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*Interdisciplinary Council on  
Developmental and Learning Disorders*

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# The Journal of Developmental and Learning Disorders

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## JOURNAL OF DEVELOPMENTAL PROCESSES

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**Editor-in-chief:** Stanley Greenspan, M.D., George Washington University  
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### **EDITORIAL STATEMENT:**

Complex developmental processes characterize the growth of all living organisms. In humans, this complexity is highly elaborated, so that developmental change is affected by many interrelated factors of the body, the mind, family, society, and the environment.

New discoveries continually add to our understanding of these processes and demonstrate the inadequacy of reductionist approaches. Modern research is attempting to capture the full complexity involved in the ways in which the environment regulates gene expression; social interaction affects the unfolding of behavioral and communicational skills; emotions influence cognition; and new interventions help children overcome developmental challenges. Similarly, emerging clinical and educational approaches to human mental health, developmental, and learning challenges are attempting to work with the full complexity of the developmental processes that contribute to healthy and disordered functioning.

The goal of *The Journal of Developmental Processes* is to provide a vehicle for research and clinical studies that advance knowledge of these areas. The *Journal* encourages exchange of ideas across fields including, but not limited to, anthropology, biology, education, linguistics, neuroscience, primatology, psychiatry, psychology, public policy, sociology, and social work.

The *Journal* is interested in both experimental and descriptive studies, including basic research, detailed case reports, ethnographic analysis, and theoretical explorations. Particularly welcome are innovative conceptual frameworks and methods that capture the complexity of developmental processes as well as assessment procedures and interventions that enable children and families to overcome mental health, developmental, and learning challenges.

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# The Journal of Developmental and Learning Disorders

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## Letter from the Editor:

We are very pleased to announce that the *Journal of Developmental and Learning Disorders* will be expanding its focus beginning with the next issue. In line with this expanded focus, the journal will be renamed, *The Journal of Developmental Processes* (JDP). The editorial policy of the JDP describes the journal's broadened perspective.

Complex developmental processes characterize the growth of all living organisms. In humans, this complexity is highly elaborated, so that developmental change is affected by many interrelated factors of the body, the mind, family, society, and the environment.

New discoveries continually add to our understanding of these processes and demonstrate the inadequacy of reductionist approaches. Modern research is attempting to capture the full complexity involved in the ways in which the environment regulates gene expression; social interaction affects the unfolding of behavioral and communicational skills; emotions influence cognition; and new interventions help children overcome developmental challenges. Similarly, emerging clinical and educational approaches to human mental health, developmental, and learning challenges are attempting to work with the full complexity of the developmental processes that contribute to healthy and disordered functioning.

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The *Journal* is interested in both experimental and descriptive studies, including basic research, detailed case reports, ethnographic analysis, and theoretical explorations. Particularly welcome are innovative conceptual frameworks and methods that capture the complexity of developmental processes as well as assessment procedures and interventions that enable children and families to overcome mental health, developmental, and learning challenges.

The new journal will continue to present pioneering clinically relevant articles for its readers. As indicated, however, it will also present research on formative developmental processes from the full range of disciplines that contribute to our understanding of human functioning.

We greatly appreciate your interest in the journal and hope to continue improving it.

*Stanley I. Greenspan, M.D., Editor*  
*Serena Wieder, Ph.D., Co-Editor*  
*Barbara J. King, Ph.D., Co-Editor*



# Does the Autistic Brain Lack Core Modules?

**Morton Ann Gernsbacher & Jennifer L. Frymiare**  
**University of Wisconsin-Madison**

**Abstract:** *Researchers have hypothesized that autistics are missing core modules of the brain, critical neural tissue necessary for accomplishing various processes. In this article, we critically review the evidence supporting two such hypothesized deficits. We ask whether autistic brains lack a module for understanding the behavior of others (i.e., theory of mind) and whether they lack a module for processing faces. We illustrate that successful performance on theory of mind tasks depends on linguistic ability; therefore, it is not surprising that autistics are more likely to fail theory of mind tasks because a qualitative impairment in communication is one of the primary diagnostic criteria for autism. Similarly, we illustrate that autistics are less likely to fixate the eye region of facial photographs and that the amount of time spent fixating the eye region correlates with activation in the face processing “module”; therefore, it is not surprising that autistics are less likely to activate the putative face processing area. These illustrations cast doubt on the arguments that the autistic brain is missing the core modules responsible for understanding theory of mind and for processing faces.*

During the 1990s, which were deemed the “Decade of the Brain,” less invasive techniques for imaging the human brain were developed. For centuries before, we humans had wanted to look inside our heads, to see what makes us tick, and to identify commonalities that unite us and differences that distinguish us. Therefore, starting in the late 1990’s, these less invasive brain imaging techniques began to be applied to numerous special populations, including individuals with autism. The application of less-invasive brain imaging techniques to special populations has allowed testing of previously conceived hypotheses. In this article we review critically two such hypotheses: Whether the brains of autistics lack two fundamental brain modules, one that controls the ability to mentalize about other people, which is known as Theory of Mind, and one that allows the ability to recognize faces.

