the correct doll. |

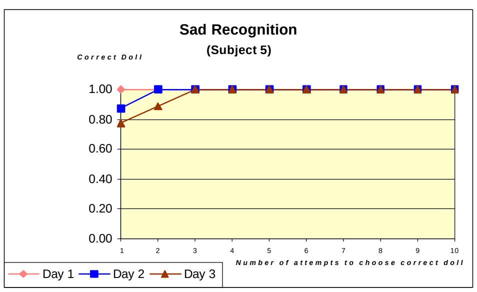
| Subject 5 | Table of Clips Presented for each Day | | | | | |
|---|---|---|---|---|---|---|
| Days | Sessions | Total Trials | Happy (ΣSessions = Day) | Angry (ΣSessions = Day) | Sad (ΣSessions = Day) | Surprised (ΣSessions = Day) |
| Day 1 | 4 | 39 | 6+1+5+6=18 | 1+0+6+1=8 | 1+2+2+2=7 | 1+1+0+4=6 |
| Day 2 | 3 | 37 | 2+9+9=20 | 1+0+1=2 | 2+3+3=8 | 1+4+2=7 |
| Day 3 | 4 | 47 | 2+7+7+10=26 | 1+3+3+0=7 | 1+0+6+2=9 | 0+3+2+0=5 |
| Totals | 11 | 123 | 10+17+21+16=64 | 3+3+10+1=17 | 4+5+11+4=24 | 2+8+4+4=18 |

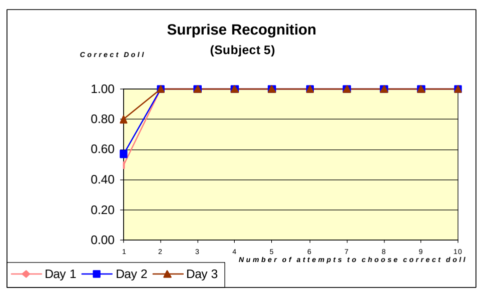


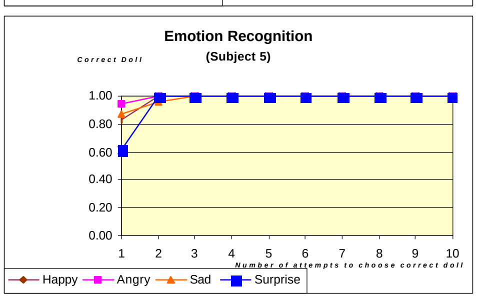




Subject 5 was diagnosed with Asperger syndrome and treated for language therapy at the Dan Marino Center. He was six years old at the time of the pilot. He learned the interaction with the dolls quickly and was social while he interacted with the system. He appeared to know most of the emotion expressions in the clips. Ones that caused him confusion he was able to guess on the second attempt because of the guide prompts. The guides prompt always states the doll to pick so he was able to listen to the prompt to know which doll to choose. If he had a question, this appeared to be his strategy. Most often he selected a doll before any prompt by the guide or practitioner was offered.

**Subject: Subject 5**

| Key: | | |
|---|---|---|
| Key: | G = guide prompt | Accuracy: correct responses / total responses = percentage correct |
| | H = human prompt | Rate: total responses / session time = seconds per response time |
| | I = incorrect attempts | Fluency: (Rate / Rmax) + Accuracy |
| | C = correct attempts | Rmax is a constant dependent on the inclusion of a reinforcement clip (with reinforcement = 0.045, without reinforcement = 0.143) |
| | | Derived by the sum of the following averages: (clip time + transition time) + (reinforcement clip time) |

**Session Information**
Session Date: 19-Apr
Session Number: 1
Number of Trials: 9
Total Time of Session: 9m 22s
Cues Present on Child Screen: Icon, Word, Dwarf, and Guide; 6 seconds between Cues; Guide Prompt: Match;
Consequence Reinforcement Clip: Yes

**Results**

| | |
|---|---|
| Rate | 0.02 |
| Accuracy | 0.90 |
| Fluency | 1.30 |

**Session Data**

| Emotion | G | H | I | C | Comments Subject 5 |
|---|---|---|---|---|---|
| Happy | | 4 | | 1 | He recognized the Cinderella clip and said “it was pink.” After a prompt he selected the happy doll. |
| Sad | | | | 1 | He correctly picked the doll but it wasn't detected by the system. He said “that’s not sad” referring to the Tigger clip and the practitioner said it was his reward. |
| Happy | 1 | 1 | 1 | 1 | He picked the sad doll first and then said “oops” and picked the correct doll. |
| Surprised | | | | 1 | He recognized the mermaid clip and picked the surprise doll. |
| Happy | | | | 1 | He said “happy” and selected the happy doll. |
| Happy | | | | 1 | He touched the happy doll. |
| Happy | | | | 1 | He said that it was “happy,” and touched the happy doll. |
| Angry | | | | 1 | He said “mad” and touched the angry doll. |
| Happy | | | | 1 | He touched the happy doll. |

**Session Information**
Session Date: 19-Apr
Session Number: 2
Number of Trials: 4
Total Time of Session: 1m 30s
Cues Present on Child Screen: Dwarf, and Guide; 6 seconds between Cues; Guide Prompt: Match;
Consequence Reinforcement Clip: No

**Results**

| | |
|---|---|
| Rate | 0.04 |
| Accuracy | 1.00 |
| Fluency | 1.31 |

**Session Data**

| Emotion | G | H | I | C | Comments Subject 5 |
|---|---|---|---|---|---|
| Sad | | | | 1 | He looked at the dwarf’s hat on the screen to match the doll’s hat and then touched |

| Emotion | G | H | I | C | Comments Subject 5 |
|---|---|---|---|---|---|
| | | | | | the correct doll. |
| Happy | | 1 | | 1 | He said it was "happy or surprised" and touched the happy doll. |
| Sad | | | | 1 | He looked to find the same hat and said "that's sad." |
| Surprised | | 1 | | 1 | He touched the surprise doll. |

