The Affective Tigger:
a study on the construction of an emotionally reactive toy

by

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ABSTRACT:

The Affective Tigger is a toy that responds to the user or playmate in a natural and emotive manner. Specifically, the Affective Tigger recognizes and reacts to the emotion the child is exhibiting. For example, when the child is 'happily' playing with the Affective Tigger, she[1] might move and hold him in a manner that expresses this happiness: she might bounce him along the floor, or hug and kiss him. The Affective Tigger senses this physical interaction, for example he might recognize that the child is bouncing him, and outwardly expresses his own happiness in turn. In this manner, the Affective Tigger is both mimicking the mood expressed by the child and reacting to a behavior exhibited by the child, namely bouncing him. The Affective Tigger was evaluated by assessing the appropriateness of his responses to the child. In twelve play sessions, children were invited into the MIT Media Laboratory to play with the Affective Tigger. The results from these trials illustrated that three year olds are just beginning to recognize emotions in others, four year olds are in the process of discovering an awareness of 'other', and five year old children are well on their way to developing empathy and other advanced emotional responses. It was also shown that a simple sensor-based behavior system such as the one in the Affective Tigger is sufficient to produce the compelling 'appearance' that the Affective Tigger has feelings of his own. The big question, however, remains unanswered, could a child learn, from repeated exposure playing with the Affective Tigger, to recognize feelings and to respond appropriately to them?

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[1]For the duration of this thesis the child will be referred to as a 'she' and Tigger as a 'he' to avoid confusion.

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Chapter 1

Introduction

The Affective Tigger is a project to construct an emotionally reactive and emotionally expressive toy[1]. An emotionally reactive toy is one that recognizes emotionally laden cues from the playmate, or responds to the playmate with an expression of an emotion. The Affective Tigger does both. Hopefully, as the child plays with the Affective Tigger, she learns to recognize his expressions, and begins to notice a causal relationship between her behavior and his responses. Eventually, she might recognize his expressions as either a positive or negative reaction to her behavior. The larger goal is for her to generalize that her actions have social consequences. At the same time, we are observing the form that the child-computer interaction takes on, and we are beginning to extrapolate what kinds of modifications to make to the computer-toy. We are interested in how to 'child-proof' computer interfaces while maintaining the sense of 'child orientedness' inherent in a toy.

There are three phases that comprise the Affective Tigger project: expression, detection, and recognition. Expression refers to the capability of the Affective Tigger to communicate his emotional state to the child. The Affective Tigger uses facial movements, voice, and responsiveness to demonstrate his current state. Detection refers to the Affective Tigger's sensory capabilities. As the child plays with the Affective

[1]For more information on defining and distinguishing emotions see, Arnold M.B., Ekman P., Friesen, W.V. & Ellsworth P (1972), Frijda N.H. (1986, 1988), Izard, Carol (1977, 1987), and Kagan J. (1994).

Tigger, she naturally holds and moves him in a manner that is emotionally expressive. The Affective Tigger is designed to sense specific cues which correspond to the child's expression of emotion. Finally, the recognition phase consists of trials with children to evaluate the Affective Tigger according to the appropriateness of his reactions to the child. This phase concluded with both an evaluation of the Affective Tigger's behavioral system, and an assessment of the child's level of emotional development.[2]

1.1 Project Motivations

The Affective Tigger project concerns both the construction of an emotionally reactive toy and the social/emotional awareness education of the child. In fact the two are intimately linked. The study of the development of emotional intelligence lends itself to the construction of a computer-toy. This construction process itself provides meaningful insight into the emotional development of children, which in turn drive the construction process and redesign, in a cycle of progress.

1.1.1 The Call for the Formalization of Emotional Education in Schools

The emotional education debate includes big questions like, why do we need to teach children about emotions in school at all, and how should such teachings be implemented. Schools are torn between taking responsibility for the emotional education of its students, and with it the liability when things don't go as planned, and leaving it as it is today up to the parents.

> Educators, long disturbed by school children's lagging in math and reading, are realizing there is a different and more alarming deficiency: emotional illiteracy. Signs of the deficiency can be seen in violent incidents,

[2]Emotional Intelligence is a term used extensively by Daniel Goleman that refers to one's ability to "rein in emotional impulse; to read another's innermost feelings; to handle relationships smoothly is - as Aristotle put it - the rare skill 'to be angry with the right person, to the right degree, at the right time, for the right purpose, and in the right way"' (Goleman, 1995).

such as the shooting of Ian and Tyrone, growing ever more common in American schools (Goleman, 1995).

Most social scientists agree with Daniel Goleman that there is a need for emotional education in a formalized setting. Recent events like the April 1999 school shooting at the Littleton High School in Colorado continue to open the eyes of the public to the problems that can accompany an underdeveloped emotional intelligence. While some scientists have been studying the effects of the emotional development of children for years, others are just beginning to look at these questions. It is unfortunate that it takes a tragedy for people to want to make a change in the current educational system.

> Children who gained more insight into their emotional lives, were better able to cope with distress and anxiety, to the extent that they gained insight into the causes of those emotions (Harris, 1989).
>
> If the education of the emotions were merely a matter of development it would proceed under its own momentum, and not require the help or intervention of teachers. In the case of human beings an essential part of this environment is the presence of other human beings who not only attend to them, meeting their physical needs, but interact with them. For man is essentially a social being. The aims of the 'education of the emotions' are to provide a suitable environment for the unfolding of the affective aspects of the person (Dunlop, 1984).
>
> Perhaps the most disturbing data comes from a massive survey of parents and teachers and shows a worldwide trend for the present generation of children to be more troubled emotionally than the last: more lonely and depresses more angry and unruly, more nervous and prone to worry, more impulsive and aggressive (Goleman, 1995).
>
> We take emotional development for granted. For the most part, we regard it as something that just happens... Thus, retarded emotional development, emotional immaturity, poor impulse control, and so forth are used

> to explain a person's inappropriate social behavior and many other kinds of pathological behavior. But perhaps we should look at ... emotional maturity as a desirable educational and social objective. To do this we must give up the idea that our emotions are innate and just transferred from one object to another... I would argue that emotional development is a product of emotional education. It is not just something that occurs naturally but it is a manifestation of parental and caretaker values. They listen to their children's comments and questions and respond to them (Dupont, 1994).
>
> If there is a remedy I feel it must lie in how we prepare our young for life. At present we leave the emotional education of our children to chance, with ever more disastrous results. As Aristotle says, the problem is not with emotionality, but with the appropriateness of emotion and its expression. The question is how can we bring intelligence to our emotions - and civility to our streets and caring to our communal life?
>
> Abilities such as being able to motivate oneself and persist in the face of frustration; to control impulse and delay gratification; to regulate one's moods and keep distress from swamping the ability to think; to empathize and to hope; to recognize emotions in our selves and others ... can indeed be learned and improved upon by children - if we bother to teach them (Goleman, 1995).

Rather than dwell on the negative, sensationalizing the problem, Daniel Goleman has searched for a solution. He has come up with a curriculum for teachers to integrate into their classroom sessions designed to augment a child's emotional development. The opponents to this implementation argue that it is not appropriate to teach kids about emotions in classrooms, rather it is the job of the family to educate their young. This opposition is beginning to wane, especially in the face of huge tragedies, linked to the underdevelopment of emotional intelligence.

> On the one hand, schools are designed to keep kids busy learning about the outer world and not about themselves. On the other hand, families are not helping... They are either disintegrating, they can't afford to waste time listening to 'teenage issues', or they just don't know how to handle the complexity of issues involved... When adults are gone, kids spend time with technology (i.e. video games, online forums, e-mail, etc.). However, most of these technologies do not support children's introspection and communication about their insights to others. Only when crisis happens, does the Internet become a collective Freud's coach. Why wait so long?
>
> I believe that we can design technological environments that would engage kids... on a regular basis, not only after a crisis. I also believe that technology by itself won't be the solution to complex social problems that give rise to events like the one in Colorado. However, I am convinced that as researchers designing learning environments, we can add our two cents to provide better technological tools to help people connect with their inner world and their communities (Excerpt from an email from Marina Umaschi Bers to the MIT Media Lab. (1999))

The use of technology to augment the emotional education in schools and at home is an exciting prospect that has not been fully realized. The Affective Tigger is one of these tools. The larger goal of the Affective Tigger project is to assess the viability of using a computer controlled toy to teach the skills of emotional intelligence in an explicit manner. The choice of a toy, specifically a plush animal, was a result of the desire to appeal to the preschool aged child.

> The preschool years are crucial ones for laying foundation skills, and there is some evidence that Head Start can have beneficial long-term emotional and social effects on the lives of its graduates even into their early adult years - fewer drug problems and arrests, better marriages, greater earning power. The Kindergarten year marks a peak ripening of the 'social emotions' - feelings such as insecurity and humility, jealousy and envy,

Figure 1-1: Rosalind Picard and son Michael holding the Affective Tigger.

pride and confidence. Children in the youngest grades get lessons in self-awareness, relationships, and decision-making. Some of the most effective programs in emotional literacy were developed as a response to a specific problem, notably violence. As a society we have not bothered to make sure every child is taught the essentials of handling anger or resolving conflicts positively - nor have we bothered to teach empathy, impulse control, or any of the other fundamentals of emotional competence. By leaving the emotional lessons children learn to chance, we risk largely wasting the window of opportunity presented by the slow maturation of the brain to help children cultivate a healthy emotional repertoire (Goleman, 1995).

1.1.2 Affective Computing

The Affective Tigger project is part of a larger field of research called Affective computing (Picard, 1997). This group is focused on combining computer science with emotion research. This excerpt from the Affective computing web page, explains the

larger goal of the Affective computing group. These goals also apply to the Affective Tigger project.

> Affective computing is computing that relates to, arises from, or deliberately influences emotions. Our research focuses on creating personal computational systems endowed with the ability to sense, recognize and understand human emotions, together with the skills to respond in an intelligent, sensitive, and respectful manner toward the user and his/her emotions. We are also interested in the development of computers that aid in communicating human emotions, computers that assist and support people in development of their skills of social-emotional intelligence, and computers that 'have' emotional mechanisms, as well as the intelligence and ethics to appropriately manage, express, and otherwise utilize these 'emotions.' Embracing the latter goal of 'giving machines emotions' is perhaps the most controversial, and is based on a variety of scientific findings, which include indications that emotion plays a crucial role in enabling a resource-limited system to adapt intelligently to complex and unpredictable situations.
>
> In short, we think mechanisms of emotion will be needed to build 'human-centered' machines, which are able to respond intelligently and sensitively to the complex and unpredictable situations common to human-computer interaction. Affective computing research aims to make fundamental improvements in the ability of computers to serve human users, including reducing the frustration that is prevalent in human-computer interaction. We expect that efforts in building affective computers will also facilitate substantial contributions to research on basic human emotions (Group, 1999, About Affective Computing).

1.1.3 Related Work

There are several other projects in progress to develop affective toys. Rather than recognizing cues from the playmate, these 'pet robots' respond to the playmate with an expression of an emotion. Some are scientific based, designed to realistically model the emotional states of a real animal. Others are more closely aligned with toys. These toy 'pet robots' are twitchy, cuddly creatures, designed to entertain the playmate. A robot that emulates the behavior of a real animal is not a new concept. The Affective Tigger is not, however, an exercise in artificial intelligence. His motivations are not self guided, nor do they arise on their own without provocation. The Affective Tigger does not get hungry or thirsty. The reason for this is that he is designed to facilitate research into the emotional education of children, rather than to explore an experimental implementation of a theoretical emotional model.

There are four specific products on the market today that are related to the Affective Tigger. The first one on the scene was Microsoft with their 1997 release of a computer and video reactive Barney doll, and their 1998 release of a similarly designed, albeit slightly more sophisticated, Arthur doll. Both Barney and Arthur are facilitators toys. That is, they are responsive only to a predetermined set of cues from either the television or the computer. Their goal is to engage the child with that medium. The Affective Tigger, on the other hand, responds to the child directly, as a social partner, rather than simply facilitating a shared television or computer experience. Both Microsoft dolls have limited responsiveness to the child directly. For example, if you cover their eyes they comment on how dark it suddenly became. However neither one strives to assess the emotional mood of the play experience. Barney and Arthur are classified as educational toys, Barney teaches the preschooler rudimentary computer skills and keeps them company while they watch television, while Arthur also teaches the slightly older child how to tell time. The Affective Tigger on the other hand is instructing the child on something far less tangible. The Affective Tigger is a toy on which to practice emotional development skills and affective communication.

The rest of the similar products are not commercial special plush as much as

they are robots. Omron, a Japanese company, has developed a robotic house cat named Tama (Tashiro Tashima, 1998), Sony has a robotic dog (Laboratory, 1999), and Honda Motor Corp has a bipedal humanoid named P-2. The focus of these groups is the implementation of a realistic emotion system. They are developing a behavior model for the cat and dog that incorporates emotions into the motivational system. The cat, for example, interacts with users and her surroundings, as well as having her own internal drives, sleep, curiosity, attention. The emotional expressions of the cat robot include satisfaction, anger, uneasiness, and disgust. Neither the cat nor the dog responds directly to the affect of the user. However, similar to the Affective Tigger, the robotic cat does reinforce 'good' behaviors like petting and stroking, and she does become angry when the user repeatedly hits her. The Affective Tigger is an instructional toy. He responds directly to the child without ulterior motives such as hunger or sleep to confuse his behavioral expression. When a child makes the Affective Tigger unhappy, it is because of something that the child has done, and not that the Affective Tigger is hungry or sleepy or has some other unfulfilled need.

Another scientific robot being developed is Kismet, a robotic infant for social interaction. Cynthia Breazeal, working under professor Rodney Brooks, of the MIT Artificial Intelligence Lab, is studying the anthropomorphic phenomenon that occurs between mother and infant. Kismet has a range of facial expressions which he and his user both learn to associate with his different drives. The focus of this research is on the way humans impose meaning on every 'coo' and 'gurgle' an infant may make. Kismet has been developed to investigate the emotional behaviors of the robot as seen through physical interaction between human and robot. You can pat, stroke, hold or even beat any of these robots. The difference is that the Affective Tigger is not an implementation of an emotional model. His internal composition is very flat so the user can see the effects of her actions directly. All of these scientific robots have complex internal Artificial Life systems that are reflected in that they strive to satisfy their own needs, and they do not necessarily obey you. Rather than toys focused on the playmate, these robots are autonomous ego-centric entities with behaviors arising from various needs. The Affective Tigger on the other hand is user

'centered'. Without the stimulus of a playmate the Affective Tigger sits lifeless on the shelf.