## THEORY OF MIND

Uta Frith, John Morton, and Alan Leslie (1991) have boldly proposed that “what all people with autism have in common is a particular cognitive deficit that gives rise to the core symptoms in the course of development” (p. 434). Frith et al.’s (1991) proposed cognitive deficit was “the development of the theory of mind, or mentalizing,” which is the “ability to predict and explain the behaviour of other humans in terms of their mental states” (p. 434). According to Frith et al. (1991) “the ability to mentalize is dependent on a specific mechanism that does not manifest itself from birth; neither can it be explained by learning” (p. 434).

Thus, this core deficit—the ability to mentalize about others, called a Theory of Mind—was believed to be (a) universal among all people with autism; (b) innate, neither manifested at birth nor learnable; and (c) biological, dependent on a specific neural mechanism (Yirmiya, Erel, Shaked, & Solomonica-Levi, 1998). Let us examine each of these three claims by first reviewing the evidence for what it means—in research terms—to lack a theory of mind.

In 1985, Baron-Cohen, Leslie and Frith were the first to ask the question of whether autistic children have a Theory of Mind (Baron-Cohen, Leslie, & Frith, 1985). These researchers answered their research article’s title question negatively; they concluded that children with autism have neither a theory of their own mind nor a theory of other people’s minds. Since the publication of Baron-Cohen et al.’s (1985) landmark paper, no fewer than one hundred research articles have asked the same question. Although the answer has not always been as resoundingly negative as that claimed by Baron-Cohen et al. (1985), the idea that persons with autism lack a theory of mind has nonetheless become integrated throughout the academic and professional literature and has pervaded our society’s collective knowledge.

For example, a few years ago, when *Newsweek* magazine focused its cover article on autism, it ran the following byline, “Why more kids and families are facing the challenge of mindblindness” (Cowley, Foote, & Tesoriero, 2000). The assumed importance of the ability to attribute mental states to one’s self and to others, and the perceived pervasiveness of the lack of this ability among persons with autism was also captured in a quote by a well-known autism researcher in a 2002 *USA Today* article: “It’s as if they [persons with autism] do not understand or are missing a core aspect of what it is to be human” (Falcon & Shoop, 2002). But what is the empirical evidence that persons with autism lack a theory of mind?

The original Baron-Cohen et al. (1985) paper and the vast majority of its successors used as an experimental task that is considered the classic assay of Theory of Mind: the “false belief task.” For example, in a false contents belief task, a research participant is shown a common container, such as a box that typically holds a particular brand of candy, and the research participant is asked to predict what is inside. Then, the research participant is shown that the contents do not fit the expectations; for example, the experimenter pulls pencils rather than candy out of the box. After these “false contents” are exposed to the research participant, he is asked to predict what he thought the contents would have been prior to the false contents being exposed (e.g., “What did you think was inside the box before I opened it?”). If the research participant identifies the actual content of the container (e.g., pencils) rather than the expected content (e.g., candy), then he fails the first phase of the false belief

task. Failing the first phase of a false contents task reputedly demonstrates that the individual lacks a theory of his own mind.

In the second phase of a false belief task, a fictional or real person is introduced who is presumably not privy to the exposure of the false contents. The research participant is then asked to predict what this other person would think the contents would be prior to the false contents being exposed (e.g., “What do you think that Jamie will think is inside the box before I open it?”). If the research participant again identifies the actual content of the container (e.g., pencils) rather than the expected content (e.g., candy), then he fails the second phase of the false contents belief tasks. Failing the second phase of a false contents task reputedly demonstrates that the individual lacks a theory of another person’s mind. Thus, performance on the false contents belief task hinges on the research participant’s ability to answer two critical questions: “What did you think was inside the box before I opened it?” and “What do you think [another person] will think is inside the box before I open it?”

Prior to its use in the autism literature, the false belief task was used predominantly with preschool children who demonstrated that before age four, they typically do not answer both questions correctly, but sometime after age four, they typically do (Astington & Gopnik, 1991; Perner, 1991; Wellman, 1990; Wellman, Cross, & Watson, 2001; Wellman & Lagattuta, 2000; Wimmer & Perner, 1983). Because it is around age four that typically developing children begin saying mentalizing expressions such as “think that,” “know that” and “believe that,” it is presumed that around age four typically developing children become aware of their own minds and the minds of others (Bartsch, 1995; Bartsch & Wellman, 1997).