**Session Information**
Session Date: 19-Apr
Session Number: 3
Number of Trials: 13
Total Time of Session: 6m 28s
Cues Present on Child Screen: Dwarf, and Guide; 6 seconds between Cues; Guide Prompt: Match;
Consequence Reinforcement Clip: No

**Results**

| | |
|---|---|
| Rate | 0.04 |
| Accuracy | 0.93 |
| Fluency | 1.18 |

**Session Data**

| Emotion | G | H | I | C | Comments Subject 5 |
|---|---|---|---|---|---|
| Happy | | | | 1 | Subject played with the dolls by hitting them in the torso. After a clip played he asked the practitioner what she thought and he said "I think it is this one" and touched the happy doll. |
| Angry | 1 | | | 1 | He touched the angry doll. |
| Angry | 1 | | | 1 | He touched the angry doll. |
| Sad | | | | 1 | He touched the doll's hat and said "the blue one" and touched the sad doll. |
| Angry | | | | 1 | He touched the angry doll without prompts. |
| Happy | 1 | 1 | 1 | 1 | He chose the surprise doll. The practitioner was fixing the happy doll and asked him where the happy doll was. He pointed to the happy doll. The practitioner replaced the happy doll and he selected it and said "happy, happy." |
| Angry | | | | 1 | He touched the angry doll. |
| Angry | | | | 1 | Subject said "I'm doing good at this." |
| Angry | | | | 1 | He touched the angry doll. |
| Sad | | | | 1 | The start of the clip the subject said he was "sad" and he was asked how he knew that before the clip finished playing. He didn't answer. |
| Happy | | | | 1 | He asked "when is the bear coming on." |
| Happy | | | | 1 | Subject recognized the Blues Clues clip and he said "I have that movie." He said that he didn't know how to do the dance and laughed. He sang along with the clip and looked at the practitioner and his mother while he watched the clip. He asked "what is on that screen," referring to the laptop screen and the practitioner said that it was the same thing that he sees on his screen. He said "now he can do the dance," and then echoed the guide prompt, "Good, that's happy," and said "I'm doing it right." |
| Happy | | | | 1 | Subject got up walked around the room and mumbled about "he's going to watch TV." |

**Session Information**
Session Date: 19-Apr
Session Number: 4
Number of Trials: 13
Total Time of Session: 7m 52s
Cues Present on Child Screen: Dwarf, and Guide; 6 seconds between Cues; Guide Prompt: Match;
Consequence Reinforcement Clip: No

**Results**

| | |
|---|---|
| Rate | 0.04 |
| Accuracy | 0.68 |
| Fluency | 0.97 |

**Session Data**

| Emotion | G | H | I | C | Comments Subject 5 |
|---|---|---|---|---|---|
| Surprised | 1 | 1 | 1 | 1 | The practitioner asked if he could tell what emotion the boy was showing and he said "angry" and selected the angry doll. He heard the correct emotion from the guide prompt and said "surprise" and touched the surprise doll. |
| Happy | | 1 | | 1 | He was asked what they were feeling in the clip and he said "happy" and he picked the correct doll. He asked what his reward was for selecting the correct doll, and the practitioner told him that she would clap and applaud his success. |
| Happy | 1 | 1 | 1 | 1 | He recognized the clip and said "animaniacs" and the practitioner asked what was he feeling and he corrected her and said "she feeling" and said "sad" in a questioning way. He selected the sad doll and with the guide prompt he touched the happy doll. After touching happy several times and it wasn't responding, he said "that is happy" and the doll detected his touch that time. |
| Sad | | | | 1 | He said at the end of the clip that "she felt like sad" and touched the sad doll. |
| Surprised | | | | 1 | He touched the surprise doll. |
| Happy | 1 | 2 | 1 | 1 | He said "tickle." The practitioner asked him what he feels like when he is tickled. He said "surprise" and touched surprise. He waited to hear the guide prompt say happy and chose the happy doll. |
| Sad | | | | 1 | He said "this is sad" and selected the sad doll and he asked when was going to see a mad clip. |
| Surprised | 1 | | 1 | 1 | He picked the angry doll, which looks like the horse's expression, and then echoed the guide prompt "surprise" and touched the surprise doll. |
| Happy | | | | 1 | He said he wanted to see a mad clip. When the clip played and Pooh spoke the subject said "happy" in a questioning voice and then said "its happy" and touched the happy doll. |
| Happy | | | | 1 | He asked about the mad clips again. While the clip played he pointed to the angry doll and then the sad doll and said he wanted to see a mad and a sad clip and not a happy clip. He then said "its happy" for the clip and selected the happy doll. |
| Angry | | | | 1 | He said that "it is sad or happy," and then he picked the angry doll and said "it is angry" after he touched the angry doll. The guide prompt validated his correct response. |
| Surprised | 1 | | 1 | 1 | He squeezed the noses of the angry and surprised doll before the clip began. He touched the angry doll and said "its angry or happy." Then he touched the sad doll. The guide prompted for surprise and then he said "surprise." His mom described the clip, she was surprised to see him on the beach, remember. He touched surprise and said that she was "surprised" as he looked at his mother seated behind him, then turned to watch the new clip. |
| Happy | 1 | 1 | 1 | 1 | His mom asked what Tigger was feeling and he said "Tigger is always happy," but he selected the sad doll. He heard the guide prompt and said "happy" and touched the happy doll. The system crashed. He asked "if they can go now" and his mother said after one more session. She suggested he come for a half-hour instead of an hour for his next visit. |

| | |
|---|---|
| Different Game | A new game was suggested. He was asked to show faces for the different emotions. He was shown the doll faces and was asked to pick the angry doll and to show a mad face. He laughed. His mom asked him to show us what he looked like when he got mad at her. He still smiled. The practitioner asked him to pick the happy doll and he picked up the happy doll. He was asked to make a happy face and he made a subdued face with no strong expression. He was asked to look at the happy doll face. He said that it wasn't happy and handed the doll to his mother. He was asked to pick the sad doll with sad affect. He was shown a sad face and he was asked to make a sad looking face. The practitioner said to look at the doll and he turned the doll upside down. The practitioner re-asked him to make a sad face and he said "no." Then the practitioner asked him to make a surprise face. He was asked to select the surprise doll and he said "no." |