Finally, there is Furby, a toy made by TIGER toys and Hasbro. Furby is a non-descript animal with huge ears, moving eyes and a beak which makes it very different from a character like Tigger, who has a well developed personality and a story. Furby is reported to *"not only belch and pass gas but it 'learns' as it matures, going from 'Furbish' nonsense to such English phrases as 'big light' when placed in the sun and 'big noise' when subjected to traffic"* (Variety, 1999). However, the idea that Furby is 'learning' is questionable at best. Furby's only exhibition of an emotional state is when he begins to sing. However, what causes Furby to become happy enough to start singing is unclear, and probably random. The Affective Tigger, on the other hand, displays emotions in response to the playmate. His happy state is a form of reward to the playmate for gentle behavior. Furby's unresponsiveness to being smacked around, or turned upside down, make him seem less like a social friend and more like a toy. Cynthia Breazeal sums up Furby's attributes quite eloquently when she says:

> I actually have 2 Furbys. I bought them to see what $34 of AI will get you these days. Turns out, it won't get you any AI. Not surprisingly, Furby is not a social creature. It doesn't have drives, goals, or any sort of internal agenda it has to satisfy. It doesn't perceive or really express any sort of emotions, feelings, affective states, etc. It doesn't learn, although that's what the Tiger folks would like kids to believe. However, they have hooked up some cute animated responses to various sensory triggers (switches, IR, inclination, simple sounds). They took the extra step of having some of these animated responses released as Furby gets 'older' which is kind of cool. So, their behavior does change over time, although not because of learning. They can also respond to each other through IR, and their interactions get more sophisticated over time (again, not because of any learning). I think that's a nice extension of past toys. However, needless to say, my fears of having my Ph.D. embodied in a $34 toy have not come to pass (Excerpt from an email sent by Cynthia Breazeal (1999)).

In general, these affective toys and robots have begun to produce emotionally conscientious computer interfaces. The Affective Tigger is in the unique position of being an educational computer-toy. He is not only recognizing and synthesizing emotional information, but also using responsiveness to teach the playmate about actions and consequences.

The Affective Tigger's reaction is indirectly produced by the child's emotional behavior. Thus, the connection can be made that if the child is hurting him, the Affective Tigger becomes unhappy. And visa versa. *"We expect the child to discover the general rule from a set of experiences by means of induction. Script metaphor: to know the meaning of the word fear, to have the concept expressed by that word, is to know the sequence of experiences which occur in a fearful situation"* (Saarni and Harris, 1989). Specifically, through normal play experience, the child learns what she can do to 'make Tigger sad'. Once the child makes the connection between her behavior and his response, she has learned and demonstrated what I am referring to as emotional recognition. If the child can take the next developmental step and discover what she can do to 'make him happy again', she has learned and demonstrated compassion and empathy. This is the beginning of emotional intelligence.

1.2 Child Development

> If we were asked to describe the sort of person we would be most frightened of, we might well think of a man whose intellectual powers were outstanding and properly trained but who had no 'heart' and no feelings. Such a person, we might think, would be capable of any enormity... We may also recall occasions when we have heard people say about their children's education: 'I don't care how clever he is, or how many qualifications he gets out of school. As long as his heart's in the right place he won't go far wrong.' ... Parents and Educational writers have consistently criticized schools for failing to out the 'heart' of their pupils 'in the right place', or in modern terms for failing to educate their emotions. There can be no

doubt of the very great importance of affective education (Dunlop, 1984).

Emotional development in the pre-operational child progresses through several stages. The first skill to be acquired is emotional recognition, then expression, and a development of a sense of self, until finally the child internalizes these lessons and becomes aware of other people's feelings. The final stage of acquiring empathy is not an end unto itself. Each individual develops differently, some end up with more social understanding and awareness of emotions and affect than others. I have chosen to explore the viability of using an emotionally reactive toy to augment the initial development of compassion and emotional understanding in young children. The study of the refinement of empathic development in older children is left for future work.

1.2.1 Moral Assumptions

Children develop at different speeds, and with different personalities, and yet there are some fundamental commonalities within that development. These general rules apply both to the emotional development of the child as well as to their physical growth. The difference between the socialization of a child, and the personal beliefs or morals we live by, is that socialization is the practice of acquiring the general rules and roles of society. There is a careful balance to be struck in what is socially appropriate behavior, and what is personal choice. However, development of the awareness of these social norms is extremely critical, because they comprise the basic tools of affective communication.

> Language enables us to communicate... There is a 'natural' language of gesture, and so on, but because of the 'open' nature of our 'instinctual' drives this has to be supplemented by 'cultural' languages, or languages that have to be taught and learnt. Language binds us together with some people and separates us from others... We speak many 'languages'... (Dunlop, 1984).

> The goal of all agents of socialization is to increase a child's social competence - to teach children what their society expects of them and to give them the skills needed to meet those expectations... The universal goals of socialization [are as follows:]
>
> 1. To fulfill physical needs in appropriate ways.
> 2. To control aggression.
> 3. To master the physical environment.
> 4. To master the social environment.
> 5. To perform essential skills.
> 6. To behave in accord with the society's moral values.
> 7. To prepare for the future.
> 8. To be both an effective individual and an effective member of the group (Fischer, 1984).

Morals are the personal goals we each choose to live by. In creating the Affective Tigger it was important to build upon the social norms listed above, and to leave the personal 'gray areas' untouched. The universal truths I leveraged off of stem from the assumption that the Affective Tigger is more than just a toy. His animal form makes him *"almost alive"* (From a conversation with Sherry Turkle (1999)) which allows me to make some assumptions regarding what behaviors exhibited by the child are 'right' or more acceptable (i.e. hugging, bouncing, etc.) whereas others are less acceptable and therefore labeled 'wrong' (i.e. hitting, poking, etc.). While it is true that my assumptions do not hold true in all occasions and for all cultures, 'for example we can imagine a culture that hunts and eats the meat of tigers, wherein it may be highly encouraged for children to gain the courage to poke at the eyes', they are a conservative place to begin given the children I was likely to encounter in these trials.

The affective education of a child is a very large task indeed, involving parents, siblings, and peers, as well as teachers. It begins almost at birth and continues to evolve throughout one's lifetime. During Piaget's pre-operational stage, from age 2 until about 7, the child undergoes the most radical socialization. The child is transformed from a dependent egocentric infant to a compassionate caring school-

child. A review of the literature on this transformation is the basis for the rest of this chapter.

1.2.2 Emotional Recognition in the Very Young Infant

> That no continuity of personality from infancy to adulthood has yet been found does not necessarily mean that none exists (Fischer, 1984).

Children seem to develop an awareness of emotional expressions extremely young. *"At about nine months of age infants begin to monitor the emotional responses of other people... By one year of age normally developing infants are discriminating in expressing emotion... During the second year, infants continue to refine their awareness of others' attention, seek out emotional cues, and increasingly use them to guide their behavior"* (Sigman and Capps, 1997) Other researchers argue that this recognition may develop even earlier but that our methods for detecting it are flawed. As an example, Piaget documented spontaneous smiling at four months, whereas Legerstee (1992) demonstrates that as early as two months infants treat people as social objects, differently than other kinds of objects.

In the first months of life the infant is quite helpless. She relies on a care giver to intervene to relieve stress, distress, fear, frustration and other negative emotions. She becomes conditioned to the idea that the people around her will respond and behave in a particular manner. For the very young child success is extremely important. To feel gratified promotes optimism and trust between the child and care giver. This gratification initially comes from the care giver directly. As the child begins to explore her world she instinctively returns to the care giver periodically for emotional cues and gratification.

> Exhibiting a behavior known as social referencing, infants look at their care givers when faced with a situation which is ambiguous... Further, infants respond to the emotional signal conveyed, approaching in response to positive affect and retreating in response to negative affect (Sigman and Capps, 1997).

Piaget demonstrated that by ten months of age the child is able to discriminate strangers, and begins to show separation anxiety from the mother (Piaget, 1952). This clearly demonstrates the child's acquisition of face recognition, but does not directly imply that recognition of emotional facial expressions has developed.

Darwin (1872, 1873) was among the first to document facial expressions in humans and animals. Darwin documented similarities in the facial expressions of people across cultures, in addition to studying posture, and movement in the limbs, trunk and head. His conclusion that emotions, their expression, and their recognition are innate and universal, are currently in dispute (P. Ekman and Ellsworth, 1972) (Carol Ellis Izard and Zajonc, 1984)(and others). Some of these reports claim that until 3 to 3.5 years, children from different cultures can not even accurately identify happy and unhappy responses in other people (Borke, 1973) (Ekman, 1994).

In summary, the internalization of emotional recognition, by the child, is approximated to occur between the first and third year. Contrary to Darwin's belief that this ability is innate, the general consensus is that through 'social referencing' a child will learn to discriminate between positive and negative valenced emotions. The Affective Tigger project provides further research into the assessment of at what age emotional recognition is acquired.

> The capacity to distinguish among different expressions of emotion is not tantamount to the possession of a concept of any of the discriminated emotions. Admittedly it is possible, - certainly Darwin argues as much - that infants have an innate capacity not simply to recognize particular facial expression of emotion but also to identify the emotional state that they convey. It seems safer to view the infant as being well tuned to the discrimination of emotional expression but requiring considerable instruction in their significance. Children can not understand the most basic emotional states unless they penetrate beyond the expression of those states (Saarni and Harris, 1989).

1.2.3 Emotional Expression in the Infant

The first step in penetrating beyond the capacity to recognize the facial expression of emotion, is the generation of that same facial expression at appropriate moments. The key to this stage is the appropriateness of the expression.

Newborns respond to the sound of another child crying in turn with their own crying. Between 4 and 8 months a child will mimic the emotional facial expressions of their care giver. Piaget explains this phenomena by saying that *"infants can not differentiate themselves from their environment, thus they are imitating what they perceive"* (Piaget, 1962). His claim that the infant is confusing the acts of others with her own, has been actively debated with many supporting and contradictory studies: Meltzoff and Moore 1983, Abravanel and DeYoung(1991), Legerstee(1991) Fontaine(1984) Hayes and Watson(1981), Koepke et all (1983) MeKenzie and Over(1983).

Piaget named such behavior 'pseudo-imitations' because of the lack of intentionality. He thought of the expressions in newborns as a reflex rather than a true display of an emotion. Piaget views imitation as the bridge from the sensorimotor response to intelligence. When the child becomes proficient at imitation, she will begin to imitate internally, thereby forming a mental representation of the expression. This signals the internalization of the emotion, value, or belief. Internalization is exhibited as the ability of the child to imitate or reference something to which they have been previously exposed.

Piaget's studies concluded that children don't internalize or emphasize emotion until age seven. However these results are contradictory even to his own findings that the pre-conceptual child (aged 2 to 4) also achieves the capacity to form mental representations for absent things or events.

> By four years of age, children attempt to talk themselves out of their frustration by trying to convince themselves that they did not want whatever it was they could not have, or, alternatively, attempt to remove the prohibition by persuading others that they should have the object they desire

(Sigman and Capps, 1997).

This more sophisticated use of logic demonstrates a mastery of control over emotional expression. While mimicry is and important tool for understanding the emotional development of the child, it can not be used alone. Rather, in conjunction with physical and verbal cues (captured on video tape), their combination forms the measure of the child's developmental level. Specifically, part of the Affective Tigger project was designed to use these criterion to asses the child's ability, and found evidence corroborating the above conclusion, that it is during the beginning of the fourth year that children finally internalize their understanding of emotional expressions.

1.2.4 Acquisition of a Sense of Self and Other

> How does the child come to understand that another person is feeling happy or sad, angry or afraid? An understanding of the feelings of other people is something that we expect of any normal human being, but the origins of that understanding are not obvious (Harris, 1989).

The emergence of an awareness of a sense of 'other' is a necessary precursor to emotional understanding. The ability to mimic appropriate emotional responses emerges well before this fundamental knowledge. However, once the child had both mimicry and a sense of 'other', she has arrived at a turning point in her development. Such knowledge enables affective communication between people.

> The preschool child has a good understanding of the causes and consequences of basic emotions such as happiness, sadness, fear, and anger. The acquisition of mature emotion categories would seem to depend on the ability to conceptualize itself and others as experiencers of particular kinds of internal states (Saarni and Harris, 1989).

Piaget characterizes preschoolers by their egocentrism, an inability to take the perspective of another person. This lack of empathy does not mean they are selfish, rather, they can not think any other way. According to Piaget, the understanding

of 'self as an object in space' develops after the understanding of other objects, and does not emerge until the middle of the second year (Piaget, 1952).

Other researchers have demonstrated that this sense of 'self' emerges even earlier.

> To establish themselves as independent individuals, children must mentally separate themselves from their mothers... This initial understanding gradually develops into self-assertion... The baby between 12 and 20 months of age begins to make his own wishes known, even when they clash with his mother's (Fischer, 1984).

Further, Piaget claims that an awareness of 'other' develops long after the awareness of self (Piaget, 1952). Piaget demonstrated this with his famous mountain range experiment (Piaget and Inhelder, 1956). In it they ask a child to draw a mountain range from the viewpoint of a doll. The child's inability to put themselves in the place of the doll resulted in the conclusion that children can not empathize until approximately the age of seven years. Subsequent experiments, however, (Flavell 1977, Marvin et al. 1976 Whitehurst & Sonnenschein, 1978) demonstrate that by the age of 4 or 5 a child can, in fact, take the point of view of another person.

The significance of the development of a clear distinction of 'self' and 'other' can be seen from the following passage. *"A small sample of depressed children clearly view depression as a combination of sadness and fear. In approximately half of the descriptions children reported that they were mad at the self, whereas the remaining accounts provided example of anger directed outward toward others"* (Saarni and Harris, 1989). This is a situation where formalized instruction could have direct benefits for the depressed children. If they knew how to direct their anger, and learned not to confuse sadness with fear, they might be able to learn how to manage their feelings.

Intentionality emerges again as the ruler for the measurement of the development of self and other. What complicates this assessment is the same problem of imitation discussed previously. Children between the ages of 2 and 7 seem to 'go through the motions' of recognizing the 'other' as an independent entity long before they have internalized the concept. In the Affective Tigger project, the emergence of a

recognition of 'other' is assessed as emerging during the third year.

1.2.5 The Emergence of Empathy in the Preschooler

> Empathy is an emotional response that arises in a person as a result of recognizing another's emotional state or condition. Colloquially we refer to 'sympathy pains' that are very similar or identical to what the other individual is perceived to experience. This ability to understand the other's internal state is characterized by a strong emotional response (Lennon and Eisenberg, 1984).
>
> Empathy builds on self-awareness; the more open we are to our own emotions, the more skilled we will be in reading feelings. Alexithymics who have no idea what they feel themselves, are at a complete loss when it comes to knowing what anyone else around them is feeling. They are emotionally tone-deaf. The emotional notes and chords that weave through people's words and actions- the telling tone of voice or shift in posture the eloquent silence or telltale tremble-go by unnoted. Confused about their own feelings, alexithymics are equally bewildered when other people express their feelings to them. It is a tragic failing in what it means to be human. For all rapport, the root of caring, stems from emotional attunement, from the capacity for empathy.
>
> That capacity- the ability to know how another feels- comes into play in a vast array of life arenas, from sales and management to romance and parenting, to compassion and political action. The absence of empathy is also telling. Its lack is seen in criminal psychopaths, rapists, and child molesters (Goleman, 1995).

Comforting behaviors seem to increase in frequency from the age of 2 to the age of 3. It is not clear at what point the child makes the transition from mimicry to internalization. Even young children often seem to be motivated by an understanding

of - and perhaps an emotional response to - another's situation and needs (Eisenberg, 1992).