### **Is Theory of Mind a Universal Deficit in Autism?**

Some theorists, most notably Baron-Cohen, believe that a lack of Theory of Mind is the core deficit in autism (Baron-Cohen, 1995). However, even in the original Baron-Cohen et al. (1985) investigation, only 80% (16 out of 20) of the autistic children failed the false belief task; 20% of the autistic children passed the false belief task, and therefore 20% presumably demonstrated that their theory of mind was intact. Other autism researchers have argued that such data demonstrate that theory of mind deficits are not universal in autism (Happé, 1995; Ozonoff, Rogers, & Pennington, 1991).

In a further study, Baron-Cohen (1989) presented a more complex theory of mind task, what is called a second-order false belief task, in which a second individual’s beliefs are queried, for example, “What will Jamie think that Mary thinks is inside the box before I open it?” In this case, only 10% of the autistic children passed the false-belief task. However, other researchers have found success rates in this task ranging up to 50%, particularly when adults are tested (Tager-Flusberg and Sullivan, 1994), leading one group of researchers to draw the rather circular conclusion that “[p]eople with autism have a selective theory of mind (ToM) deficit. . . . Traditional ToM tests . . . are not subtle enough to detect deficits in adults of normal intelligence. . . . More subtle tests . . . are needed” (Rutherford, Baron-Cohen, & Wheelwright, 2002, p. 189). Rather than continue around that circle, one can ask whether individuals with other clinical diagnoses fail theory of mind tests. They do.

Numerous populations have been observed to fail tests of theory of mind, such as false belief tasks, including deaf children (Peterson & Siegal, 1995), blind children (Tager-Flusberg, 2001), non-autistic children and adolescents with mental retardation (Benson, Abbeduto, Short, Nuccio, & Maas, 1993), minimally verbal children with Cerebral Palsy (Dahlgreen, 2002), children with Down's Syndrome (Zelazo, Burack, Benedetto & Frye, 1996), Parkinson's patients (Saltzman, Strauss, Hunter, & Archibald, 2000), frontal lobe patients (Rowe, Bullock, Polkey, & Morris, 2001), and, rather curiously, children with specific language impairment (Miller, 2001). Children with specific language impairment have—by diagnostic definition—no disabilities in social or emotional processes and must score in the average range on every other measure of cognitive function save language skill. It is only their language that is impaired, hence the name, specific language impairment. So, why should children with specific language impairment appear to lack a theory of mind?

Recall the two key questions asked during the false belief task. The syntactic form of these two questions is one of the most complex in the English language. These sentences exhibit sentential complement constructions, in which a complement clause is embedded in the matrix clause. Indeed, all mentalizing statements require sentence complement constructions, which are some of the most complex syntactic structures in the English language.

Does performance on false belief tasks within the general population depend on linguistic sophistication? Correlational studies document significant correlations between language comprehension measures and performance on false belief tasks (Cutting & Dunn, 1999; Hughes & Dunn, 1997; Jenkins & Astington, 1996). Cross-linguistic studies, that is, studies comparing across different languages, document that children acquiring languages in which the analog of the English sentential complement structure is acquired earlier versus later demonstrate earlier versus later success on false belief tasks (de Villiers & de Villiers, 2000; Perez-Leroux, 1998). Longitudinal studies investigating which comes first—successful comprehension of complement structures or passing false belief tasks—document that successful comprehension of complement structures must occur first (de Villiers, 2000; de Villiers & Pyers, 1997).

Recall that a primary diagnostic criterion for autism is a qualitative impairment in communication that can be manifested by a “delay in or total lack of spoken language” (American Psychiatric Association, 1994). One of Tager-Flusberg's longitudinal studies (Steele, Joseph, & Tager-Flusberg, 2003) investigated theory of mind among 57 children with autism between the ages of 4 to 14 years, at the start of the study. Over a one-year period, there were significant developmental improvements in theory of mind ability, and those improvements were primarily related to the children's developing language abilities. Other cross-sectional studies have demonstrated the same relation: Theory of mind ability in autism is tightly coupled developmentally with language ability (Tager-Flusberg, 1997).

Furthermore, Tager-Flusberg and Sullivan (1994) have demonstrated that when autistic children are compared with non-autistic children who are matched to the autistic children's language skills, the difference between autistic and non-autistic children in their success rate of passing first and second-order false belief tasks disappears. In other words, if one controls for language abilities, theory of mind deficits are not unique to autism. Moreover, if one creates a false drawing task that tests theory of

mind without reliance on language, one finds that children with autism and children with deafness actually outperform children with normal hearing (Peterson, 2002).