**Session Information**
Session Date: 22-Apr
Session Number: 1
Number of Trials: 6
Total Time of Session: 3m 56s
Cues Present on Child Screen: Icon, Word, Dwarf, and Guide; 6 seconds between Cues; Guide Prompt: Match; Consequence Reinforcement Clip: Yes

**Results**

| | |
|---|---|
| Rate | 0.03 |
| Accuracy | 1.00 |
| Fluency | 1.56 |

**Session Data**

| Emotion | G | H | I | C | Comments Subject 5 |
|---|---|---|---|---|---|
| Angry | | | | 1 | The dolls were arranged differently from the previous day visit. He brought in a party horn that he was blowing. He watched the first clip and picked the angry doll. When Tigger played he asked if the Tigger clip was his reward and the practitioner said yes. |
| Happy | | | | 1 | He asked when the bear was going to come on. |
| Surprised | | | | 1 | He said "that is surprised," and said "the bear had a tooth" and pointed to his teeth. |
| Happy | | | | 1 | He touched the happy doll when the clip stopped playing. |
| Sad | | | | 1 | He said "that he's sad" and selected the sad doll. It didn't detect his touch and he punched the sad doll. He said, "hey," and the practitioner helped him squeeze the doll. He blew his horn to the Tigger song. |
| Sad | | | | 1 | Subject said "sad again," and picked the sad doll. He had to touch it twice. The practitioner changed the configuration and pulled the screen aids out. |

**Session Information**
Session Date: 22-Apr
Session Number: 2
Number of Trials: 16
Total Time of Session: 7m 5s
Cues Present on Child Screen: Guide; 6 seconds between Cues; Guide Prompt: Match; Consequence Reinforcement Clip: No

**Results**

| | |
|---|---|
| Rate | 0.04 |
| Accuracy | 0.89 |
| Fluency | 1.19 |

**Session Data**

| Emotion | G | H | I | C | Comments Subject 5 |
|---|---|---|---|---|---|

| Emotion | G | H | I | C | Comments Subject 5 |
|---|---|---|---|---|---|
| Surprised | 1 | | 1 | 1 | He said “what is she,” and said “sad” with a question. The practitioner said to try to touch a doll. After the guide prompt said surprise, he said “surprise” in a surprised voice. The practitioner read him the story Beauty and the Beast during his session breaks. |
| Sad | | | | 1 | He touched the sad doll. |
| Surprised | 1 | 2 | | 1 | The practitioner asked him what she was feeling and he said “a fairy” and the practitioner re-asked what was she feeling. The guide prompt said to pick surprise, and he picked the surprise doll. He said to the practitioner “that he knew that.” |
| Surprised | | | | 1 | He said, "Good, that's surprised" with the guide response. |
| Happy | | 1 | | 1 | Practitioner asked him what she was feeling and he said “happy” and touched happy. |
| Happy | | | | 1 | He said “that’s Pee Wee” and “that’s Tessa’s (his sister) favorite” and said he feels happy. |
| Happy | | | | 1 | He giggled and said “that’s funny” and picked happy. |
| Happy | | 1 | | 1 | He said he wanted a mad clip. |
| Sad | | | | 1 | He said sad and touched the sad doll and sang “when is it going to be mad?” |
| Happy | | | | 1 | He said he wanted a surprise or mad clip. |
| Surprised | | | | 1 | When this clip played he said “that’s surprise” and the practitioner asked if he remembered that from last time and he said “yeah.” |
| Happy | | | | 1 | He sang along with the clip and then selected doll. He asked when a mad one would play. The practitioner said she didn’t know. |
| Happy | | | | 1 | He said he wanted a mad clip and sang "mad mad mad." |
| Happy | | 1 | | 1 | He sang and animated “hooray, hooray.” He asked if the practitioner knew Pooh and the practitioner said that she knew pooh from the stories she had read. He said he did too. He watched himself in the video camera. The practitioner asked him what most of the characters were feeling in the clip and he said “happy” and touched the happy doll. |
| Happy | 1 | | 1 | 1 | He said that that was a mad clip. The practitioner asked him if that was right and he touched the angry doll. From the guide prompt he picked the happy doll. |
| Sad | | | | 1 | He then touched each doll and said their emotions. He handled the noses and said "big nose" and "thhhhh" as he touched each one. He kidded around with the dolls and sang 'the hurray' song. He said, "thhhhh" when he touched the noses again. He said, "that’s good" when he touched the happy and angry doll. He said, "match happy" and "thhhh" to the happy doll's nose, and did the same for the angry doll. The practitioner asked him to show her an angry face and he pointed to the angry doll and said “like this,” and then tried to make the grimaced expression on his face. The practitioner asked him to make a happy face and he slowly smiled. As he was further prompted his smile got bigger. He played with a toy phone as the practitioner set up the next interaction. The practitioner asked what was the character feeling and he said “its mister grump” in a horse voice and touched the sad doll. |

**Session Information**
Session Date: 22-Apr
Session Number: 3
Number of Trials: 15
Total Time of Session: 8m 11s
Cues Present on Child Screen: Guide; 6 seconds between Cues; Guide Prompt: Match;
Consequence Reinforcement Clip: No