> Children's reactions to another person's distress change with age. Until the end of the first year, they usually remain bystanders. They often become upset themselves, but they do not make any active attempt to comfort somebody else in distress... In their second year young children begin to deliberately try to alleviate distress in another person; they comfort their parents and siblings at home and later they comfort other children in the nursery school, particularly if they are hurt... Elder children are often observed comforting younger ones. And in turn the younger children often turn to the older ones for comfort.
>
> Reactions to another person's distress vary enormously from child to child... By the age of 2 years, children responded on one third of those occasions in which they saw someone in distress. They did not respond differently if they had or had not caused the distress. Some children responded to more than half the incidents, whereas others responded to only one in twenty.
>
> There is also the matter of expectation of a parent on an older child that the child will be sympathetic to a younger sibling. Most children will be told at some point that it is good to help, comfort or share with other children and bad to upset them. They are quite sensitive to issues of right and wrong, whatever their behavior might lead one to expect. Young children focus not on the adult reactions but on the ways that the victims themselves react for a clear indication that moral transgressions are more serious than violations of convention. Children start to categorize an action as morally wrong, rather than conventionally wrong if they learn that it causes distress. A child who has spent a lot of time with other children will have been exposed to a good deal of information about what does and does not constitute a serious breach. The child's moral intuitions

> are inextricably bound up with an understand of emotion. A child who does not understand that someone is distressed nor what causes it will scarcely conclude that the action that caused it is wrong (Eisenberg, 1992).

The notion of who caused the distress is an important component of the Affective Tigger project. Some children were reluctant to 'make Tigger sad' even when their accompanying adult encouraged it. Other children found the power of 'hurting' the Affective Tigger to be quite intoxicating. In preschools it has been demonstrated that there is an increase in teasing with age (Harris, 1989). This suggests that the preschool children are both developing a sense of 'other' and an awareness of emotions. The increase in teasing might be attributable to the child's way of exploring her new found power. The Affective Tigger becomes a safe space to practice on. With repeated play, hopefully, she can learn that there are similar consequences with the Affective Tigger as with her other playmates. The benefit is that the Affective Tigger can withstand numerous repetitions, whereas a real playmate may never come to play again.

Again we see the confounding source is imitation. The child may be 'going through the motions' of comforting without understanding what it is she is doing. Piaget resolved this imitation dilemma by resorting to the child's ability to produce a coherent verbal account of the mental processes underlying her behavior. This limited his findings to the operational stage (approximately seven or eight years old). Again there is a danger that the young child's true ability is seriously under-estimated. As expected, many studies have found the emergence of empathy much earlier (Lennon and Eisenberg, 1984). The Affective Tigger project relies on empathy as a marker of emotional development. In conjunction with the demonstration of emotional restraint, a behavior that can not be 'faked', they provide an overall assessment of the child's level of emotional development.

1.2.6 The Role of Play in the Emotional Development of a Child

Play is a form of communication for children. Soon after her first birthday a child will begin to exhibit empathy toward her dolls. By her second birthday, she is actively engaged in pretend play. She will imitate domestic roles, and take on the role of other people (mother, teacher, etc.). The ability to play pretend games signals the development of symbolic representation within the child.

> Between two and two and a half years, children begin to endow dolls with a capacity for action and experience: the dolls are made to talk and act independently, and eventually credited with desires, sensations and emotions. Three year olds can make a distinction between the real world and the world of imagination. If they are given an emotion, they can suggest a situation likely to cause it. Three and four year olds are good at figuring out which emotions go with which situations. Children can conjure up pretend or imaginary psychological states, such as desires or beliefs, and project them on to their dolls and toy soldiers (Harris, 1989).

How Gender Biases a Child's Play

> Preschoolers are more likely to cooperate when their peers attend to their cooperative behaviors... Children who view other children sharing, expressing sympathy, or helping someone are more likely to do so themselves (Eisenberg, 1992).

Although the influential role of peers in the emotional development of a child goes without question, the issue of gender is highly controversial. Some researchers cite clear gender distinctions in the early years. *"The learning of sex roles begins in the preschool years, and by the end of that period, the behavior of boys and girls has become different in many ways... Boys play much more with objects, such as building blocks and trucks; they do more outside activities, like riding tricycles and playing*

in the sand box; and they fight a lot more" (Fischer, 1984). Others argue that no such distinction is apparent. *"Children do not display gender differences in empathy when empathy is assessed with facial/gestural or vocal measures. Gender differences in empathy may be an artifact of the method of measurement"* (Hoffman (1984)). *"Although girls may perform some types of prosocial behaviors more than boys do, there are no clear sex differences in pro social behavior"* (Eisenberg, 1992).

1.2.7 The theoretical use of the Affective Tigger as a tool for the emotional education of children with developmental impairments such as autism

A secondary motivation in building a reactive affective toy comes from research with autistic children (Blocher, 1999). Autism is a rare psychological disorder that has been the subject of much research.

> There are four main symptoms that partially identify the disorder. First Autistic children do not seek social interaction; in fact they often avoid other people... The second sign of autism is prolonged repetitive behaviors. These children may spend hours performing one or two actions with a single object or with their own bodies. The third symptom is the children's characteristic reaction to interruption of this ritualistic play and to changes in familiar parts of their environment: they often respond with a terrible temper tantrum. The fourth characteristic of autistic children is their severe inability to communicate, in infancy through gestures and later through language... The cause of autism is unknown... Most researchers now agree that autism is caused by some biological factor, although no one has yet been able to identify it (Fischer, 1984).
>
> Autistic children feel and express emotion but have a difficulty in making sense of other people's emotions. Although autistic children may learn to understand what will earn them approval and disapproval, in the absence

> of other people they should experience neither pride nor guilt (Harris, 1989).

Kanner (1959), the man who first diagnosed and named autism, emphasizes that the abnormality in the autistic child's emotional response to other people is the fundamental impairment. *"When children with autism do engage in triadic interaction, then, it is generally to make a request, and very rarely to share an emotion or experience"* (Sigman and Capps, 1997).

> As with deficits in imitation and joint attention behaviors, the effects of insufficient social referencing behavior are far-reaching and cumulative. These deficits restrict access to information that is relevant to a given situation, and - what is more important - they diminish autistic persons' participation in creating shared meaning. Joint attention and social referencing behaviors enable children to learn through and from other people how to respond to objects and events, both emotionally and behaviorally (Sigman and Capps, 1997).

> Often these children seem not to know what they are experiencing... One little girl told her therapist, 'I'd like my feelings to be dead because I get afraid they're going on and on and never stop and then I will just disappear in the feeling' (Cohen and Donnellan, 1987).

Autistic children need increased repetition to learn certain social skills. Lovaas (et. all. 1967) successfully used repetition as the primary teaching technique for autistic children, and it is still used today. By engaging the autistic child with a toy, such as the Affective Tigger, that has infinite patience, the child can practice emotional recognition skills with hundreds of repetitions.

The questions surrounding the emotional development of a child remain quite unanswered. Do infants have feeling states? At what age do expressive behaviors begin to reflect those states reliably? Thus far, we can only show that the age range from 2 years to 7 is marked with some dramatic emotional development milestones.

We can, however, now identify some of the criterion on which to measure our assessment of the child's emotional intelligence. With this ruler, we can look at the 3 - 5 year old children and begin to identify their progress in quantitative ways.

The Affective Tigger project attempts to demonstrate the usefulness of employing a computer controlled toy in the study of children's emotional development. To this end, we looked at the effects of age, shyness, and siblings, on a measure of emotional intelligence of eleven different children. To quantify the level of emotional development of the child, we looked for signs of a developed sense of 'other', recognition of the emotion expressed by the Affective Tigger, mimicry of his expressions, verbalization of feelings, emotional restraint, and physical acts of empathy.

Chapter 2

Pilot Study

Before the Affective Tigger was constructed and evaluated, the hypothesis that a child could learn about emotions from a toy was formulated. To assist in enabling this formulation two preliminary questions had to be resolved. First, do children impose emotions onto their stuffed animals? Prior research (Eisenberg, 1992) suggests that 3-4 year old children are beginning to imagine their dolls have feelings. Secondly, can a child recognize the emotional expressions of the Affective Tigger? The following pilot study was specifically made to test this question.

2.1 Playing with a Stuffed Animal

The systems, sensors, and behaviors at work in the Affective Tigger are customized to both the Disney version of Tigger's personality, and to one particular stuffed animal. One could not, for example, take out the workings and put them into say a Smurf and expect it to make sense. For one thing, a Smurf doesn't bounce like a happy Tigger does. A Smurf would express happiness in ways wholly different from Tigger, depending on which Smurf was chosen.

There are dozens of stuffed Tigger dolls available on the toy store shelves today. From plain old plush toys, to mechanical springy toys, to fully automated bouncing Tiggers. From the gamut of choices, a single animal was chosen for its expressivity, size, and weight. The chosen toy was a readily available Disney store variation of

Figure 2-1: A happy Tigger.

Tigger, with big ears, and a long tail.

To study the impact of the chosen Tigger shape, three female and one male child, aged five to thirteen years, were asked to play with the unaltered stuffed Tigger. In the course of their play, the children were asked to 'make Tigger look happy' as well as sad. From observing these play sessions, several interesting features were identified as potentially emotionally relevant. The most prominent feature to their play was the availability of the ears. This Disney doll has especially large ears and the children immediately grabbed and pulled on them when asked to make Tigger look happy or sad. Tigger's mouth was the secondary feature of interest: the children closed it to make him look sad, and let it spring back open when he was happy. One child mimed the action of opening and closing a zipper over Tigger's mouth. The association of mouth with the distinction of happy and sad is corroborated by the research of Field (et. all, 1992) who noted that infants looked primarily at the mouth for happy and sad expressions. One child specifically bent Tigger's head forward in response to my request to make the Affective Tigger look sad. Three of the children bounced the Affective Tigger to express happiness.

Voice was another compelling feature, laden with emotional information and ex-

pressivity. Although it was not available in the preliminary studies, the children in the main study have been extremely responsive to the vocalizations of the Affective Tigger. They all seem to expect a toy to speak, even if that utterance is complete nonsense.

Once the play sessions were underway, children repeatedly asked me for more interaction from the Affective Tigger. Specifically, they want to make him happy when they clap his hands together, and sad when they pull on his whiskers. A child who can reason well enough to ask questions like these, is indeed projecting feelings onto his/her toy, and has an understanding of the causes for various emotions.

2.2 Recognizing Tigger's Expressions

From the results of the first experiment, I created a prototype Affective Tigger, capable of limited expression. Initially only his ears moved. I asked three teenage children in an informal survey if they could identify the Affective Tigger's expressions. They easily identified 'happy' and 'not-as-happy' from 'sad' but mentioned that in general he always looked happy. Once I sewed the Affective Tigger's mouth shut they all agreed that the 'unhappy' expression was more easily identified, than before.

2.2.1 Redesigning the Affective Tigger

The first prototype of the Affective Tigger was constructed using a single servo motor, the HANDY board, a switch, and a bend sensor. I printed a skull on the Stratasys Genisys 3D printer using True Space and Quick Slice. This skull housed the servo motor controlling the positioning of The Affective Tigger's ears. This skull was determined to be too hard, and heavy. It was replaced with a soft rubber ball in the Affective Tigger's head, and a custom housing for the servo in his body. This prototype had no vocal expression and only responded to being bounced and having his neck bent.

In the second generation of the Affective Tigger, a small plastic jaw was included that closed the Affective Tigger's mouth when he was 'unhappy' and opened it when

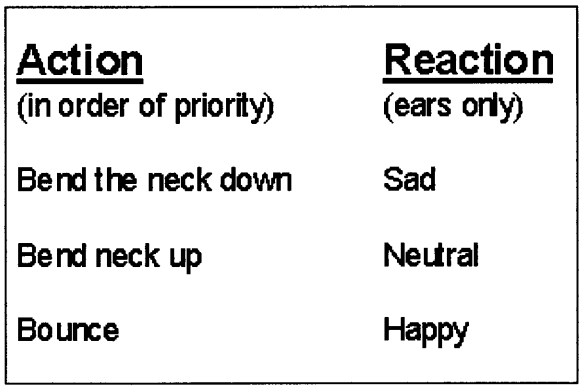

Figure 2-2: The state diagram for the prototype Affective Tigger used in the pilot study.

he was 'happy'. Several vocalizations were added (see section 3.2.2) that represented the various emotional states. When the three teenaged children were asked to identify the expressions of the Affective Tigger after the inclusion of voice, they all commented on how much easier it was.

In three of the main trials, the three to five year old children were introduced to the Affective Tigger with no preliminary instruction, and asked to figure out on their own what it is that the Affective Tigger does. The children had little difficulty identifying the Affective Tigger's emotions, even when they could not understand his words they could identify that he was happy or sad. On other occasions, either the parent prompted the child to 'make Tigger happy' or the experimenter demonstrated what to do to the Affective Tigger. Sometimes the experimenter was compelled to prompt the child by asking 'does Tigger look happy or sad?'.

On one occasion, 18 third grade students from a nearby elementary school were presented with two Furbys and the Affective Tigger. They took to the Furbys first, then started to play with and identify the Affective Tigger's behaviors. After ten minutes, the boys in the class were primarily clustered around the Furbys, and making up stories about their chatter. The girls on the other hand were primarily interested in the Affective Tigger, and were teaching each other what to do to elicit a response from him.

It was counter to my intuition that the boys of the group would be more interested

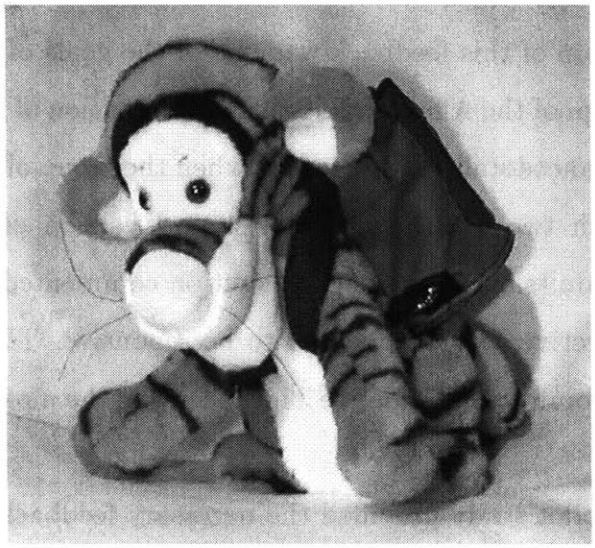

Figure 2-3: An unhappy Tigger with his mouth sewn shut.

in the passivity of the Furby. They were not interested in his switches or buttons, only in the vocalization produced. It surprised me to see the girls involved in the more hands on discovery process of what makes the Affective Tigger work.

2.3 Preliminary Conclusions

The four children in the first experiment were observed playing with the unaltered stuffed Tigger (see 2.1). From these observations, a prototype Affective Tigger was constructed. This prototype had animated ears that make him 'look' happy when he was bounced, and 'sad' when the child bend his neck forward.

The prototype Affective Tigger was then given to three teenaged children, and they were asked to identify his expressions, both with and without voice. The teenagers were eager to offer suggestions and comments on how to improve upon the prototype. They made it clear that more features should be included in the next version of the Affective Tigger. Going back to the observations from the first experiment, three more behaviors were selected (tilt, abuse, and tail pull) to be measured. The sensors were carefully chosen and positioned in the second Affective Tigger to measure these

behaviors and to heighten the illusion that the Affective Tigger was responding to the child. Acquisition of this feedback was one of the goals of the pilot study.

After the redesign of the Affective Tigger, the evaluation of his success at achieving responsiveness was anecdotally corroborated when the group of 18 third grade children were presented with two Furby's and the second version of the Affective Tigger. The teachers and adults observing the interaction commented that even under these conditions, the Affective Tigger appeared to be reponsive. The children who figured out how to hurt or comfort the Affective Tigger seemed the most excited about playing with him.