### **Is Theory of Mind Innate?**

Although training in mind reading has become a popular intervention for autism (Howlin, Baron-Cohen, & Hadwin, 1998), Tager-Flusberg and her colleagues (Hale & Tager-Flusberg, 2003) have demonstrated that grammatical training on sentential complement structures—low-frequency grammatical constructions such as “what will Jesse think is inside the box before I open it”—improves performance of false belief tasks as successfully as training on only false belief tasks. And training on sentential complement constructions has an added benefit: Improving the understanding of other sentential complement sentences.

Thus, to return to the first two claims made about Theory of Mind as a core deficit in autism: Theory of Mind does not pass the universality criterion. Unsuccessful Theory of Mind performance is neither characteristic of all persons with autism nor characteristic of only persons with autism. Theory of Mind performance is not impervious to training either. Recall that Frith et al.’s original proposal was that the ability to mentalize, while not manifest at birth, could not be explained by learning. Let us now consider the third criterion, the putative existence of a specialized neural mechanism.

### **Does Theory of Mind Depend on a Specific Neural Mechanism?**

While at least ten studies have concluded that the putative Theory of Mind module resides in the medial prefrontal cortex (MPC; Brunet, Sarfati, Hardy-Bayle, & Decety, 2000; Calarge, Andreasen, & O’Leary, 2003; Castelli, Frith, Happe, & Frith, 2002; Castelli, Happe, Frith, & Frith, 2000; Fletcher et al., 1995; Gallagher, Happe, Brunswick, Fletcher, Frith, & Frith, 2000; Goel, Grafman, Sadato, & Hallett, 1995; Happe et al., 1996; Nieminen-von Wendt et al., 2003; Vogeley et al., 2001), other studies have suggested the temporal parietal junction (Castelli et al., 2000; Gallagher et al., 2000; Saxe & Kanwisher, 2003), the orbito-frontal cortex (Baron-Cohen, Ring, Moriarty, Schmitz, Costa, & Ell, 1994), the temporal pole (Calarge et al., 2003; Castelli et al., 2000, 2002; Gallagher et al., 2000; Happe et al., 1996), the extrastriate cortex (Brunet et al., 2000; Castelli et al., 2000, 2002; Nieminen-von Wendt et al., 2003), the precuneus (Gallagher et al., 2000; Saxe & Kanwisher, 2003), the thalamus (Nieminen-von Wendt et al., 2003), the anterior cingulate gyrus (Brunet et al., 2000; Calarge et al., 2003; Fletcher et al., 1995; Nieminen-von Wendt et al., 2003; Vogeley et al., 2001), and the cerebellum (Brunet et al., 2000; Calarge et al., 2003). Figure 1 illustrates the range of neuroanatomical locations claimed to be the seat of mentalizing (and Theory of Mind) abilities. The inability of dozens of brain imaging studies to localize a consistent neural area casts strong doubt on there being a single neural module that is missing in autism.

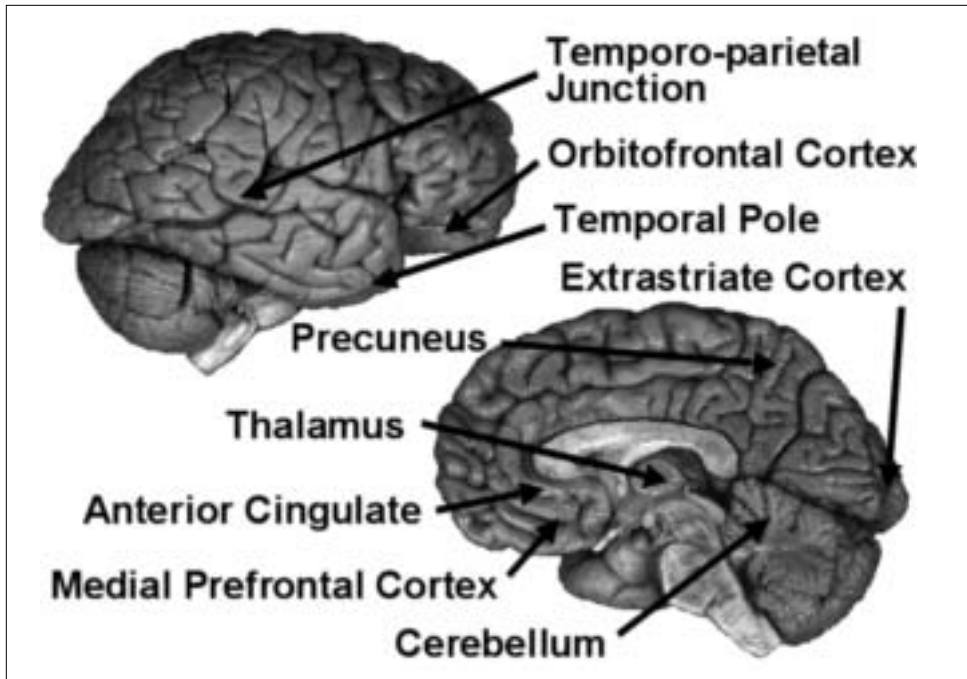


FIGURE 1. Putative areas of the Theory of Mind module from 12 neuroimaging studies.