**Results**

| | |
|---|---|
| Rate | 0.04 |
| Accuracy | 0.71 |
| Fluency | 1.01 |

**Session Data**

| Emotion | G | H | I | C | Comments Subject 5 |
|---|---|---|---|---|---|
| Happy | | 1 | | 1 | He touched the happy doll. |
| Surprised | 1 | 1 | 1 | 1 | The practitioner asked him what Tigger was feeling and he selected the angry doll and after the guide prompt he picked the surprise doll (the clip is confusing because Tigger is happy and rabbit is surprised then distressed.) He echoed “that’s surprised” in the same flat-affective tone. |
| Happy | 1 | | 1 | 1 | He touched the surprise doll and laughed, then selected the correct doll after guide prompt. |
| Happy | 1 | | 1 | 1 | He selected the angry doll and then the happy doll. The practitioner said that he must really want to see an angry clip, and that is all there is to it. He smiled. |
| Happy | | | | 1 | He smiled and selected the happy doll and continued to play with the toy phone. |
| Happy | | | | 1 | He echoed Christopher Robin say “well rabbit” and picked the happy doll. |
| Surprised | 1 | | 1 | 1 | It was a difficult clip and he said surprise and touched the surprise doll and giggles when the guide prompt overlapped. |
| Sad | | | | 1 | He said he wanted a mad one, and said, "mad mad mad." |
| Happy | | | | 1 | He touched the happy doll. |
| Happy | 1 | | 1 | 1 | He selected the angry doll (a different chef clip starts the same way and that one is angry) and then he picked the happy doll after the guide prompt. |
| Happy | | | | 1 | He said the blues clues one and picked the happy doll. He mimicked the guide and said “match sad” as he touched the sad doll. |
| Sad | | | | 1 | After he touched the sad doll, he said match angry in angry choice. |
| Angry | | | | 1 | He said “here we go” and selected the angry doll and said “that was angry” gleefully. |
| Happy | | | | 1 | He mimicked Christopher Robin’s and said “that's a very good idea eeyore.” He looked at the practitioner and said “they do that all the time” and asked her why they do that all the time. The practitioner asked him what he was referring to and he was re-asked what he meant ‘they do that all the time’ and he selected the happy doll. |
| Sad | 1 | | 1 | 1 | He said “this is happy” and picked the happy doll. After the guide prompt he touched the sad doll. |

**Session Information**
Session Date: 28-Apr
Session Number: 1
Number of Trials: 4
Total Time of Session: 3m 7s
Cues Present on Child Screen: Icon, Word, Dwarf, and Guide; 6 seconds between Cues; Guide Prompt: Match; Consequence Reinforcement Clip: Yes

**Results**

| | |
|---|---|
| Rate | 0.02 |
| Accuracy | 1.00 |
| Fluency | 1.48 |

**Session Data**

| Emotion | G | H | I | C | Comments Subject 5 |
|---|---|---|---|---|---|
| Happy | | | | 1 | He shows the practitioner his figurines and told her how he was so brave. |
| Happy | | | | 1 | He said “Tigger is always happy.” |
| Sad | | | | 1 | He said “she’s sad.” |
| Angry | | | | 1 | He said “yeah, its mad” and said “remember, I’ve been waiting for this.” |

**Session Information**

Session Date: 28-Apr
Session Number: 2
Number of Trials: 13
Total Time of Session: 10m
Cues Present on Child Screen: Guide; 6 seconds between Cues; Guide Prompt: Match;
Consequence Reinforcement Clip: Yes

**Results**

| | |
|---|---|
| Rate | 0.03 |
| Accuracy | 0.87 |
| Fluency | 1.42 |

**Session Data**

| Emotion | G | H | I | C | Comments Subject 5 |
|---|---|---|---|---|---|
| Angry | | | | 1 | He touched the angry doll with a smile on his face. |
| Happy | 1 | | 1 | 1 | He picked the sad doll first, then he picked the happy doll. |
| Happy | 1 | | 1 | 1 | He said that's sad and picked the sad doll, then he picked the happy doll. |
| Angry | | | | 1 | He yawns during the Tigger clip. |
| Surprised | | | | 1 | He touched the surprise doll. |
| Angry | | | | 1 | He said "its mad or angry" and touches the angry doll. |
| Happy | | | | 1 | He mimicked Christopher robin and the guide prompt. The practitioner asked him to show happy and he gestured in a shy way and looked away. |
| Happy | | | | 1 | He mimicked the guide again. He asked the practitioner if she was shy. The practitioner said no she wasn't shy, and asked him if he was and he said yes. |
| Happy | | | | 1 | He touched the happy doll. |
| Happy | | | | 1 | He touched the happy doll. |
| Surprised | | | | 1 | He touched the surprise doll. |
| Happy | | | | 1 | He touched the happy doll. |
| Surprised | | 1 | | 1 | He said he liked the honey reinforcement clip. He then said "its not fun after it plays." The practitioner said, "I'll speed it up and remove the reinforcement clips." |

**Session Information**

Session Date: 28-Apr
Session Number: 3
Number of Trials: 18
Total Time of Session: 12m 34s
Cues Present on Child Screen: Guide; 6 seconds between Cues; Guide Prompt: Match;
Consequence Reinforcement Clip: No

**Results**

| | |
|---|---|
| Rate | 0.03 |
| Accuracy | 0.78 |
| Fluency | 1.00 |

**Session Data**

| Emotion | G | H | I | C | Comments Subject 5 |
|---|---|---|---|---|---|
| Sad | | | | 1 | He said he was bored. |
| Surprised | 1 | | 1 | 1 | He picked happy then touched the surprise doll. He started to jump on the chairs and move around the room. |
| Happy | | | | 1 | He touched the happy doll. |
| Happy | | | | 1 | He touched the happy doll. |
| Angry | | | | 1 | He leaned on the angry doll. |

| Emotion | G | H | I | C | Comments Subject 5 |
|---|---|---|---|---|---|
| Sad | 1 | | 1 | 1 | He continues to jump on the chairs and move around the room. He picked the surprise doll and then with a guide prompt he said “sad?” He wanted to know why he was sad and the practitioner said that when the clip plays he could watch the emotion. |
| Happy | | | | 1 | He touched the happy doll. |
| Happy | | | | 1 | He touched the happy doll. |
| Happy | | | | 1 | He touched the happy doll. |
| Surprised | | | | 1 | He touched the surprise doll. |
| Happy | | | | 1 | A new clip he hadn’t seen got his attention and he sat down to watch it and stopped bouncing on the chairs. |
| Angry | | | | 1 | He said he was cold and wanted a blanket. |
| Happy | | | | 1 | The practitioner brought him a sweater and he said he wanted a blanket and not the sweater. |
| Sad | 3 | | 2 | 1 | He picked the angry doll and the practitioner asked him what he emotion that looked like and he said angry. The practitioner described the scene and he picked the sad doll. |
| Sad | | | | 1 | He looked at each of the dolls before making a selection. |
| Sad | | | | 1 | He touched the sad doll. |
| Angry | 1 | | 1 | 1 | He touched angry doll and the practitioner asked him if he did that to see what the guide prompt would tell him and he nodded. |
| Sad | | | | 1 | He touched the sad doll. |