In general, the pilot study provided the necessary feedback of which behaviors to measure for the redesign of the Affective Tigger. It also demonstrated that teenage children could recognize, more-so with the inclusion of voice than without, the two moods of the Affective Tigger - happy and sad.

Chapter 3

Constructing an Expressive Toy

The construction portion of this project involved significant design and redesign efforts. Once several interesting features of the child-toy interaction had been isolated, a sensor was incorporated into the Affective Tigger which could detect that behavior. The Affective Tigger evolved to include the incorporation of voice, and his sensors became more refined as the children talked about what they did and did not like about this toy.

3.1 Design Goals and Philosophy

To the child, the Affective Tigger seems to have his own emotions. As the child plays with him, she learns both how to recognize his emotional expressions and to predict which of her own behaviors give rise to his various emotional expressions.

Since the Affective Tigger does not have real emotions, much of the design effort went into creating the illusion that he does. With the focus on what the child perceived and not on the hidden layers and complex processing of the sensor input, the Affective Tigger has become a believable character apparently endowed with a spectrum of feelings. While the sensory interpretation is an important part of the project, keeping it simple was the main goal in the design and re-design process. This facilitates a connection between child and toy such that she can directly see the consequences of her actions. Once the child has learned the consequences (that is, the

Affective Tigger's response) to her behavior, both good and bad, hopefully she can begin to apply that knowledge to other areas of her life.

The Affective Tigger has a passive personality. When left on his own, he remains in a neutral emotional state, and sits quietly on the shelf. However, as the child begins to interact with him, he 'comes to life' strengthening the bond between child and toy. This passivity increases the contrast between when the child is and is not playing with him. Thereby making his ability to respond to the child even more apparent.

3.1.1 Huggable Computing

The Affective Tigger is the first computer a child might be exposed to. He's portable like a wearable computer but far more huggable. Rather than a fragile or delicate computer, the Affective Tigger encourages the child to play with him in a physical hands-on manner. The Affective Tigger can be 'programmed' in that there are perceived direct consequences (output) for the actions and behavior (input) of the child. Rather than inputting programs via a keyboard, the Affective Tigger employs a behavioral method of interfacing with a computer. This hands-on computer play is similar to the technique used on Noobie a large stuffed computer made by (Druin, 1987). The Affective Tigger, like Noobie, occupies a physical space in our world, unlike a computer program, and that foam and fluff existence make him eminently huggable.

3.1.2 Theory Why it will Work

Emotional intelligence is an important component of a child's development. The recognition of expressions in others is not a skill that is typically taught in school, rather, children learn it by trial and error. As with any skill, some people become better at it than others. Research has shown that children who can recognize facial expressions and body language of others, grow up into adults who can recognize the emotional expressions, of others (Goleman, 1995).

The recognition of emotions in others begins with an awareness of body language.

Figure 3-1: A close up of the Affective Tigger.

Darwin documented posture, and movement in the limbs, trunk and head as well as facial expression to typify emotional expression (Darwin, 1965). Body language and the affective information contained therein, is a critical complement to vocal communication. Playing with the Affective Tigger, the child learns to associate slouched shoulders and a drooping head with unhappiness.

Teaching children social skills is more than an exercise in futility. Many people argue that children will learn that their actions have consequences without the aid of a toy. However, there are dozens of alarming statistics documenting the increase in violence in today's schools (Leiderman, 1981). This terrifying trend is being blamed on the lack of a formalized emotional educational curriculum in schools. Such instruction can benefit the child when emotional intelligence is explicitly taught in the classroom and is reinforced at home, when the child has toys such as the Affective Tigger to practice her skills on.

3.2 Description of the Affective Tigger

Today's Tigger is a Disney character. Originally created by Alan Alexander Milne in 1926, the Tigger character is the psychological child of the Winnie-the-Pooh collection, bouncy and exciting (Hoff, 1992). Tigger is described as *"a Very Bouncy Animal,*

with a way of saying How-do-you-do, which always left your ears full of sand..." (Milne, 1928). Of all the Winnie The Pooh characters, Tigger is the most emotionally expressive. His primitive range of emotions (happy to sad) are easily identified by even the youngest of children. Additionally, his vibrant orange coat with the jet black stripes offer an immediate attraction to infants. Tigger's personality is most often happy, or joyful. This is what permits him to easily 'bounce' back from an unpleasant emotional episode.

3.2.1 Phase 1: Expression

The Walt Disney Tigger is a very expressive character capable of using both verbal and nonverbal means of communication. His face has eyebrows that go up and down, and a huge mouth that can curl itself into the saddest frown or stretch into the happiest smile. Additionally, Disney's Tigger uses body language, the position of his ears and the hunch in his back to outwardly show when he is perked up happy or drooping down sad (Thomas, 1995). Tiger's vocalizations also include non verbal cues of emotion. There is the happy "worraworraworra" growl when Tigger is in an especially good mood, and the sniveling *sigh* he makes when he is unhappy.

The Affective Tigger's expressive capability is presently limited to happy, neutral, and unhappy. While children have and can express many different emotions from very early on, the happy, neutral, and unhappy emotions are the most immediate, and can be directly coupled to good and bad. *"Young children are likely to rely on cognitively uncomplicated emotions such as happy and sad which are not only early elements of a child's emotional lexicon but can also be easily understood due to their reliance on a straightforward assessment of success of failure"* (Saarni and Harris, 1989). When the child makes the Affective Tigger 'unhappy', he exhibits that unhappiness in his ears and in his voice. As researchers we can observe the child's response to an unhappy Tigger immediately and directly. While moods often take a long time to develop, and persist for many minutes, the immediacy of the Affective Tigger's response to the child's behavior gives the child, and by extension the researchers, direct feedback.

Due to the vagueness of the Affective Tigger's behavior, the cause of his emotional

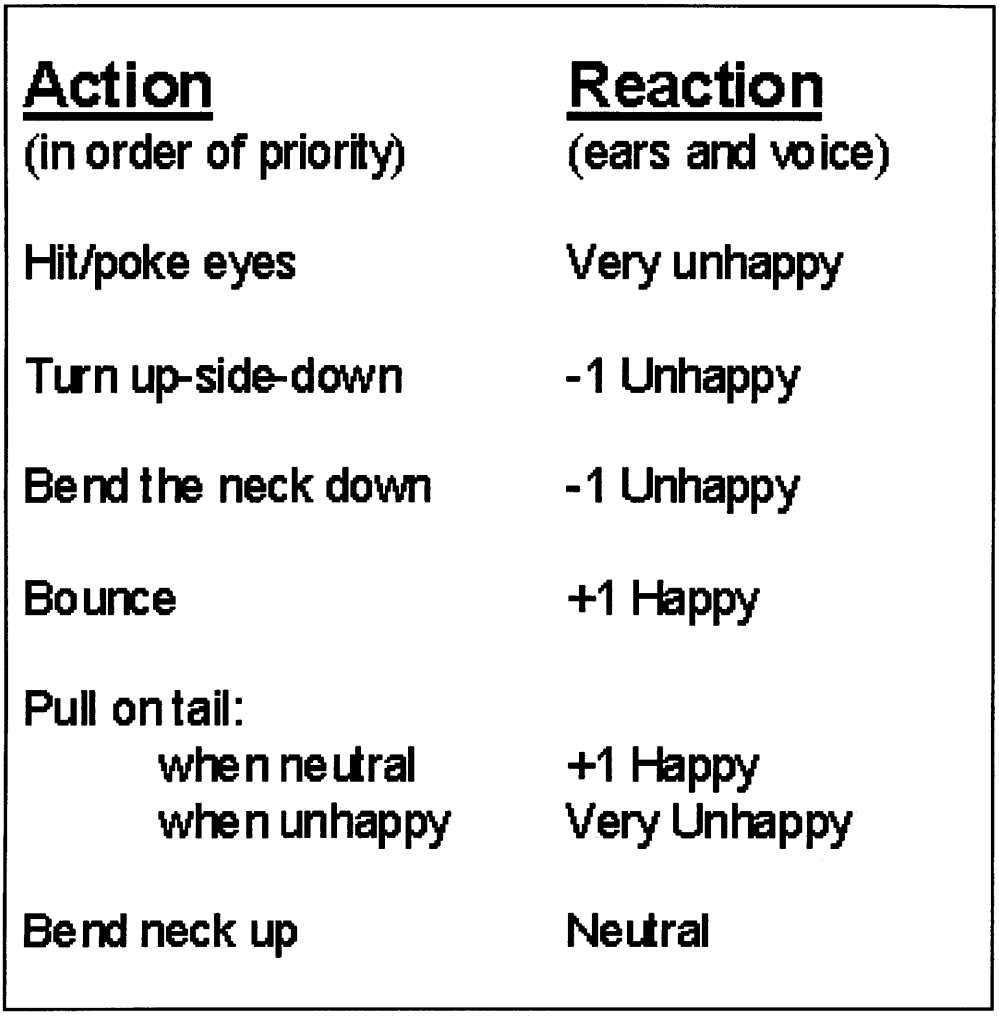

Figure 3-2: The state diagram for the redesigned Affective Tigger. The Affective Tigger progresses up and down in his 'mood' according to the interaction of the child. When left alone, he will 'drift' toward neutral every fifteen seconds.

states are left open to the user's interpretation. This is one of the biggest advantages to the toy, because it allows the child to use her imagination to invent stories surrounding why she has caused the Affective Tigger to be unhappy today, or especially happy. As the child becomes increasingly familiar with the Affective Tigger she will impart upon his behavior a semblance of a personality. She might call him 'silly' or 'easily upset', or refer to him with other categorizations that were not directly built-in.

Tigger's most expressive characteristic is his face. From the extra happy and bouncy Tigger to the sad humble de-bounced Tigger, what changes most dramatically is his posture. I capitalized on this preexisting personality trait by animating the large ears of the plush I was working with. This manner of expression is closely associated with cartoon characters in general, and Tigger in specific (Thomas, 1995). In conjunction with other emotionally charged cues such as a drooping head, the act of bouncing, and other situational contexts and story lines, the motion of the Affective Tigger's ears provide a compelling visual sign of his emotional state. This is in addition to the Affective Tigger's vocal expressivity.

The ears have three positions for each of Tigger's three emotional displays: happy (see figure 2-1), neutral (see figure 3-3), and unhappy (see figure 2-3). There is a stiff wire attached to a small servo motor inside Tigger's head, such that as the wire rotates, the ears move through the three positions.

Two separate servo motors would permit the Affective Tigger to look confused by putting one of his ears up while the other is down. The addition of a confused state is a tangent to the three primary moods of the Affective Tigger, and was determined to be unnecessary for this study. The use of two servos introduced excessive power requirements, space demands, too much extra noise, and was a major part of the cost of the toy[1]. The Affective Tigger would have become confused when the child bounces him in a happy manner during a sad mood, or gave other mixed signals.

A string attached to the Affective Tigger's jaw is pulled in coordination with the movement of the ears by the servo motor. During unhappy moods, the Affective

[1]For more information on the cost of the Affective Tigger see the table in Appendix E.

Figure 3-3: A neutral Tigger.

Tigger closes his mouth. The closed mouth augments the illusion of unhappiness, whereas the open mouth incurs a happy expression.

Sound in general, and voice in particular, is a very important piece of the interaction between young children and their toys (Erikson, 1977). The Affective Tigger has four vocalizations (see section 3.2.2), two with happy overtones and two with unhappy ones. When exceptionally happy, the Affective Tigger says, "a hoo hoo hoo hoooo, wheeee...". When happy he says, "that's what Tigger's like best!". Making the Affective Tigger unhappy elicits a growl, and when very unhappy he will say, "Stop that, kid, please, 'S' 'T' 'O' 'P' STOP!"

The second version of The Affective Tigger included an Airtronic servo motor, housed in a specially designed encasement within Tigger's body. Flexible push rods in Tigger's spine controlled the ear movements. A rubber ball in Tigger's head shielded the moving joints from impact and excessive fluff.

The controller is a HANDY board (Martin, 1998) running IC [2] (a subset of the C programming language designed specifically for the 6.270 robot contest at MIT). The

[2]IC version R2 2.852 is a C compiler/interpreter for use with 6811 boards. The IC software system was written by Randy Sargent (rsargent@media.mit.edu) and Anne Wright (anarch@ai.mit.edu) It makes use of a pcode interpreter and drivers that live on the robot board, which were written by Randy Sargent, Fred Martin, and Anne Wright.

processor is a Motorola HC11. Chris Metcalfe provided the vocal Tigger imitations resident on a ISD 1020 voice record/playback chip.

3.2.2 Phase 2: Detection

Much of this stage of the research includes determining what kinds of sensors to use in the Affective Tigger and where to put them. The goal was to include sensors that would give the Affective Tigger enough information about his environment to be able to respond to the child directly and appropriately. By observing the child when the Affective Tigger responds to a behavior, we can learn which interactions are important during play. For example during the first trial session, the Affective Tigger's bounce sensor was slightly too sensitive. The result was that he was overly happy throughout the play session. A redesign of the Affective Tigger involved physically shielding the sensor so that the child had to intentionally and forcibly 'bounce' the Affective Tigger to elicit a response. This cyclical nature of testing the Affective Tigger in the hands of a child, then redesigning it according to our findings, was critical to the development of a properly responsive toy.

The important considerations in the design of the Affective Tigger's input system included: how many sensors, of what kind, and in what places. Each sensor was specifically chosen and tested for its ability to detect a narrow range of behaviors. For example the bounce switch can also be activated by spanking the Affective Tigger, thus producing an inappropriately happy response. To counter this particular effect a tilt sensor was installed that overrides the bounce detector and produces an unhappy state.

From observing children playing with stuffed animals, we noted that they sometimes pose them, like a puppet, to express an emotion. Specifically, a couple of the children in this study pushed the Affective Tigger's head down to make Tigger 'look unhappy'. Leveraging off this observation, the Affective Tigger has a bend sensor in his neck that measures the droopiness of his head. When the child bends his head down, the Affective Tigger recognizes this as an 'unhappy' motion. As a result the Affective Tigger puts his ears down and growls to augment the illusion of his sadness.

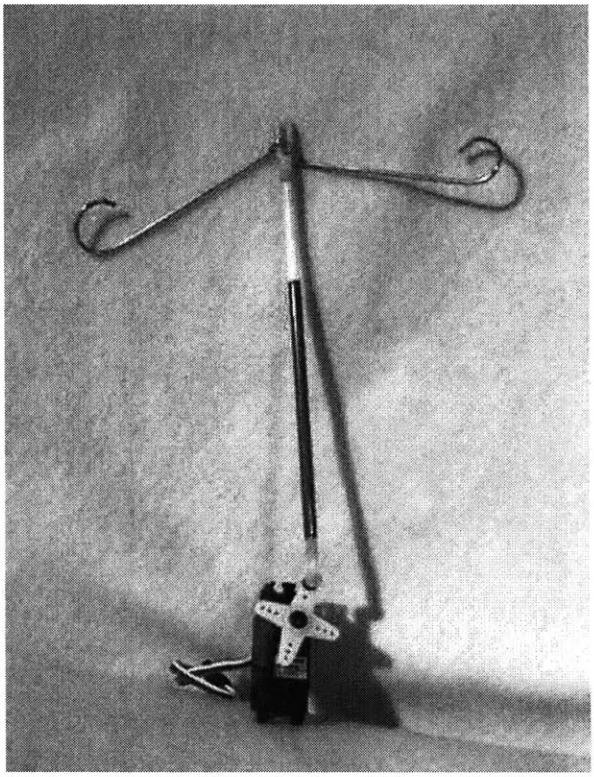

Figure 3-4: The Affective Tigger's ears are servo controlled. As the servo rotates down, it pulls on the push rod, causing the Affective Tigger's ears to go up.