## FACE PROCESSING

We turn now to a deficit for which there is consistent agreement, at least with regard to the neural tissue involved. Several brain imaging studies have demonstrated that when viewing facial photographs, autistics show less brain activation in the right fusiform gyrus (FG), an area which has been dubbed the “face processing area” because it is prominently activated when non-autistics view facial photographs (Critchley et al., 2000; Hall, Szechtman, & Nahmias, 2003; Pierce, Muller, Ambrose, Allen, & Courchesne, 2001; Schultz et al., 2000). For example, Pierce et al., (2001) reported a robust region of activation in the right fusiform gyrus of non-autistics that was not observed in the right fusiform gyrus of autistics. Such data have led some researchers to speculate that “autism and [Asperger’s Syndrome] involve a congenital abnormality in face ensembles within the [fusiform gyrus] region” (Schultz et al., 2000, p. 338).

However, it is not too surprising that autistics are less likely to activate the putative face processing area; autistics are less likely to look at faces. Indeed, one of the DSM IV criteria for autism is infrequency of eye contact; so by diagnostic definition autistics are less likely to look at faces. But *why*? Why do persons with autism avoid eye contact? Is it because of social indifference, as some theorists have suggested? Consider instead the words of autistics about this important issue.

In her book, *Through the Eyes of Aliens: A Book about Autistic People*, Jasmine Lee O’Neill, a mute autistic, gives the following admonition to non-autistics, “Autistics often avoid eye contact, so don’t assume you’re being ignored or treated rudely, if you’re not looked at directly” (O’Neill, 1999, p. 26). Matthew Ward, an honors math

major at the University of Wisconsin, and also an autistic who participated in an experiment described below, stated the following when he was addressing a seminar, “It’s painful for me to look at other people’s faces. Other people’s eyes and mouths are especially hard for me to look at. My lack of eye contact sometimes makes people, especially my teachers and professors, think that I’m not paying attention to them” (Ward, personal communication).

Thus, rather than being socially indifferent, these autistics are fully aware that eye contact is not only expected but also that its lack can be interpreted as rudeness or apathy. But as Matthew Ward points out, eye contact can be painful. Jasmine O’Neill writes that “eyes are very intense and show emotions. It can feel creepy to be searched with the eyes. Some autistic people don’t even look at the eyes of actors or news reporters on television” (O’Neill, 1999, p. 26).

In her book, *The World of the Autistic Child*, Bryna Siegel, a non-autistic clinician, gave the following analogy: “For autistic children, making eye contact with most people seems to be as difficult as [non-autistic people] staring down someone very threatening. One way I sometimes explain this to parents is to say that for an autistic child, giving eye contact is like it might be for you, if you suddenly found yourself at a crowded party, in a strange country where everyone felt it was quite normal to talk to you from within four inches of your face, and ignored signals you might make to indicate you wished to move farther away. In that case, *you* would probably try to avoid eye contact and turn away, too” (Siegel, 1998, p. 47).

Dalton et al. (2005) recently investigated the biological basis of these intuitions. Their experiment involved 14 right-handed males, all of whom had a DSM IV diagnosis of autism, whose ages ranged from 10–25 years. Included also was a comparison group of 12 right-handed males, none of whom had any DSM IV diagnosis, whose ages ranged from 13–23 years. Participants were acclimated to the brain scanner via participation in a simulation session using a mock scanner, complete with mock scanner noise and many sample trials of the task. Some of the autistic participants chose to participate in more than one simulation session. The experimental task involved viewing 40 facial photographs. Sixteen of the photographs were neutral in their expression of emotion in contrast to 24 that were demonstratively expressive of happiness, anger, or fear. Thus, the emotional expressiveness of the facial photographs was one of two variables that were manipulated.