**Session Information**
Session Date: 28-Apr
Session Number: 3
Number of Trials: 12
Total Time of Session: 6m 56s
Cues Present on Child Screen: Guide; 6 seconds between Cues; Guide Prompt: Match;
Consequence Reinforcement Clip: No

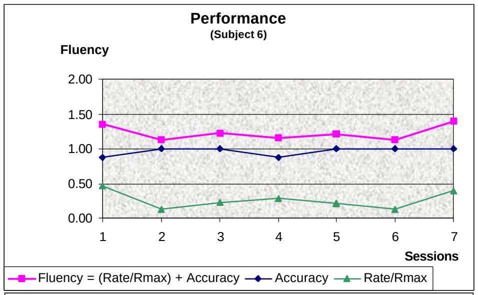
**Results**

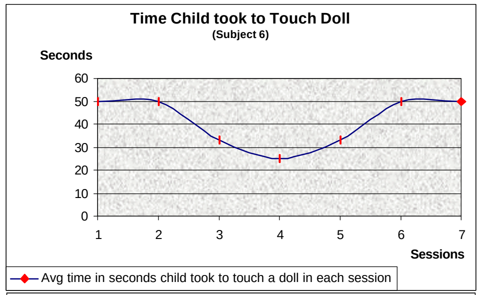
| | |
|---|---|
| Rate | 0.03 |
| Accuracy | 1.00 |
| Fluency | 1.20 |

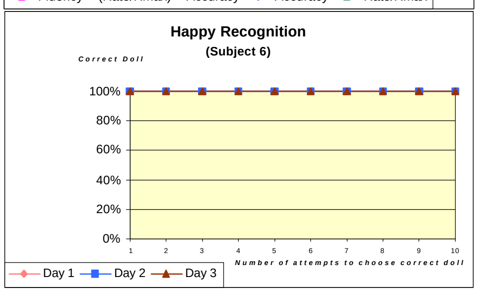
**Session Data**

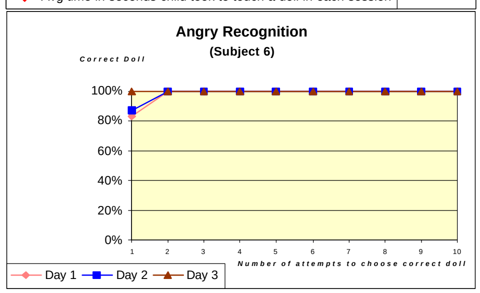
| Emotion | G | H | I | C | Comments Subject 5 |
|---|---|---|---|---|---|
| Happy | | | | 1 | He touched the happy doll. |
| Happy | | | | 1 | He touched the happy doll. |
| Sad | | 1 | | 1 | The practitioner asked him what he thought about the emotion in the clip and he said sad as he picked the sad doll. |
| Happy | | | | 1 | He touched the happy doll. |
| Happy | | | | 1 | He leaned on two dolls at once, happy and angry. |
| Happy | | | | 1 | He echoed the clip line. |
| Happy | | | | 1 | He leaned on two dolls, happy and angry, at the same time. |
| Happy | | | | 1 | He echoed guide prompt. |
| Happy | | | | 1 | He said “its easy.” |
| Happy | | | | 1 | He tried to remember the clip and then he said happy. |
| Sad | 1 | 1 | | 1 | He chose sad and surprise at the same time. |
| Happy | | | | 1 | He touched the happy doll. |

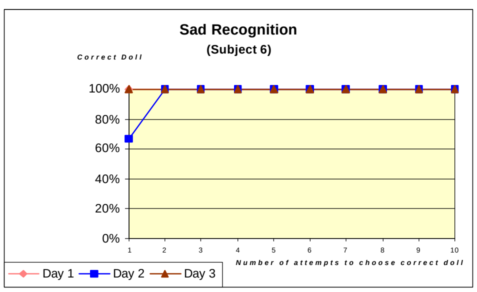
| Subject 6 | Table of Clips Presented for each Day | | | | | |
|---|---|---|---|---|---|---|
| Days | Sessions | Total Trials | Happy (ΣSessions = Day) | Angry (ΣSessions = Day) | Sad (ΣSessions = Day) | Surprised (ΣSessions = Day) |
| Day 1 | 2 | 31 | 8+13=21 | 5+1=6 | 0+1=1 | 2+1=3 |
| Day 2 | 3 | 36 | 4+8+8=20 | 3+2+3=8 | 0+3+0=3 | 2+1+2=5 |
| Day 3 | 2 | 24 | 11+5=16 | 1+3=4 | 0+1=1 | 1+2=3 |
| Totals | 7 | 91 | 23+26+8=57 | 9+6+3=18 | 0+5+0=5 | 5+4+2=11 |