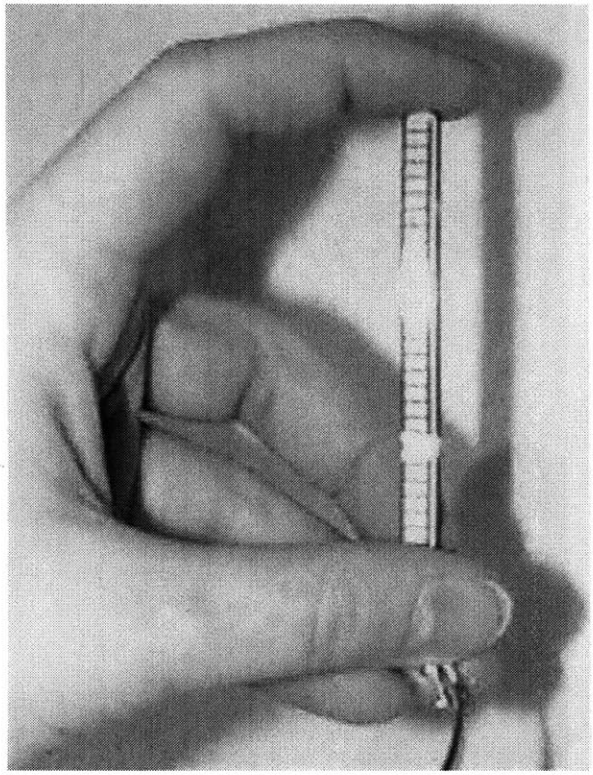

Figure 3-5: This is a commercially available resistor-type bend sensor. The strip only bends in one direction; the more it is bent the lower the resistance.

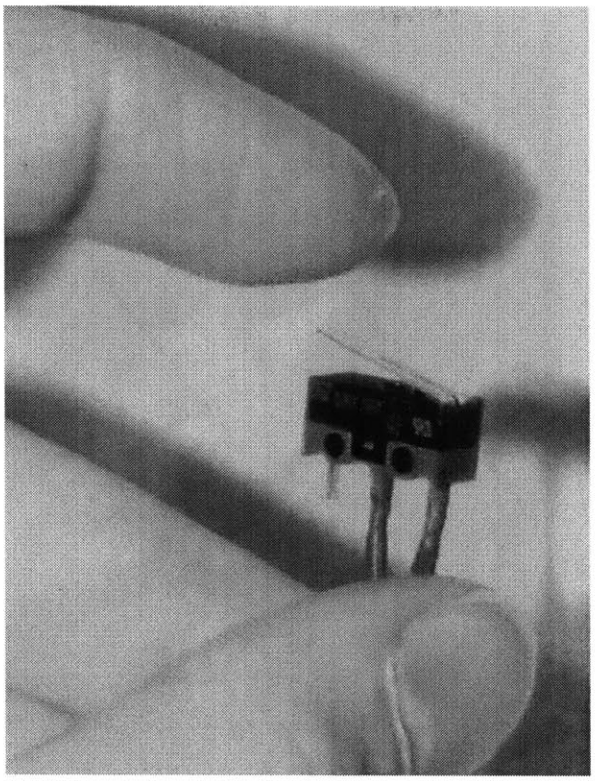

Figure 3-6: The bounce detector is a small flat lever switch, mounted in the Affective Tigger's rump, that detectes when the Affective Tigger is bounced.

Children almost instinctively know that Tigger is a character that likes to bounce. Even a child who is not familiar with the Disney Tigger character will take one look at his "rickey-tickey striped pajamas" and understand the action of bouncing. In one case, the child became so enamored with bouncing that she began jumping all around the room to demonstrate to me that bouncing is what makes her happy too.

In the bottom of the Affective Tigger's body is a small flat lever switch surrounded by a ring of foam. This 'hernia-pillow' softens the bouncing of the switch making it slightly less sensitive. When the child bounces the Affective Tigger, activating this switch, the Affective Tigger becomes happy. If he is already unhappy (see figure 3-2), say his neck is bent, he will remain unhappy. If however he is merely neutral, 'bouncing' will make the Affective Tigger happy, his ears will go up and he will say "That's what Tigger's like best!". If the Affective Tigger is already happy, he will become VERY happy and say "a hoo hoo hoo hoooo, wheeeee".

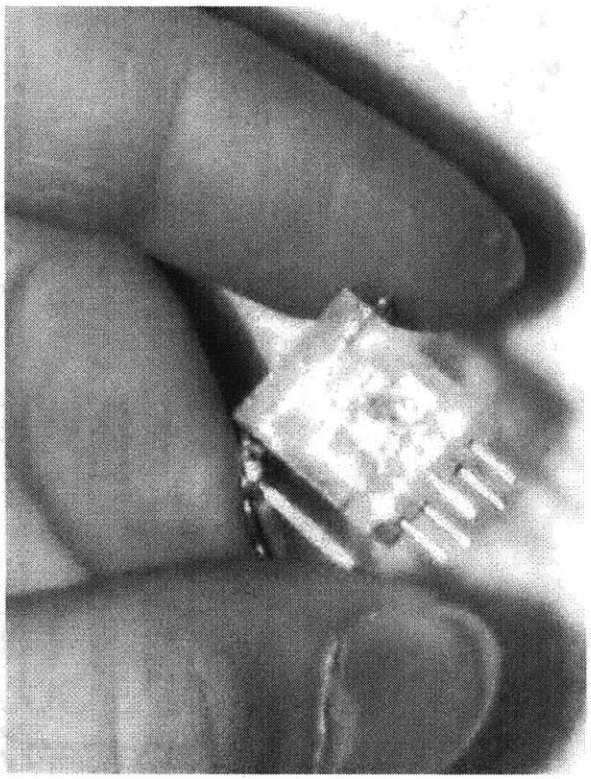

Figure 3-7: The tilt sensor is a metallic ball inside a plastic cube. As the ball rolls around, it makes contact with the metal posts visible sticking out of the bottom of the sensor. A measurement of which posts are connected provides an accurate reading of the orientation of the cube.

A hall effect sensor detects when Tigger is turned up-side-down. Left this way for too long, the Affective Tigger becomes unhappy, then VERY unhappy, and eventually will turn off altogether.

The length of time it takes the Affective Tigger to get to the point of shutting off will vary based on his previous state (see figure 3-2). It takes 15 seconds for the Affective Tigger to progress down one mood level. Therefore, if the Affective Tigger is 'happy' it takes 60 seconds of holding him upside down for him to reach the stage where he shuts off. This 15 second parameter was chosen to allow the children, with short attention spans and only half an hour to conduct the experiment, to see the changing moods of the Affective Tigger.

The post and coil accelerometer is positioned behind the Affective Tigger's eyes to

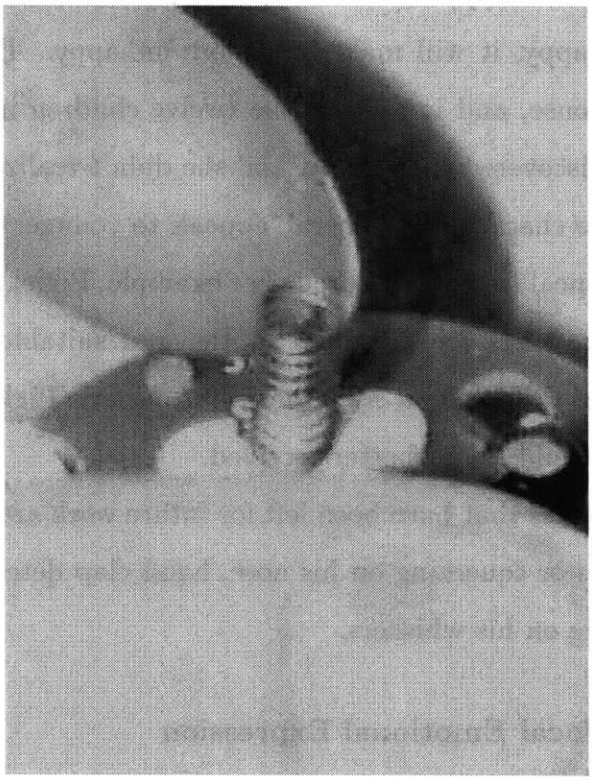

Figure 3-8: The abuse sensor is a simple post and coil accelerometer. A sharp blow or physical poke, as depicted here, will trigger the sensor.

detect abuse. If the child throws Tigger against a wall or drops him on the floor this sensor is activated, and the Affective Tigger immediately becomes VERY unhappy. This particular positioning also produces the side effect that if a child pokes him in the eye, he becomes VERY unhappy. These offenses are considered more severe than bending the neck, or turning upside down. As a result the Affective Tigger skips the unhappy stage and will go into shut down mode more quickly.

A string attached to a spring in the Affective Tigger's tail is attached to a switch. As the child pulls on the tail the spring is extended, eventually producing enough force to activate the switch. The tail provided the opportunity to try different reactions. When asked in a brief informal survey, five people thought pulling on Tigger's tail should elicit a happy response and four responded that it should make him unhappy. My solution was to do both, dependent on the Affective Tigger's previous 'mood'. Thus, the tail pulling behavior amplified the current state of the Affective Tigger. If

the Affective Tigger is happy or neutral, pulling on his tail makes him happier. If, however, he is unhappy, it will make him more unhappy. This provided a slightly more complex response, and in fact, of the twelve children in the main study, only one of them even discovered this oddity, and she didn't realize the implications.

While the Tigger character, in general, appeals to younger children, other Winnie-the-Pooh friends appeal to older children. For example, Piglet is a small quiet animal. His emotional expressions are far more subtle, and suitable for the slightly more emotionally mature child. In a hypothetical Affective Piglet doll, the duality of pulling on his tail would be far better received.

Three other features that have been left for future work are, the Affective Tigger's recognition of a kiss or squeezing on his nose, hand clap detection, and a sensitivity to the child's pulling on his whiskers.

Intonation and Vocal Emotional Expression

There are 5 sound files...
VERY HAPPY "a hoo hoo hoo hoooo, wheeeeee"
HAPPY "That's what Tigger's like best!"
NEUTRAL <silent>
UNHAPPY <growls> "woraworawora"
VERY UNHAPPY (pro-actively sad) 'Stop that kid please S-T-O-P stop'
SHUT DOWN MODE <silent>

> Voices convey emotion not just through words themselves, but through intonation-rising and falling pitch, variation in rhythm, volume, and intensity... By seven months they appear to connect facial expressions with tones of voice... (Sigman and Capps, 1997).
>
> Surprisingly little work has been done on infants' perception of emotion in vocal expression. What work there is suggests that discrimination of vocally expressed emotion appears somewhat earlier than discrimination

> of facial emotions... This, however, rather than indicating a limitation of young infants' ability, suggests that they are well tuned to pick up emotion in situations that approximate more to real life, in which emotion is typically conveyed by tone of voice as well as facial expression (Bremner, 1994).

Piaget's resorting to verbal report as the indicator of 'internalization' may or may not have been accurate(Piaget, 1981). While two and three year olds have a large vocabulary, the imitation dilemma may also persist in language acquisition. Bretherton and Beeghly (1982) note that children as young as two years of age use terms that refer to mental states, with references to self states as somewhat ahead of references to the states of others. This is significantly earlier than the seven year old that Piaget claims is just beginning to verbalize their emotional lexicon.

3.2.3 Phase 3: Recognition

The most critical part of this project is the recognition system within the Affective Tigger. The sensors are designed to detect very specific behaviors but it is the ability of the Affective Tigger to interpret and appropriately respond to those signals which make the interaction a success.

The recognition system was initially implemented with experimentally determined parameters. For example, when I bounce the Affective Tigger can I trigger the sensor? Then I handed the toy to the first subject. She was not strong enough to trigger the sensor, so I recalibrated the system (both in hardware and software) to be more sensitive. The next child proved strong enough, and the appearance of an appropriate response from the Affective Tigger signified that the parameters were correctly set. This procedure was carried out with all the sensors simultaneously and iteratively, until the Affective Tigger was correctly responding to the intentions of the average child.

The behavior of the Affective Tigger is entirely software based. Each sensor produces an emotional trigger either in the positive or negative direction. When the

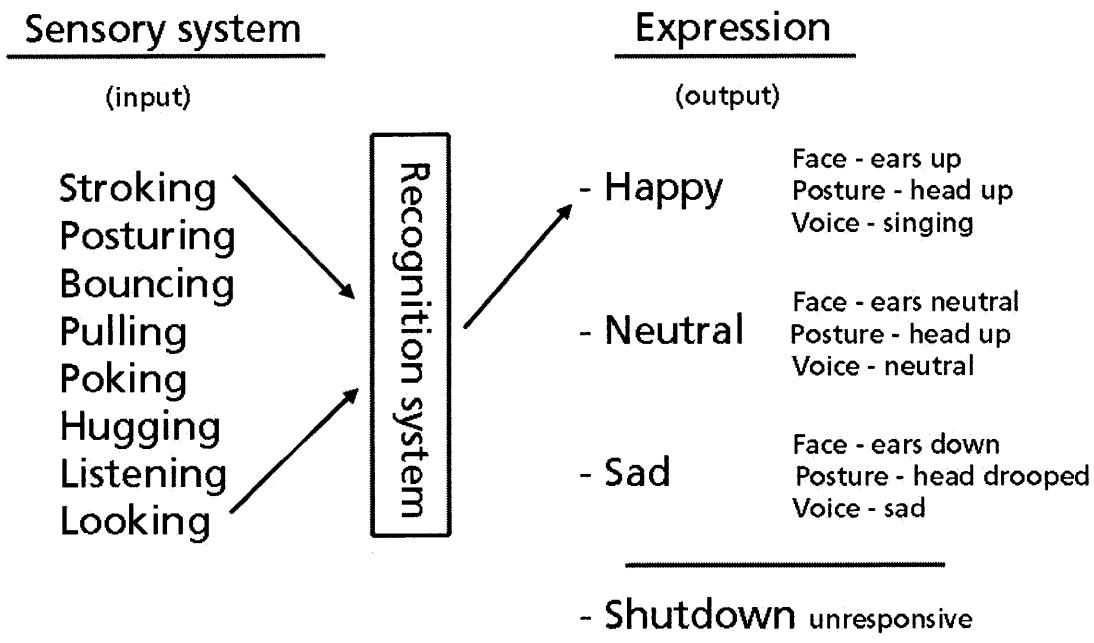

Figure 3-9: The Affective Tigger has a series of input sensors, the signals from which are mediated by an interpreter before they are turned into output expressions.

Affective Tigger is 'VERY happy' and he gets turned upside down, he drops down a level to 'happy' before becoming 'neutral' then 'unhappy', 'VERY unhappy', and finally shutting down. This progression occurs on the order of a minute, and is stretched out by the child's continued interaction and activation of other sensors.