The other variable manipulated by Dalton et al. (2005) was motivated by a lecture given by Temple Grandin that the senior author of this article attended a few years ago. Grandin is the autistic about whom neurologist Oliver Sacks wrote the essay “An Anthropologist on Mars” in his best seller of the same title. Although Grandin has written several books about autism, such as *Thinking in Pictures and Other Reports from My Life with Autism*, and although Grandin tours the world speaking about autism, the lecture that inspired the experimental manipulation was based on Grandin’s animal science research, which has received international attention as well (Weise, 2003). Grandin’s analysis of animal behavior provides the basis of specific recommendations for more humane interaction. For instance, Grandin advises that when working with a new or a familiar-but-slightly-skittish animal, handlers should avoid making direct eye contact, because direct eye contact can be too threatening. Instead, Grandin advises handlers to avert their gaze, or wear a wide-brimmed baseball cap to occlude their eyes.

Therefore, in the Dalton et al. (2005) experiment, half of both the neutral and emotional faces had been photographed with their eyes straight ahead, and half were photographed with their eyes averted by a quarter turn of the head. The participants' task was to judge whether each facial photograph expressed emotion or whether it was neutral. An event-related functional MRI design was employed, in which each facial photograph was shown for 3 seconds followed by a 5, 6, or 7-second interval. Each participant's electrodermal activity—that is, his or her skin conductance—was measured throughout the experiment, and each participant's eye movements were measured, using an iView eye tracker inside the magnet.

The motivation for including eye tracking was drawn from a couple of recent non-imaging studies that demonstrated that autistic participants were less likely to fixate the eye region of facial photographs (Klin, Jones, Schultz, Volkmar, & Cohen, 2002a, 2002b). Again, this is not *too* surprising if you pay attention to the words of autistics. For example, Lars Perner is an assistant professor of marketing at San Diego State and an autistic who gives presentations at autism conferences. During one such presentation, Dr. Perner fielded the following comment from a 60 year-old autistic audience member, "For all my life, my brothers and everyone up 'til very recently, have been trying to make me look at them straight in the face. And that is about the hardest thing that I, as an autistic person, can do, because it's like hypnosis. And you're looking at each other square in the eye, and it's very draining." Perner replied, "Eye contact is very draining indeed. I have developed a strategy for that. I look at people's noses instead. That works. And people don't notice" (Perner, 2002).

Similar advice is offered in the *Self-Help Guide for Special Kids and Their Parents*, co-authored by a mother and her autistic son (Matthews & Williams, 2000). These authors suggest that to practice making eye contact, "first look at a person's nose. Noses are not as scary as eyes because they do not change their expression or convey a person's feelings" (Matthews & Williams, 2000, p. 22). These authors' insight is correct: Noses do not convey very much emotional expression. So, in real life it could be quite adaptive to look at a person's nose, but in a laboratory experiment, in which the task is to judge whether a facial photograph expresses emotion, you are apt to perform more poorly.

Indeed, as shown in Figure 2 the autistics in the Dalton et al. (2005) experiment were less accurate in their judgments about whether the photographed faces portrayed emotion or whether they were neutral. The non-autistics were close to ceiling in their accuracy, with a mean of 39.4 out of 40 correct, whereas the autistics' mean was around 34 out of 40, or 85%. But there was great variability among the autistics' accuracy. There were no significant differences between the two groups' judgment times when the photographed faces were neutral, regardless of whether the photographed persons' eyes were looking straight ahead or were averted to the side. In contrast, there were significant group differences in judgment time when the photographed faces displayed emotion: The autistic participants made their judgments less rapidly, particularly when the photographed eyes were looking straight ahead, but also when the photographed eyes were averted.

Dalton et al. (2005) observed both qualitative and quantitative differences between the two groups of participants' patterns of eye tracking, as expected from autistic persons' insights. Typically non-autistic participants began in the eye region