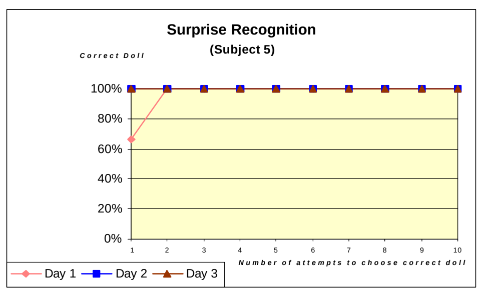


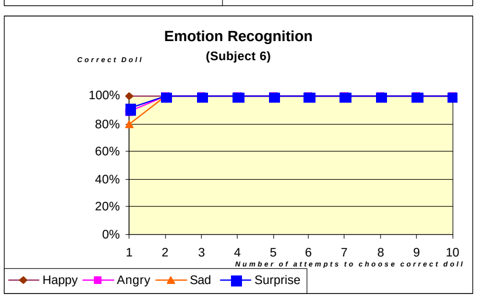




Subject 6 was the oldest child. He turned nine on his third day visit. He was diagnosed with autism at age seven. At the time he had social difficulties and deficits in language, social communication, and repetitive behavior. He was able to understand the interaction. His emotional understanding was high for emotions except surprised. He enjoyed the video clips and suggested content to be included in the future. He had a sense of humor through the interaction and with the dolls. If a delay or incorrect prompt occurred in the system, he said, “he’s just kidding,” referring to the guide.

**Subject: Subject 6**

| | | |
|---|---|---|
| Key: | G = guide prompt<br>H = human prompt<br>I = incorrect attempts<br>C = correct attempts | Accuracy: correct responses / total responses = percentage correct<br>Rate: total responses / session time = seconds per response time<br>Fluency: (Rate / Rmax) + Accuracy<br>Rmax is a constant dependent on the inclusion of a reinforcement clip<br>(with reinforcement = 0.045, without reinforcement = 0.143)<br>Derived by the sum of the following averages:<br>(clip time + transition time) + (reinforcement clip time) |

**Session Information**
Session Date: 16-Apr
Session Number: 1
Number of Trials: 15
Total Time of Session: 13m 26s
Cues Present on Child Screen: Icon, Word, Dwarf, and Guide; 6 seconds between Cues; Guide Prompt: Match; Consequence Reinforcement Clip: Yes

**Results**

| | |
|---|---|
| Rate | 0.02 |
| Accuracy | 0.88 |
| Fluency | 1.35 |

**Session Data**

| Emotion | G | H | I | C | Comments Subject 6 |
|---|---|---|---|---|---|
| Angry | | | | 1 | Subject was introduced to the dolls. He was able to pick the correct doll the first time. When the reinforcement played the practitioner told him it was a reward. He touched the happy doll anyway. |
| Angry | | | | 1 | He placed his hands over eyes and smiled when the reinforcement clip started to play. He asked, "is the lion king in here." The practitioner said that no lion king clips would appear in the video clips. |
| Happy | | | | 1 | He re-asked "if the lion king is in there." His mom said he didn't like the lion king. He pushed the happy doll whenever the Tigger reinforcement clip played. He looked at the laptop screen. The practitioner explained that both screens were the same. Clicking a special hidden button in the interface, she manually started the next clip. |
| Angry | | 2 | 1 | 1 | The practitioner asked what that emotion was and he said "surprise" and touched the surprise doll, after the guide prompt he touched angry. |
| Happy | | | | 1 | He rocked back and forth in his chair to the Tigger clip and his mother stopped him by touching his shoulder. He went to touch the happy doll before the clip finished and then waited and said "she had belly" and asked what was on the other screen. The practitioner said the same thing he sees on his screen and prompted him to pick the doll that matched the emotion. The guide prompt said to pick happy. When he touched the doll it wasn't detected, he said "there is no lion king in there," and said "the lion king in there is broken." The practitioner assisted him. His mother asked if it's a happy or surprised clip. She thought that it could be either one (clip showed both emotions surprised at first and then happy and freezes on the happy frame.) |
| Happy | | | | 1 | He correctly selected the doll and bounced like Tigger. |
| Angry | | | | 1 | He said he wanted to do it again and touched the angry doll. |
| Happy | | | | 1 | He went to touch the happy doll during the stimulus clip, but stopped before touching it, and waited for the guide and then said "match happy." |
| Surprised | 1 | | 1 | 1 | He said "Tigger is singing," and said "that's happy" and picked the happy doll. The guide prompt said that's happy pick surprise, and he touched the surprise doll. |
| Happy | 2 | | | 1 | He waited and looked at the screen. His mom asked which one he thought matched the emotion and he said "how about Star Wars" and with a second prompt he said "its happy" and picked the happy doll. |

| Emotion | G | H | I | C | Comments Subject 6 |
|---|---|---|---|---|---|
| Angry | | | | 1 | He asked if there was “any twentieth century fox,” and sang the star wars song. The practitioner asked what was that emotion and he said “she’s mad” and touched the angry doll. The practitioner asked why the character was angry and he said “because the cat was following tracks.” |
| Surprised | | | | 1 | He said “she is nice” and picked the surprise doll and said “she’s not bad.” |
| Happy | | | | 1 | He said “how about star wars” and touched the happy doll. He then said “do they have twentieth century fox,” The practitioner re-prompts him to pick the doll and he lightly touched the doll again. He touched the happy doll another time and the doll was detected. |
| Happy | | | | 1 | He sang “that's the only one” with the clip. He went to touch the happy doll during the clip, and started touching the doll several times and asked “if that’s twentieth century fox,” and the doll was finally detected. He pulled his ears like Tigger and then said it had melody and rocked in his chair until his mother touched his shoulder. He sang “I’m the only one” and then said “Tigger with the night.” |
| Happy | | 1 | | 1 | He said “he's happy” and “he is Mr. bean,” Pee Wee does look like Mr. Bean. His mother said he had to pick the happy doll. The guide prompted him. He was asked to touch the happy again, but a little harder. The practitioner assisted him until the doll was detected. He sang the Tigger song most of the way through the clip and flapped his hands. He said “Tigger is silly” and his mom said just like you, and he said “lets do a Tigger on the piano.” His mom said that he had been playing the piano for awhile. |

**Session Information**
Session Date: 16-Apr
Session Number: 2
Number of Trials: 16
Total Time of Session: 14m 29s
Cues Present on Child Screen: Icon, Word, Dwarf, and Guide; 6 seconds between Cues; Guide Prompt: Match; Consequence Reinforcement Clip: No