The interaction between the child and the Affective Tigger is not completely unchecked. When the Affective Tigger is already 'very unhappy' and the child continues to 'make him unhappy' the Affective Tigger will take a time-out. The Affective Tigger shuts down for a period of 60 seconds to allow the child a moment to compose herself. He remains completely unresponsive during this time. This time-out, as much as the negative emotional cues, is what teaches the child that this kind of behavior is unacceptable. In the twelve trials, the Affective Tigger only timed-out once. The time-out made the child very agitated.

A proposal was made to include external input to the Affective Tigger from a pager or radio control. For example, the Affective Tigger might become unhappy

and say "I'm hungry, let's go eat" when he receives a page from a parent who just put dinner on the table. This allows someone like a parent or therapist, to break into the interaction if so needed. With autistic children it is sometimes important to break into the interaction like this, in order to stop the repetition and provide a new stimulus (Cohen and Donnellan, 1987).

3.3 Description of the Child for Which the Affective Tigger is Intended

The Affective Tigger is primarily targeted at three to five year old children. This is the pre-operational age at which emotional development is most dramatic, and at which age an affective educational toy may have the most impact. The target child that will find the Affective Tigger engaging is one who already has a sense of emotional recognition, a limited ability to express emotions of her own, and is just beginning to develop a sense of 'self' that is distinct from 'other'. Such a child is learning to play and cooperate with other children, and the Affective Tigger may help to teach her about empathy and compassion.

There are no specific motor or language skills necessary to play with the Affective Tigger. A child who can not recognize the expressions of the Affective Tigger, may enjoy playing with him but she may not know why. She may even learn all the proper responses to the Affective Tigger's various moods long before she has either an understanding of or a name for these feelings.

In my study, I found that the three year olds didn't understand the interaction or have any response beyond the fascination with a new toy. The five year-olds seemed already advanced beyond the skills and intentions of the Affective Tigger, but an interesting secondary group of teen aged children found the Affective Tigger to be engaging. From this, I hypothesize that there may be a second wave of emotional development in the teenage years that echo back to the lessons learned the first time around.

The most interesting reactions I found were among the four year-olds. They

seemed absolutely fascinated with the ability to make the Affective Tigger unhappy. As opposed to a sign of an abusive child, it seems to be a developmental phase that children go through as they discover the power they wield over the emotions of 'others'.

> Although [four year olds] become more adept at comforting and relieving distress, they also become more adept at provoking distress by teasing, hurting and annoying other children and adults. This combination of sympathy and spite arises as young children begin to identify the conditions or actions that will start or stop an emotional state in another person (Harris, 1989).

It is interesting to think of teasing as a form of changing the emotional state of the other. Even more interesting is the notion that a child will 'experiment' with the emotions of others in this manner.

3.4 Emotional Sensitivity

The manipulation of emotions has some real dangers (Ekman, 1991). What if the Affective Tigger became permanently depressed and the owner couldn't snap him out of it? Could such an occurrence produce schizophrenic, or depressive behavior in a child? What if a child found the Affective Tigger 'overly' engaging? Might she become emotionally manipulative as a result of extended interaction with the Affective Tigger? These are a important questions which need further research.

Chapter 4

The Child Trials

The child trials were designed to simultaneously evaluate the Affective Tigger and his potential for helping children with their understanding of emotions. From these trials the Affective Tigger was modified, when possible, in accordance with the feedback from the child and parent, until he was 'tuned' for the average child. For example, during the first trial, the Affective Tigger was overly happy. After the parent mentioned that he was overly happy, the threshold on the bounce detector was modified to make it less sensitive. This iterative process of design corrections and child trials proved to be an effective technique for determining the proper thresholds for the Affective Tigger's sensory system.

4.1 Method

Twelve subjects and their respective accompanying adults were asked to play with the Affective Tigger. Initially, (see Appendix A) the child was introduced to a 'priming' play set to help them overcome their initial shyness of the Media Lab and the experimenter. The parent was distracted with release forms and a preliminary questionnaire (see Appendix B) while the experimenter attempted to engage the child with the 'distracter' toy (a construction set made by Rokenbok). The subject's accompanying adult were fully informed at the outset of the experiment as to the nature of the trials about to occur, and what would be expected of them and their child.

Figure 4-1: Tigger's experimental setup.

After approximately five minutes, both child and parent followed the experimenter into a separate room to play with the Affective Tigger. The parent was presented with the Affective Tigger so that they might help overcome any residual shyness the child might have. This also provided the parent with an opportunity to examine the toy themselves for safety before giving it to the child. The child and parent were encouraged to experiment with the Affective Tigger to determine how he worked. As the child figured out what behaviors elicited responses from the Affective Tigger, the experimenter attempted to engage the child in a story (for a copy of the story and the interview questions, see Appendix C). At the conclusion of the experiment a few follow up questions were asked of both the adult and child. One week later, a follow up phone call was made to the accompanying adult. These follow up phone calls produced no significant change in attitude, or opinion on behalf of the child or adult.

4.1.1 Subjects

To solicit the participation of children, posters were hung outside of the MIT pre-schools and near the MIT Medical Center, pediatrics office. Additionally, email an-

nouncements were circulated, and the majority of children who participated in this study heard about it through word of mouth. Two subjects were studied in California, and the rest at the MIT Media Lab, in Cambridge Massachusetts. The majority of accompanying parents were the child's mother, but there were several other relations as well. I had hoped to attract at least one father to the study, but only managed to get two boy subjects instead of the six I had intended. Finally, the children who were attracted to this study all had extensive prior exposure to the Disney Tigger character.

4.1.2 Data Quantification Procedure

All of the subjects freely consented to having their session videotaped. At the conclusion of the experimental trials, an independent observer[1] was asked to rank each child in nine specific categories (see Appendix C), based on a combination of the child's behavior in the video, and the written responses to the questionnaires. The observer did not know the hypothesized relationships between any of the categories, but may have inferred a correlation on her own. This independent assessment provided a quantification of each child's behavior.

4.2 Summary of Results and Discussion from the Child Trials

The null hypothesis was that we would find no correlation between either age, presence of siblings, or shyness, to the display of mimicry, empathy, emotional restraint, understanding of sense of 'other', or overall assessment of emotional intelligence.

The results (see Appendix D, table D.1) produced something quite different. There was a distinct correlation of age with everything except mimicry and empathy (see figures 5-1, 5-2, 5-3, and 5-4). Additionally, the correlation of siblings with recognition, a sense of 'other', and their general assessment of emotional intelligence, was an

[1] Again, many thanks to Linda Kiley for her time and attention.

unexpected result that suggests that having siblings may enhance the emotional development of a child (see section 5.2 The Child). The results also demonstrated that shyness was not much of an obstacle to emotional development, correlating inversely with emotional restraint, but not impacting other areas under measurement.

Most of the children in the main study were delighted to play with the Affective Tigger. Only two of the twelve children who participated in the main study showed little to no interest in the Affective Tigger. It was the two boys, who incidentally came to the lab together, who were far more intrigued by my distracter toy than by the Affective Tigger. The other nine children in the main study were girls, and it was they who seemed excited to play with the Affective Tigger. With such a small sample set of boys, no conclusions regarding gender can be made from this observation.

On three of the trials in the main study, the child and parent didn't believe that the Affective Tigger was reactive enough. In every case they understood that the Affective Tigger was responding to the predetermined cues, but often commented that his voice was not loud enough, and his ears did not move enough. In general though, they all understood the emotional expression the Affective Tigger was trying to convey, and in no case did they confuse sadness for happiness or vice versa. Even when the child could not understand the words the Affective Tigger was speaking, she none-the-less discerned the emotional content of the Affective Tigger's vocalizations.

As much as the children liked playing with the Affective Tigger, the adults also seemed impressed by the Affective Tigger. They understood the educational value of the toy, and vocalized opinions that they regarded these intentions very highly. In some situations, the parent was even more excited about the toy than the child. One parent expressed her negativity towards the Affective Tigger, but made it clear that the main problem, in her eyes, was a mismatch in the age of her child to the aims of the Affective Tigger. Five of the accompanying adults voiced concerns about 'all these new robotic toys' and how they only keep the interest of their child for a very short time. For example, one mother complained about how boring it is to squeeze the paw of a toy to hear it play a song. These concerns appeared to be alleviated after the parent realized that the Affective Tigger is specifically designed to 'teach'

their child about feelings. This offers the child a more complex interaction than many similar computer-toys on the shelf today.

4.2.1 Error Analysis

As with any behavioral study, the risk of error introduction is high. Some potential sources of error could come from: the experimenter or accompanying adult's 'coaching' the subject, the failure of the Affective Tigger's hardware, the inattention of the child to the Affective Tigger, and the inaccurate assessment of the child by the independent observer.

In fact, many of the trials were plagued with problems. As mentioned previously, the Affective Tigger's voice was too soft for the child to make out what he was saying. In two of the trials. the experimenter had to tell the child what he was saying before they could understand it. Additionally, his ears moved in a very subtle manner which was often hard to see amidst the bouncing and thrashing about. Four of the twelve children failed to notice that his ears were moving at all. In one case the hardware failed altogether and the Affective Tigger had no responses, however this didn't seem to bother the child and she was quite happy to demonstrate what he should look like when he is happy or sad. The two boys liked the 'distracter' toy so much they refused to play with the Affective Tigger for more than a few moments each.

In general, future work should provide a more standardized setting for the experiments to occur, and the toy should function exactly the same for each child, rather than the approach here of modifying it slightly after each trial.

Chapter 5

Evaluation

The evaluation of the Affective Tigger project is two fold. First, does the toy qualify as emotionally reactive, that is, does he recognize emotionally laden cues from the playmate, and respond to the playmate with a recognizable expression of an emotion? The assessment of the Affective Tigger toy comes from the child's reaction to him. The child's reaction leads into the second component of the evaluation of the Affective Tigger project. This second component is an assessment of the teaching ability of the Affective Tigger. Can the child learn to recognize his expressions as a positive or negative reaction to her behavior? Can she generalize this knowledge to other people, is she demonstrating signs of a developing emotional intelligence? These questions are evaluated by and independent observer who rated the perceived level of emotional development of each child.

5.1 The Plush

The process of constructing an emotionally reactive stuffed animal has proven itself to be helpful in furthering our understanding of the development of social communication in children. The use of a computer controlled toy was a natural and logical means for beginning to look at 'child-proofing' computer interfaces while maintaining the sense of 'child orientedness' inherent in a toy.

The Affective Tigger toy, overall, was well received. A few people said they didn't

like the toy after they'd seen it, or didn't think their children would want to play with it, but the overwhelming response was positive. Of all the people who have seen and played with the Affective Tigger, well over two-thirds said, either it was a good toy, or at least the idea of an emotionally reactive toy was promising.

The interface issues were addressed individually and, in the end, provided the combined effect of a passive stuffed animal, which was the initial goal. Such issues as size, character, expressive features, number of moods, and the design of the sensory system, were resolved to the point that they did not intrude on the child-computer interaction. Other issues like weight, and degree of expressivity, still need improvement.

The biggest factor in determining if the Affective Tigger was successfully constructed was the question: does the child recognize the expressions of the Affective Tigger? The answer to this question lies in the behaviors expressed by the child. Is she mimicking his expressions, or is she able to vocalize her recognition of his expressions?

As discussed previously, the perception, and even vocalization of an emotion can emerge long before the ability to internalize this information to guide one's actions (Piaget, 1981). This ability of young children to say what they don't mean, and to vocalize as well as imitate what they don't understand is the largest obstacle to this study. The emergence of mimicry as early as 4 months (see section 1.2.2, Emotional recognition in the very young infant and the following section on Emotional expression in the infant), suggests that it is not in itself a reliable measure of a child's recognition of an expression. However, combining vocalization with mimicry, we begin to be able to put more faith in the child's ability to recognize the emotion being displayed. The criterion for the independent assessment of the child's ability to recognize the Affective Tigger's expressions included: demonstrations of empathy and vocalizations in addition to mimicry.

There was a significant correlation of age with perceived recognition, and an interesting correlation between the children who have siblings and increased performance with emotional recognition. The correlation of age with recognition was expected,

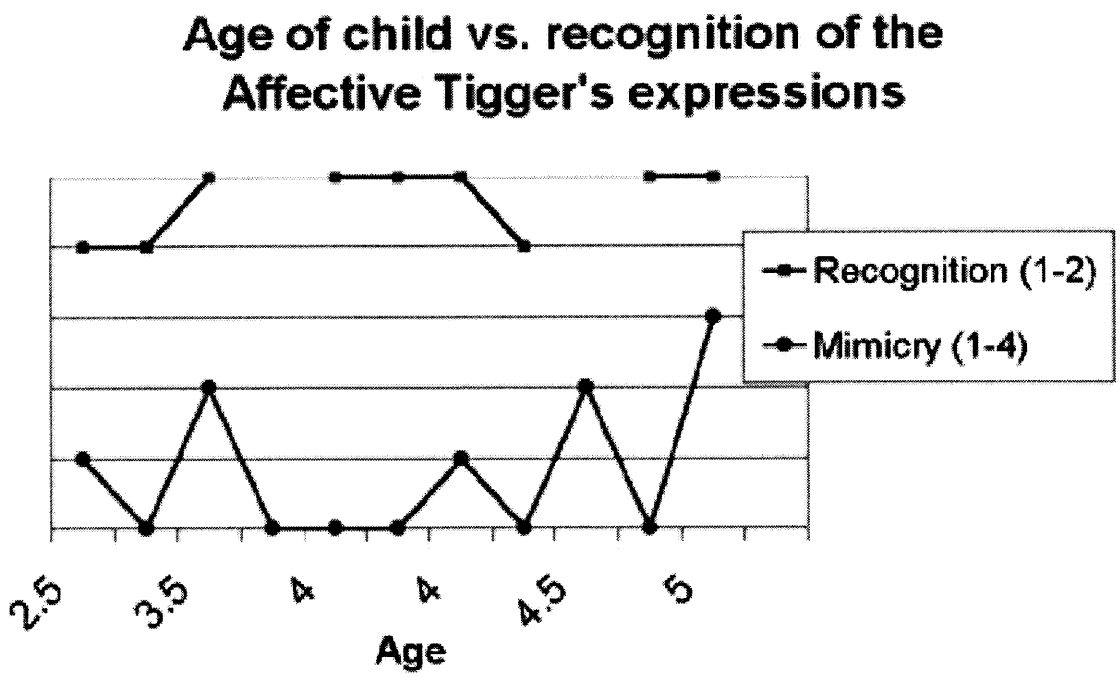

Figure 5-1: The ability of the child to demonstrate recognition of the expressions of the Affective Tigger correlated with the age of the child.

and it verifies that the Affective Tigger was able to project an emotion which was recognizable to the child. Additionally, the parents often commented on the expressions of the Affective Tigger in ways that demonstrated that they could identify the emotion being conveyed in both his posture and voice.

The second question regarding the success of the Affective Tigger was: does the Affective Tigger make clear the causal relationship between the actions of the child and his expressions? This was the Affective Tigger's greatest failing. Many of the parents, 45%, commented that his expressions were not dramatic enough. Additionally, 72% of the parents, and most of the other people who saw and played with the Affective Tigger, said that his voice needed to be louder. These two factors were a huge detriment to the Affective Tigger's ability to create the illusion of reactivity.