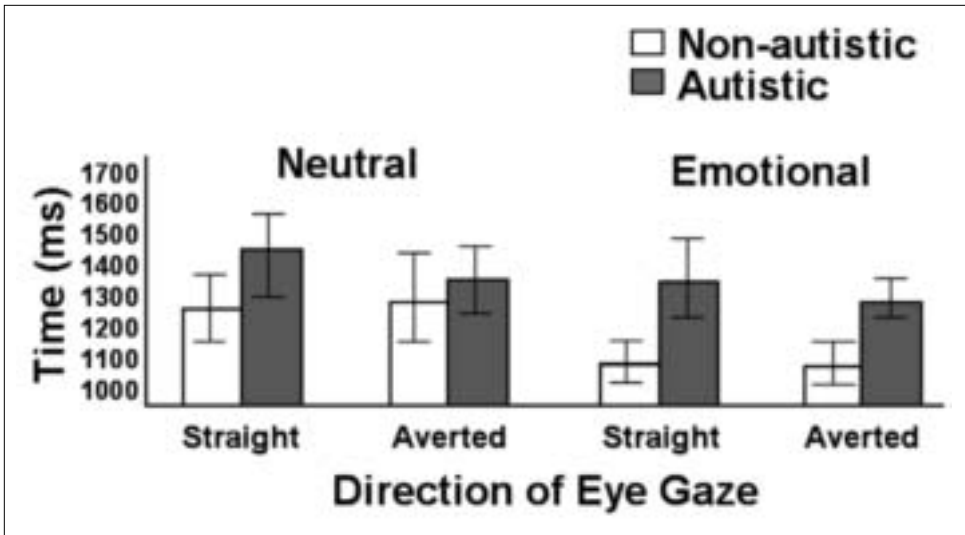


FIGURE 2. Judgment times of neutral and emotional faces with straight or averted eye gaze by non-autistics and autistics in the Dalton et al. (2005) study.

and remained relatively close to the eyes. In contrast, autistic participants did not always begin in the eye region and might instead scan the mouth or the nose. An examination of the average time that the participants spent fixating on the photographed face's right eye revealed that the autistics spent significantly less time fixating the photographs eyes.

Although the autistics and non-autistics did not differ significantly in the number of fixations they made on either the eyes or the mouths, the non-autistics were significantly more likely to fixate the eyes rather than the mouths. This was not a significant difference for the autistics; they were just as likely to fixate the mouths as the eyes. The number of eyes fixated was correlated with the number of correctly judged faces, although this correlation was significant only for the autistics, most likely because the non-autistics were near ceiling in the number of faces they judged correctly, and, therefore, the non-autistics' range was not as variable as that of the autistics. The autistics were also more variable in the number of fixations they made on the right eyes, the faces in general, and both eyes combined.

Turning to the brain imaging data, Dalton et al. (2005) replicated the finding that when viewing facial photographs non-autistics activate the right fusiform gyrus more than autistics do, as shown in Figure 3. Significant between-group differences in percent MRI signal change were observed for both the right fusiform and the left fusiform: The non-autistic participants showed greater activation in the right than the left-fusiform, whereas the autistic participants showed equivalent activation in the right- and left-fusiform. Very importantly, for both groups, the magnitude of the right fusiform activation was correlated with the time that the participants spent fixating the photographs' right eye; indeed, the correlation coefficient for the autistics ( $r=.75$ ) was numerically higher than that for the non-autistics ( $r=.42$ ).

Thus, the more time the participants spent fixating the photographs' eyes—in other words, the more time the participants spent making eye contact—the greater

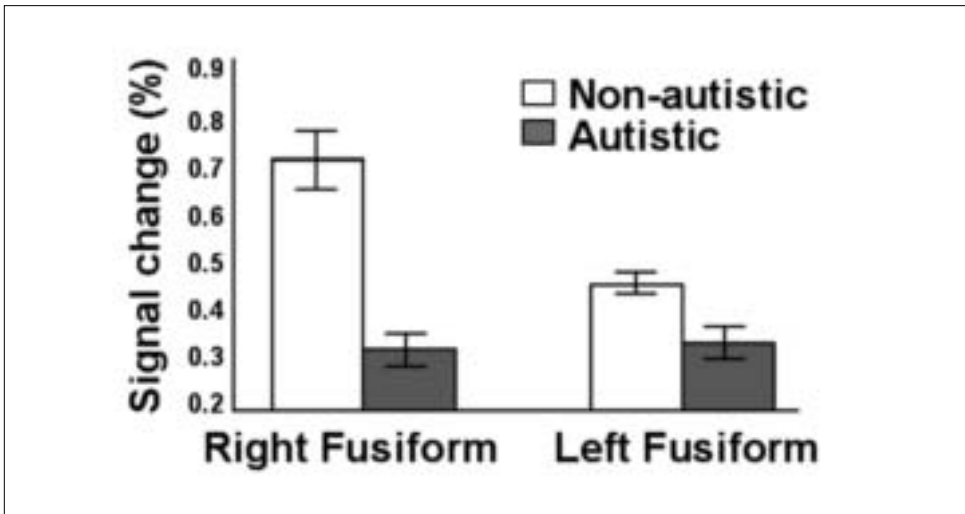


FIGURE 3. Percentage of MRI signal change in the fusiform gyrus by non-autistics and autistics while viewing facial photographs in the Dalton et al. (2005) study.

the activation in the fusiform gyrus of their brains. This finding alone can explain why previous studies have suggested that autistic brains are missing the critical face processing area of the brain. It is not that autistics' face processing "module" is broken or missing—it is simply that they use it for briefer periods of time.