**Results**

| | |
|---|---|
| Rate | 0.02 |
| Accuracy | 1.00 |
| Fluency | 1.13 |

**Session Data**

| Emotion | G | H | I | C | Comments Subject 6 |
|---|---|---|---|---|---|
| Happy | | | | 1 | He mimicked the dance movements on the screen and laughed and went to touch the happy doll and played with its nose. He tried to touch the doll during the clip and then again afterwards. The doll was detected after a couple more tries. |
| Happy | | | | 1 | He touched happy and asked for “star wars.” |
| Happy | | 1 | | 1 | He danced in his seat to the song and then said “yeah” at end of the clip. His mom asked him to pick the doll and he picked the happy doll. |
| Happy | | | | 1 | He said “oh no look out” and then touched the happy doll. The doll was not detecting his touch and he performed a scene from star wars. He said he “didn't want to play the computer.” |
| Happy | | | | 1 | He said “lets quit,” but the practitioner suggested he play a little bit longer. |
| Happy | | | | 1 | He got excited at a new clip and jumped up to touch the happy doll. He said “lets do something else” and then asked “how can the you play the computer.” |
| Angry | | | | 1 | He said “she is mad.” |
| Happy | | | | 1 | He said “that’s Mr. Bean” and touched the happy doll. |
| Happy | | | | 1 | He giggled and touched the happy hard many times. The doll was not detected and then he tried to touch happy again. After another try he started to wonder around the room and the practitioner assisted him with the happy doll. He said “exit,” and the practitioner said after five more times. |

| Emotion | G | H | I | C | Comments Subject 6 |
|---|---|---|---|---|---|
| Happy | | 1 | | 1 | He said, "Nickalodien." His mom said to press the matching doll. He said "happy" and touched the happy doll several times. |
| Surprised | | 1 | | 1 | The practitioner asked him what that was and he said surprised and touched the surprise doll. |
| Happy | 1 | | | 1 | He looked on the other screen. He needed help him touching the dolls throughout the session because they were not detecting his touch. |
| Happy | | | | 1 | He giggled and then darted to touch the happy doll and said "happy" and “that kanga looked like Allele from 'A Land From Time.'” |
| Happy | | | | 1 | He said “he is silly” and his mother asked him to pick a doll. He played with the belt buckle of the doll but didn't press it. He said “happy is the winner” then pressed the doll after the guide prompt. He clapped his hands and then leaned into all the dolls. |
| Happy | 1 | 1 | | 1 | He giggled and looked to laptop’s screen and went back to sit in his chair. His mom asked him to pick a doll and he selected the happy doll. |
| Sad | | 1 | | 1 | The practitioner told him that this was the last one and asked, "What is Tigger feeling?" He said, "they died" and touched the sad doll. He said, "lets get out of here." His mother commented that he was used to faster moving games and that he was used to a keyboard. He looked at the last clip and mimicked the scene where the cat and horse look surprised. He asked if that "was the wrong one" when the practitioner exited the system. His mother said that he is impatient and the practitioner apologize for the dolls not responding well to his touch |

**Session Information**
Session Date: 19-Apr
Session Number: 1
Number of Trials: 9
Total Time of Session: 4m 43s
Cues Present on Child Screen: Icon and Guide; 6 seconds between Cues; Guide Prompt: Match;
Consequence Reinforcement Clip: No

**Results**

| | |
|---|---|
| Rate | 0.03 |
| Accuracy | 1.00 |
| Fluency | 1.22 |

**Session Data**

| Emotion | G | H | I | C | Comments Subject 6 |
|---|---|---|---|---|---|
| Happy | | | | | He touched the happy doll. |
| Happy | | | | 1 | He touched the happy doll. |
| Happy | | | | 1 | He touched the happy doll. |
| Happy | | | | 1 | He touched the happy doll. |
| Angry | | | | 1 | He touched the angry doll. |
| Angry | | | | 1 | He touched the angry doll. |
| Surprised | | | | 1 | He touched the surprise doll. |
| Surprised | | 1 | | 1 | He touched the surprise doll. |
| Angry | | | | 1 | He touched the angry doll. |

**Session Information**
Session Date: 19-Apr
Session Number: 2
Number of Trials: 14
Total Time of Session: 6m 39s
Cues Present on Child Screen: Guide; 6 seconds between Cues; Guide Prompt: Match;
Consequence Reinforcement Clip: No

**Results**

Rate 0.04
Accuracy 0.88
Fluency 1.16

**Session Data**

| Emotion | G | H | I | C | Comments Subject 6 |
|---|---|---|---|---|---|
| Sad | | 2 | 1 | 1 | The first time with no cues. He chose the happy doll first then the sad doll. Subject re-arranged all the dolls like they were the first day. He rocked in his chair. A guest of family visited and stayed to observe his interaction. |
| Happy | 1 | 1 | | 1 | His mother commented on the doll's detection problem. |
| Happy | | 1 | | 1 | He touched the happy doll. |
| Sad | | | | 1 | He said sad before touching the sad doll. |
| Angry | | | | 1 | He was complimented after he touched the correct doll. He said "oh look, its angry." |
| Happy | | 1 | | 1 | After a prompt he said happy as he touched the happy doll. His mother commented that she thought it was an angry clip. |
| Angry | | | 1 | 1 | Subject said angry, but touched sad first. |
| Happy | | 1 | | 1 | He touched the happy doll. |
| Happy | | | | 1 | He touched the happy doll. |
| Happy | | | | 1 | He said "tickles" for the clip. |
| Happy | | | | 1 | He said happy when he touched the happy doll. |
| Happy | | | | 1 | Subject said "he's just kidding" referring to the guide prompt overlapping audio. |
| Sad | | | | 1 | He said "sad." |
| Surprised | | | | 1 | He said "mad" before attempting to pick a doll, and then touched the surprise doll. The practitioner was talking to guest and missed the subject's first attempt and asked him to repeat it. |