Overall the Affective Tigger, as a toy, was a partial success. With more time and resources, the obstacles of weight, voice loudness, and the subtlety of his expressions

could all be overcome. The fact that 58% of the children spontaneously recognized his expressions, - happy vs. sad - despite these failings, is very encouraging.

5.2 The Child

The big question in the human part of the Affective Tigger project is: could an emotionally reactive toy augment emotional development? The scope of this study did not permit observation of the children over multiple play sessions, but it begins to scratch the surface. What we know from previous work is that, a child with a well developed sense of 'other', who exhibits emotional restraint and demonstrates empathy, can be said to have a well developed emotional intelligence. These three criterion are evaluated for each child in the child-trials, to assess the age at which each developmental step occurs.

This study corroborates existing evidence that children develop a sense of 'other' during the third year of life (see Appendix D, table D.1). Two out of the three three-year-olds did not have a well developed sense of other, as opposed to all of the older children who distinctly did understand the concept of 'other'. Additionally, none of the younger children had an understanding of the existence of 'other'. The demonstration of a sense of 'other' could include sharing, or other signs that the child is no longer egocentric. More children need to be evaluated to produce definitive results, however, it can be suggested from this data that the sense of 'other' develops very early in the third year for an average child.

The demonstration of emotional restraint is the one factor that a child does not 'fake'. It is our most accessible means for assessing emotional development. This research helps to confirm the development of emotional restraint during the beginning of the fourth year. The data (see Appendix D, table D.1) supports a correlation between emotional restraint and age (see figure 5-3). Two of the five four-year-olds failed to demonstrate emotional restraint. It is interesting to note that these two children exhibited a high degree of emotional intelligence despite their seeming lack of emotional restraint (see figure 5-3). This signals the age of transition at which the

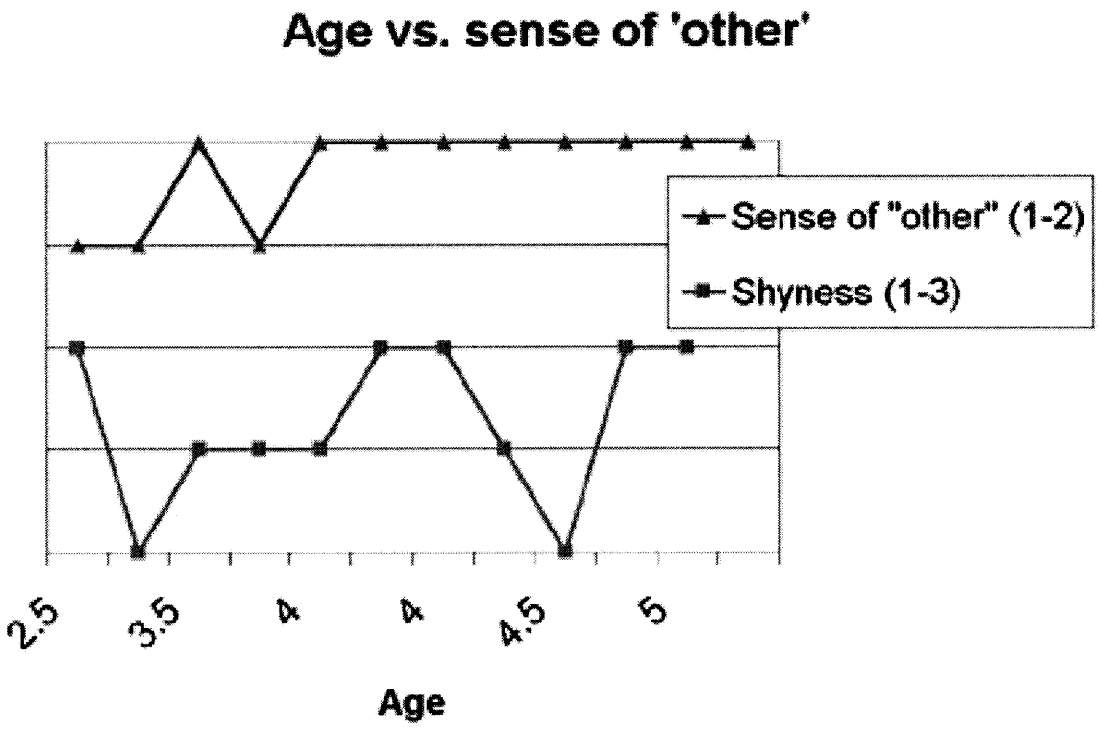

Figure 5-2: The sense of 'other' seemed to develop early in the third year. Shyness, on the other hand, does not correlate, suggesting that it has little effect on the emotional development of a child.

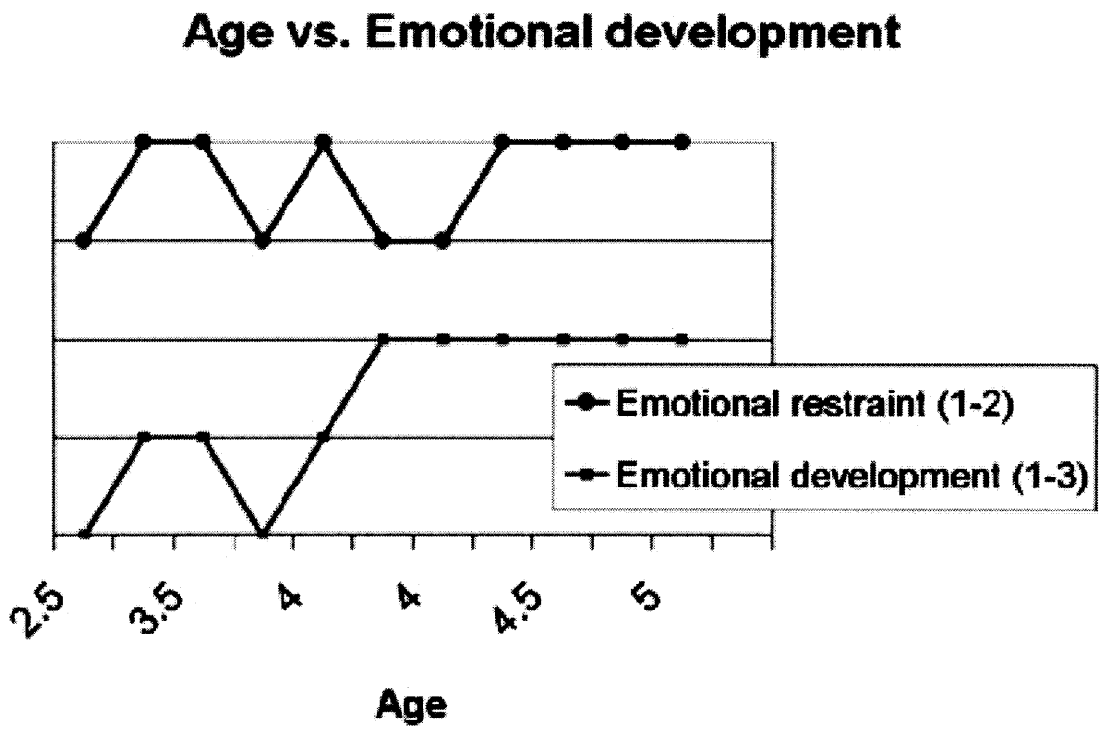

Figure 5-3: Both emotional restraint and the general assessment of emotional development correlate with age.

child is on the verge of acquiring emotional restraint. The premature demonstration of emotional intelligence may be yet another instance of mimicry, where the child 'fakes' the behavior before she internalizes it.

The second cue to the level of emotional development of a child is the demonstration of empathy. Demonstrating empathy means the child understands what to do to make the Affective Tigger 'happy' or 'unhappy'. As mentioned previously, this does not require the child to understand the causal relationship between her actions and his responses. The hypothesis was that a child who comforts the Affective Tigger is displaying the highest form of emotional intelligence. Surprisingly enough, the data collected on empathy (see Appendix D, table D.1) did not correlate well with anything (see figure 5-4. Perhaps the paradigm of displaying empathy to a stuffed animal is not correct for this age group.

This study also suggests that shyness may not be a hindrance to the emotional de-

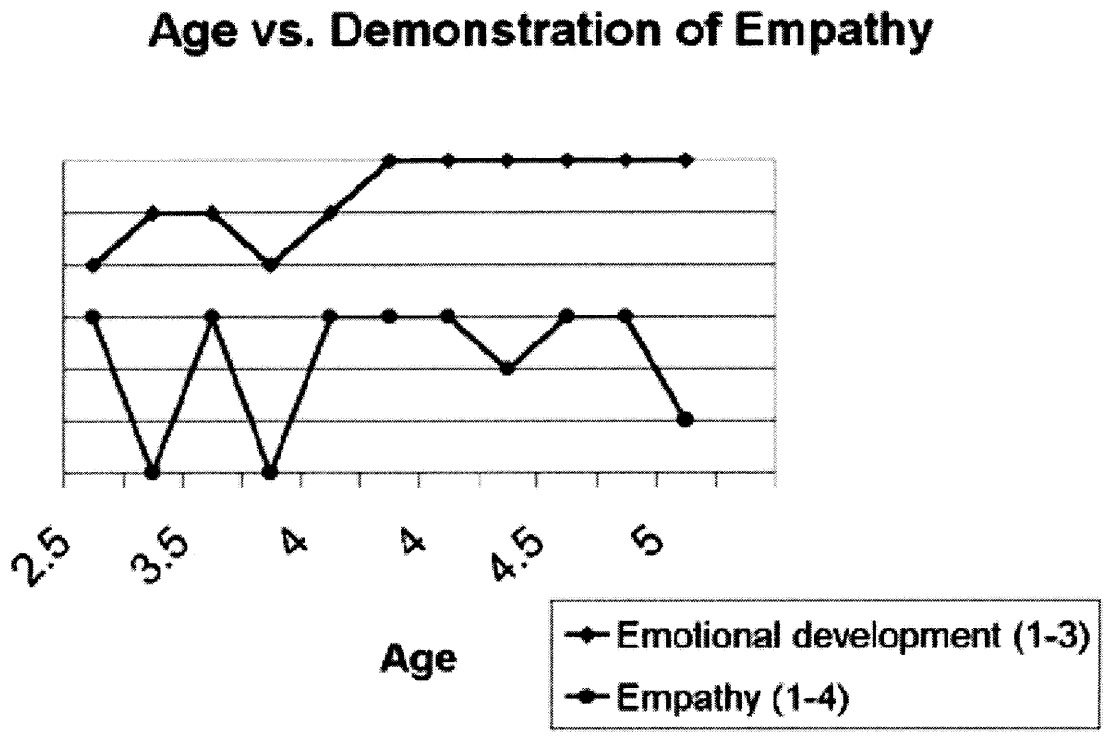

Figure 5-4: Empathy failed to correlate with age. This suggests that either these children were too young, or the paradigm of empathizing with a stuffed animal is inappropriate for this age group.

velopmental process. The only thing shyness correlated with was emotional restraint (see Appendix D, table D.1). Of course a child who is shy will exhibit few emotional outbursts. More importantly, the lack of correlation in other areas is what suggests that shyness has little to no adverse impact on the emotional development of a child.

5.3 Conclusion

In general the conclusions from the Affective Tigger project are promising. The toy itself qualifies as an emotionally reactive instrument. At the very least, the Affective Tigger captures the interest of the children of the intended age, and at most, might be able to augment their emotional development. To summarize, the three year olds in general don't get it. They don't have the emotional restraint, and are only just beginning to develop the sense of 'other' necessary to understand this toy. The four year olds in my observation, are learning the most from the Affective Tigger. As such, they spend their time mostly hurting him. The five year olds, as a group, understood the emotional responses of the Affective Tigger. They figured out what he does, and why, faster than I could have demonstrated it to them.

Could the Affective Tigger assist the development of emotional intelligence within the child? It is not clear. What is apparent is that he provides the child with a safe play space to explore and experiment with feelings and behavior. The Affective Tigger lets the child make social mistakes, yell too loudly or play too roughly, without the permanence or severity of a lost friend or upset parent. There are no instructions, there is no right or wrong way to play with the Affective Tigger, there are only actions and consequences.

Appendix A

Laboratory Procedures

ALWAYS USE PEN

1. Welcome

   Show the guardian and child into the quiet room.

   Set up the play set for the child to entertain him/herself with.

2. Consent forms

   Read and explain consent forms to the guardian.

   Extra consent forms are in my desk. Double check that it says MIT on the top.

   If you have to write a new number in the corner pick one that is not used.

   Remember to mention the follow-up phone call.

   Stress to the guardian that neither they nor their child is being evaluated.

   Nothing they or their child does is wrong.

3. Preliminary questions

   Remember to WRITE DOWN EVERYTHING!

4. Set up camera

   Start filming, then call in the child.

   Hand the Tigger to the parent.

   Let the parent and child play with Tigger for at least 5 minutes.

5. Story line

   Ask the parent to stand behind you while you engage the child with the story.

   Allow the parent to intervene but continue to re-engage the child when possible.

6. Debrief

   Leave the camera rolling for the debriefing but continue to write everything down.

7. Goodbye

   Thank them and pay them.

   Be courteous even if it didn't go well.

Appendix B

The Release Forms for the Affective Tigger Trials

B.1 Consent Form (for the MIT community) for the Affective Tigger project

Researchers from Massachusetts Institute of Technology, in the group of Affective Computing, are conducting a study to evaluate a prototype toy that was designed to respond to how your child interacts with it. Your and your child's participation in the following experiment are completely voluntary. Either of 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 either of you feel uncomfortable, or unsure that you wish your results to be part of the experiment, you may discontinue your participation with no repercussions.

By participating in this study, you will receive $10 in monetary compensation for your and your child's participation. The results of this study may result in a better understanding of new methods for interaction between computers and children. Participation in this study presents minimal risk to your child. Your child may become confused during their participation as they play with a toy that is unfamiliar to them, and which may respond to your child in unexpected ways. However, the

level of this confusion should not exceed anything that they would have during an everyday encounter with a new toy. This is a two part time commitment of your and your child's time. The session should last less than an hour. In one week there will be a follow up phone interview of approximately five minutes in length. In a few minutes, you will begin participating in an experiment that will include the following:

A) Answering a few preliminary questions.
B) Introduction to a new kind of toy.
C) Performing a series of playful tasks with this new toy.
D) Sharing your opinion of the toy.

These tasks are designed to expose the Affective Tigger's reaction to different emotional situations. They are expected to elicit responses and feelings within your child. Any and all responses are normal. If at any time either of you are uncomfortable, either physically, or with what you or your child are being asked to do, or how the Affective Tigger is responding, you are free to ask that the experiment be suspended.

Any responses that are collected during this experiment will be completely anonymous. From this point forward, your data will be referred to by the ID number that appears on the upper right corner of this paper.

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 my and my child's participation 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 MIT Medical Department, including first aid 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 investigator's fault. I also understand that by my participation in this study I am not waiving any of my legal rights.

I understand that if I experience any ill effects (either mentally or physically) post-experimentation, I will contact the experiment coordinator: Dana Kirsch (617)253-0384 or (617)666-8378.

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 or my child has been treated unfairly as a subject.

B.2 Consent Form (for the California Community) for the Affective Tigger project

The consent form for the California community was almost identical to the one above for the MIT community. They could not receive compensation but were informed that "Subjects solicited from the MIT community receive $10 compensation." Additionally since the medical center was not available to them the following modification to the above consent form was made: "In the unlikely event of physical injury resulting from participation in this research, I understand that no compensation can be provided for medical care. I further understand that this does not imply that such injury is the investigator's fault."