**Session Information**

Session Date: 19-Apr
Session Number: 3
Number of Trials: 13
Total Time of Session: 7m 15s
Cues Present on Child Screen: Guide; 6 seconds between Cues; Guide Prompt: Match;
Consequence Reinforcement Clip: No

**Results**

Rate 0.03
Accuracy 1.00
Fluency 1.21

**Session Data**

| Emotion | G | H | I | C | Comments Subject 6 |
|---|---|---|---|---|---|
| Happy | | 1 | | 1 | The guest commented on how the system had short circuited because the picture aids were blinking on the screen. |
| Angry | 1 | | | 1 | Subject said "he hated that guy," and said "mad" as he picked the angry doll. He said "he's not nice." |
| Happy | | 1 | | 1 | He touched the happy doll. |
| Surprised | 1 | | | 1 | He touched the surprise doll. |
| Happy | | | | 1 | He said "he's happy" before attempting to touch the doll. |
| Surprised | | | | 1 | He touched the surprise doll. |
| Happy | | 1 | | 1 | Subject bounced happily and rocked in his chair. The practitioner was concerned that the subject might confuse the reinforcement clip with a stimulus clip. He sang along, "I'm the only one." Tigger jumping, because of his lack of response in selecting doll the practitioner |

| Emotion | G | H | I | C | Comments Subject 6 |
|---|---|---|---|---|---|
| | | | | | think he thought that that was a reinforcement clip, so the practitioner verbally prompted him and verbally responded and then touched doll, subject said "he's just kidding" when the guide overlapped the confusing prompts |
| Happy | | | | 1 | Subject said "he's just kidding." |
| Happy | | | | 1 | He said "oh look, happy." |
| Happy | | | | 1 | He touched the happy doll. |
| Angry | | | | 1 | He touched the angry doll. |
| Happy | | 1 | | 1 | The practitioner asked him what was Tigger feeling and he said "happy" and touched the happy doll. |
| Angry | | 1 | | 1 | Subject said "mad" before attempting to touch a doll. The practitioner suggested that he touch the angry doll. He said the "mad doll" as he touched it. |

**Session Information**
Session Date: 26-Apr
Session Number: 1
Number of Trials: 13
Total Time of Session: 11m 26s
Cues Present on Child Screen: Guide; 6 seconds between Cues; Guide Prompt: Match;
Consequence Reinforcement Clip: No

**Results**

| | |
|---|---|
| Rate | 0.02 |
| Accuracy | 1.00 |
| Fluency | 1.13 |

**Session Data**

| Emotion | G | H | I | C | Comments Subject 6 |
|---|---|---|---|---|---|
| Happy | | | | 1 | Today is the subject's birthday. He arranged all the dolls in the order he was used to and waited for the guide prompt. He touched happy. |
| Happy | | | | 1 | He tried to touch the happy doll, but the way he was touching it wasn't detected. The practitioner helped. |
| Happy | | | | 1 | He asked "if there is lion king," said "that's karate" because he also came to the center for karate lessons. |
| Happy | | | | 1 | When he touched happy, he touched sad too and both responded. He said "just kidding." |
| Happy | | | | 1 | The practitioner asked if she could switch the dolls and he said "no that is sad" and wanted to keep the order he was used to. |
| Happy | | | | 1 | He said happy and touched the happy doll. |
| Happy | | | | 1 | The practitioner tried to teach him a special way to touch the dolls. He sang the Tigger song, said happy and tried to touch the doll the way the practitioner taught him. |
| Surprised | | | | 1 | He tried to touch happy and the practitioner gave him some help. |
| Happy | | | | 1 | He started to say "the computer…" and the practitioner said yes, the computer was frustrating. He tried the new touch method and got it. |
| Angry | | | | 1 | He echoed the clip and said "that's mad" and "that's not right for him to fire her" referring to the clip. |
| Happy | | | | 1 | He contemplates his decision and then said happy and tried to touch the happy doll. The practitioner told him not to lean on the doll and to try again. |
| Happy | | | | 1 | The practitioner helped him with his selection and the doll did not work. He said that the guide on the screen was "ignoring us" because the audio stopped playing. He said that "he shouldn't ignore us because only mean people ignore other people." He tried to touch the recliner for that doll as the practitioner fixed the doll. He said that this was hard and the practitioner started a new clip. |
| Happy | | | | 1 | He leaned on the dolls and echoed "mam." |

**Session Information**
Session Date: 26-Apr
Session Number: 2
Number of Trials: 11
Total Time of Session: 10m 22s
Cues Present on Child Screen: Guide; 6 seconds between Cues; Guide Prompt: Match;
Consequence Reinforcement Clip: Yes

**Results**

| | |
|---|---|
| Rate | 0.02 |
| Accuracy | 1.00 |
| Fluency | 1.39 |

Session Data

| Emotion | G | H | I | C | Comments |
|---|---|---|---|---|---|
| Angry | | | | 1 | He said “she's mad,” “she's the bad girl,” and he sang the Tigger song and rocked in his chair and laughed. Then he sang the star wars song. |
| Surprised | | | | 1 | He said “surprise” and said it looked scared. |
| Surprised | | | | 1 | He touched the surprise doll. |
| Angry | 1 | | | 1 | He touched the angry doll. |
| Happy | | | | 1 | He said “he’s just kidding.” |
| Happy | | | | 1 | He said “he's happy” and then successfully touched the happy doll. |
| Sad | | | | 1 | He said “he's sad” and started to tell the story of why he was sad. He sang with the Tigger tape. |
| Happy | | | | 1 | He said “look star wars” as he touched happy. |
| Happy | | 1 | | 1 | The practitioner asked what they are feeling and he said “happy.” |
| Happy | | | | 1 | He said “he quits,” he said he is “surprised or happy” and tried to touch the happy doll, and said “now we're done.” |
| Angry | | | | 1 | He said “she's mad,” and he got up and got ready to leave. |