B.3 Video Tape Consent

Videotapes will be collected of my and 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 or

used for experimental purposes. At any time during or after the experiment you may request that the tapes of you and your child be destroyed. This consent is entirely separate from your consent to participate in the experiment and may be withdrawn at any time in the future. Please sign on the lines below to give special permission for the videotaping of my and my child's participation.

To give your permission to have an excerpt from the videotape shown for research and teaching purpose, please sign below. Please note that if you do not wish to give your permission for this, we would still like your participation in the study for analysis purposes only. I have read and understood the above and agree to have an excerpt from my videotaped interaction shown for educational purposes.

Appendix C

Documents for the Affective Tigger Child Trials

C.1 The Story Line for the Affective Tigger

This orange spot is Tigger's house. Can you put Tigger in his house?

Let's pretend that pink spot is Tigger's friend Piglet's house. Do you know who Piglet is? Can you show me how happy Tigger is to go visit Piglet at Piglet's house?

Can you tell me a story about how happy Tigger is? Why is he so happy to go visit Piglet? What do Tiggers do when they are happy? What happens when you pull his tail?

Now it is late. The sun has gone down. And it is time for Tigger to go home. But Tigger does not want to leave Piglet's house. Can you show me how a sad Tigger goes home? Tigger is very sad, isn't he? What other kinds of things make Tigger sad? Can you show me what a sad Tigger looks like? What happens when you pull his tail?

What would you do to make Tigger happy again? Can you tell Tigger a story that will make him happy? Can you show me what a happy Tigger looks like?

C.2 Preliminary Questions for the Affective Tigger Child Trials

The following questionnaire was orally administered to the accompanying adult with each child before the Affective Tigger was introduced. The results from all trials are summarized in italics directly beneath each question. The number of responses does not sum to twelve because presumably the accompanying adult did not know the answer or did not wish to respond for some other reason.

Questions for accompanying adult:

The following few questions are to help me know a little more about your child. I will be giving you both a new kind of toy, and I would like to know how you believe your child will respond to the toy. There are no right or wrong answers. If you do not know or are not comfortable answering any of the questions feel free to tell me to skip to the next. Finally, do not worry if your child does not behave the way you expected him/her to, this is very natural and does not reflect poorly on you in any way.

How familiar is your child with the Disney Winnie the Pooh characters?

(6 very familiar, 5 knows them)

Has he/she seen any of the movies?

(4 yes, 6 have seen the videos)

Does he/she watch the Saturday morning cartoon?

(2 yes, 2 in small amounts, 4 no)

Have you read the books to him/her?

(7 yes, 1 a little, 1 no)

Does your child know and like the Tigger character?

(10 yes)

Does your child own any Tigger toys?

(4 yes , 6 no)

How does your child respond to new places?

(3 fine, 2 shy for the first few minutes, 1 intellectual, 1 curious)

Would you say that your child is timid about exploring new environments?

(1 yes, 1 somewhat, 1 just a little at first, 1 not overly so, 6 no)

Does your child enjoy playing with new toys?

(7 yes, 2 no)

What is your child's favorite toy, currently?

(a felt princess, mermaids, race cars, 2 Winnie-the-Pooh, 2 Barbie, Arthur, 2 blocks, LEGO, 2 construction, airplanes, 2 trains, a Teddy bear, a baby doll, a kangaroo)

How does your child like stuffed animals as compared to other toys?

(2 loves, 3 likes)

How do you anticipate your child will react when I give you the Tigger?

(1 intrigued, 1 excited to see Tigger, 1 fine)

Do you think he/she will be shy about playing with this new Tigger?

(1 medium, 1 maybe, 1 depends, 6 no)

How do you think your child will respond to my questions for him/her? Do you think he/she will cooperate with me?

(7 yes, 2 after she gets to know you, 1 no she is too shy)

C.3 Debriefing the Affective Tigger trial

The following questionnaire was orally administered to both the child and their accompanying adult at the end of the trial. The results from all trials are summarized in italics directly beneath each question. The number of responses does not sum to twelve because presumably the child or accompanying adult did not know the answer or did not wish to respond for some other reason.

To the child:

Did you like playing with this Tigger?

(7 yes, 3 no)

Did Tigger scare you?

(6 no)

What was your favorite thing that Tigger did?

(2 he got happy, 1 bouncing, 1 got sad, 1 clapped hands)

What was your favorite thing that Tigger said?

(1 growled, 1 happy, 1 he is sad)

Does this Tigger like to bounce?

(4 yes)

What does this Tigger do when you bounce him?

(2 he likes it, 2 he gets happy)

Does this Tigger like it when you pull his tail?

(2 yes, 1 I don't want to)

What does he do when you pull his tail?

(1 talked, 1 got happy)

Do you like it better when Tigger is happy or sad?

(5 happy, 4 sad)

How can you make Tigger sad?

(2 poke him in the eye, 1 turn him upside down)

What should you do when Tigger is sad?

(1 pull his tail, 1 give him a hug)

What happens when you pull his tail if he is already sad?

(1 he goes on the ceiling)

What should you do to make Tigger happy again? What can you do for Tigger to become happy?

(2 bounce him, 1 no)

To the adult:

How well do you think your child did?

(3 typical, 2 short attention span, 1 more shy, 2 good)

Did he/she do anything that you didn't expect?

(3 no, 1 little nervous, 1 not wish to play, 1 the story telling was the most exciting)

Was he/she more or less shy than usual?

(2 more, 6 normal, 1 only a little unsure, 1 less)

What was your impression of the toy?

(too subtle, I wouldn't buy it, for a younger child, not sure what it was doing, nice, neat, I would buy one)

Do you think Tigger is responding to your child?

(1 it's not clear, 1 no, 3 yes)

Do you think your child could learn anything from a toy like this?

(1 not at this age, 1 can't tell, 1 if it had more reactions, 1 if we had more time)

What would you like to see included in the next model Tigger?

(1 louder voice, 1 more things, 1 whiskers)

Do you think your child will remember Tigger in a week?

(6 yes, 2 hard to say)

C.4 The Follow up Phone call

The following questionnaire was orally administered over the phone to the accompanying adult approximately one week after the session. The results from all trials are summarized in italics directly beneath each question. The number of responses does not sum to twelve because presumably the accompanying adult did not know the answer or did not wish to respond.

Do you think your child remembers Tigger?

(6 yes, 1 hasn't mentioned it)

Do you think your child would play with a Tigger like that?

(1 yes, 1 pretend play, 2 only for a little while, 1 no)

Do you still think Tigger could teach your child something? What is it? Why do you think that is important to learn?

(1 imagination play, 2 not into stuffed animals, 1 no)

Do you think a toy like Tigger should be used in schools?

(1 yes to learn about feelings, 1 for younger children, 1 no)

Has your opinion of Tigger changed at all?

(2 it is a good idea, 1 the ears were too subtle but otherwise good, 1 too passive, 1 no)

Appendix D

Quantified Results

The following questionnaire was given to an independent observer. This observer was instructed to view the video tapes, and read the written surveys for each child. The results of this assessment of each child were assigned a number, these numbers appear interspersed throughout the questionnaire, highlighted in italics.

D.1 The Independent Data Collection Survey

How old was the child, and what gender?

(circle one)

Is this child familiar with Tigger?

very familiar - 3 - 2 - 1 - not at all

Is this child outgoing or shy?

very outgoing - 3 - 2 - 1 - very shy

Does this child have any siblings?

yes definitely - I don't know - none

2 *0* *1*

Did the child recognize Tigger's expressions?

yes, definitely - unclear - no definitely not

2 *0* *1*

Did the child exhibit any mimicry of Tigger's emotions? (smile or frown)

Happy - Sad - Bouncing - no, nothing

Plus 1 for 'no, nothing' and an additional point for each emotion. Total of 4.

Did the child demonstrate caring or concern for Tigger when he was sad? *(add 1)*

Could the child vocalize what to do to make him happy again?

demonstrated - vocalized - no empathy displayed

3 *2* *1*

Grand total including point from above is 4.

Did the child demonstrate an understand of or awareness of other?

yes - unclear - no

2 *0* *1*

Did the child demonstrate emotional restraint? Could the child control outbursts?

yes - unclear - no

2 *0* *1*

How would you characterize this child's emotional development/understanding of emotions within him/herself AND others in general?

well developed - medium - very immature

3 *2* *1*

Age	Shyness	Siblings	Recognition	Mimicry
(3-5)	(1-3)	(1-2)	(1-2)	(1-4)
2.5	3	1	1	2
3.5	1	2	1	1
3.5	2	2	2	3
3.83	2	2	0	1
4	2	0	2	1
4	3	2	2	1
4	3	2	2	2
4.3	2	2	1	1
4.5	1	2	0	3
5	3	0	2	1
5	3	2	2	4
8-9				
Pearson			0.53	0.18
	Pearson		0.46	0.06
		Pearson	0.47	0.00

Table D.1: Age, siblings and shyness vs. mimicry and recognition

The data (The zeros in the data sets signify that the evaluator was not able to assign a value, this may be due to vagueness in the child's response, technical difficulties with the video camera, or other unforeseen factors.) demonstrated significant correlations between age and recognition. This was to be expected. What was not expected was the better than chance correlation of siblings and shyness to recognition. What is possibly the most interesting is the distinct lack of correlation with mimicry. This result suggests that Piaget's hypothesis that children who have become proficient at imitation begin to imitate internally, may occur well before the third year of age. A larger sample set would be better able to confirm or deny such correlations.

Age	Shyness	Siblings	Sense of "other"
(3-5)	(1-3)	(1-2)	(1-2)
2.5	3	1	1
3.5	1	2	1
3.5	2	2	2
3.83	2	2	1
4	2	0	2
4	3	2	2
4	3	2	2
4.3	2	2	2
4.5	1	2	2
5	3	0	2
5	3	2	2
8-9			2
Pearson	0.08		0.66
	Pearson		0.22
	-0.35	Pearson	0.50

Table D.2: Age, siblings and shyness vs. sense of "other"

The highly significant result from this data is the apparent correlation between both age and a sense of "other" (which is to be expected) and the presence of siblings to the development of a sense of "other". This is a very interesting result, and one that begs for further study.

Age	Shyness	Siblings	Empathy	Emotional restraint	assessment of EI
(3-5)	(1-3)	(1-2)	(1-4)	(1-2)	(1-3)
2.5	3	1	4	1	1
3.5	1	2	1	2	2
3.5	2	2	4	2	2
3.83	2	2	1	1	1
4	2	0	4	2	2
4	3	2	4	1	3
4	3	2	4	1	3
4.3	2	2	3	2	3
4.5	1	2	4	2	3
5	3	0	4	2	3
5	3	2	2	2	3
8-9					
Pearson			-0.02	0.48	0.76
	Pearson		0.35	-0.48	0.14
		Pearson	-0.28	0.40	0.58

Table D.3: Age, siblings and shyness vs. emotional restraint, empathy, and general assessment of emotional intelligence

This final block of data clearly demonstrates the correlation between age and perceived emotional intelligence. This correlation was expected, and as such provides support to the validity of the other measures in the Affective Tigger project. Interestingly, there is also a significant correlation between having siblings and emotional intelligence. As mentioned before, this controversial issue distinctly needs further study. The correlation between age and emotional restraint suggest that this is one of the last factors to develop within the child, and perhaps a study including 6 year olds would show more correlation. Finally, there is an inverse correlation between shyness and emotional restraint. This too is to be expected, in that the more shy the child appears, the less likely she is to exhibit extreme emotional reactions. Overall the lack of shyness correlation demonstrates that it is not detrimental to the development of a child.

Appendix E

Cost Estimate for the Affective Tigger Toy

The Affective Tigger toy was constructed using available tools and supplies. The table below is a projection of what it would cost to build a second unit. The cost of the HANDY board could be reduced by an order of magnitude if one were to custom build these controller circuits. The cost of the HANDY board includes the price of the Lithium battery pack and re-charging circuitry (roughly $50).

Part	Cost (in $)
HANDY board	300
Servo	50
Plush	8
Bend sensor	10
Tilt sensor	3
Switches	1
Accelerometer	.25
Push rods	2
Misc.	2
Total	379.25

Table E.1: A Projection of the Cost to Build the Affective Tigger

Appendix F

About the Author

I used to be a competitive figure skater. I also used to love to ride my mountain bike. My life changed when I was diagnosed with cancer in the Fall of 1997. The surgery on my hip was a complete success though the recovery was long and arduous. During the spring and summer of 1998 I became involved in several new activities as I made progress in my recovery.

I've been something of an amateur Architect for as long as I can remember. I am a partner in the Kirsch/Shepherd construction corporation which builds about one custom home per year in the Palo Alto area of California. During the earliest parts of my recovery I had people bring me library books on Italian Villas and I immersed myself in the works of the great Italian Rennasaince artists and Architects including Vignola, Michaelangelo, and Palladio. From this study I have drawn up a full set of floor plans for a three story Italian Villa to be constructed in the city of Los Altos Hills.

As my mobility increased I decided to take a couple of courses at Stanford. I suffered from one final hospitalization but still managed to attend most lectures as I was walking around with my cane at this point. By the end of the summer I was working full time for the construction corporation, and part time with a movie crew shooting a short film in 16mm.

I am very proud to have completed the two courses, and even more excited at the prospect of graduating with my S.M. on time, despite my losing half a year to illness.

F.1 Publications:

The SIT Books: Using Electro-magnetic Fields for Data Transmission
CHI Late Breaking, Pittsburgh, 1999.

The Sentic Mouse: Developing a tool for Measuring Emotional Valence
(Bachelor's Thesis) MIT Department of Brain and Cognitive Sciences and Program in Media Arts and Sciences, May 1997.

The Locust Swarm: An Environmentally-powered, Networkless Location and Messaging System
T. Starner, D. Kirsch and S. Assefa,
International Symposium on Wearable Computing, 1997

Augmented Reality through Wearable Computing
T. Starner, S. Mann, B. Rhodes, J. Levine, J. Healey, D. Kirsch,
Presence - Special Issue on Augmented Reality, 1997.

Human Pattern Recognition: A Study of the Relationship Between Rotation and Reaction Time in a Head Mounted Display
D. Kirsch, M. Figueroa, MIT Department of Brain and Cognitive Sciences, 1996.

F.2 Awards:

Excellence in Science and Technology Award, Xerox PARC, 1998.

Outstanding leadership award
Civil Air Patrol, California wing, NCO of the Year, 1993.
Awarded highest recognition of leadership skills in the State of California.

Attendance at an intensive military leadership school
Noncommissioned officer's Academy 1992
Selected as one of 30 students from a pool of 100 to attend this California state event.

Attendance at an intensive military leadership school
Pararescue Orientation Course 1992
Selected as one of 30 students from throughout the US to attend this national event.

Outstanding leadership award
Noncommissioned Officer's school intensive seminar 1990
Awarded best overall leader (Honor Cadet) and best presentation in class of 50 students.

Outstanding leadership award Civil Air Patrol Encampment 1989
Awarded best overall leader (Honor Cadet) in class of 100 students.

F.3 Other:

I am a licensed pilot qualified to fly single engine, fixed-wing, land based aircraft.

I am also a licensed NAUI scuba diver.

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