## CONCLUSION

To substantiate the claim that theory of mind is a core deficit in autism, three requirements must be met: individuals with autism must universally fail tests of theory of mind; theory of mind must be innate; and theory of mind must depend on a specific neural mechanism. However, in some studies up to 50% of autistics succeed on theory of mind tasks, and other populations including individuals with specific language impairment fail. Therefore, a "lack of theory of mind" is neither universal in autism nor specific to autism. Training in mind reading or grammatical constructions improves performance on theory of mind tasks, suggesting that theory of mind is not innate. Finally, numerous brain imaging studies have failed to pinpoint one singular neural mechanism.

Previous research has been interpreted as demonstrating that autistic individuals do not activate the putative face area while viewing faces to the same extent as do non-autistics has led to speculation that autistics are missing or have broken "fusiform face processing areas." However, autistics are less likely to look at faces, especially at the eye region. In fact, Dalton et al. (2005) reported that the time autistics spent fixating the eye region of facial photographs correlates with the neural activity in the putative face region.

Taken together, the evidence presented in this paper casts doubt on the arguments that the autistic brain is missing the core modules responsible for understanding theory of mind and for processing faces.

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# THE EVOLUTION OF THE EMOTIONAL FAMILY SYSTEM:

## An Ape Case Study

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**Abstract:** *Like human families, the families of African apes, our closest living relatives, can be thought of as emotional systems. Ape family members are emotionally connected to each other, so that the actions of one affect the actions of others; interactions are often co-regulated in a contingent and unpredictable “dance.” As ape infants develop in this context, they must learn how to separate perception from action, that is, to negotiate for desired outcomes rather than to act out with whole-body, emotionally-driven behavior. In this case study, I examine how a gorilla infant begins to use gesture to communicate his desires to family members in the context of co-regulated interactions. I consider changes over time in this infant’s developmental trajectory, and the meaning-making behavior within this gorilla family, in light of recent books by Temple Grandin and by Stanley Greenspan and Stuart Shanker.*

In *Animals in Translation*, Temple Grandin (2005) acknowledges that animals see the world differently than most humans do. For animals, the world is “a swirling mass of tiny details.” This hyper-specificity, or failure to generalize, is shared in some ways by autistic people.

Famously eloquent about how it feels to be a person with autism, and about how clinicians and parents can help children with developmental disorders, Grandin has now become an effective spokesperson in detailing linkages among intelligence, consciousness, and language (Grandin, 2002). Without language and with brains distinct from ours, animals think differently—but *they do think*. And certainly they are conscious (Gernsbacher, 2004).

In *The First Idea*, Stanley Greenspan and Stuart Shanker (2004) show that emotion is the key to understanding evolutionary advances in the intelligence of animals, specifically primates. The ability to separate perception from emotional action is key. Thinking calmly and symbolically rather than rushing to act or react is an ability that develops gradually, both in the lifetime of a particular individual and in the

primate lineage during the course of evolution. “Early to midway in the first year of life,” Greenspan and Shanker (2004) say, “caregivers help babies begin to learn how to transform catastrophic emotions into interactive signals.” Thus begins a long developmental process by which emotional signaling in the context of nurturing care drives the development of ever-higher levels of thinking.

Here, I use the pivotal ideas in these two books as a springboard to discuss my research with African apes (King, 2004). Three points are central to my approach. First, my research on the communication and consciousness of our closest living relatives supports a decoupling of consciousness and language in evolutionary history. Second, African apes live in social groups in which emotional connections between social partners are paramount. This emotionality permeates their lives moment by moment. Gradually, infants and juveniles learn to manage their emotions and to respond to challenges strategically, through higher-order communication and imagination (and possibly through symbol formation, though I remain agnostic on this question here). Third, because of their unique significance as models for our own prehistory, the African apes can clue us in to ways to better shape adult-child relationships.

Let’s start with a pair of social events. Imagine an evening in San Francisco. Dinner over, a tired mother settles down to relax. Her daughter—we will call her N.—lays next to her, then turns her head and looks at her mother’s chest. A breast-fed child, N. stares at one of her mother’s nipples. As she does, her mother covers that breast with her hand, calmly and without turning her head or closing her eyes.

N. is in the process of being weaned. Sometimes when her mother refuses to allow her access to the breast, N. has a temper tantrum. This evening, however, she does not; she just continues to stare at her mother and at the nipple. From N.’s facial expression it is clear that she is distressed, even though she doesn’t “act out” in any way. N. then reaches up, and with her thumb and index finger, tries gently to close her mother’s eye—the eye closest to the breast that has been such an object of interest.

You may have guessed that N. and her mother are apes; western lowland gorillas, they live at the San Francisco Zoo<sup>1</sup>. In this event, N. clearly wanted the comfort and/or the nutrition available from her mother’s breast, yet she didn’t act on her desire in an emotionally intense, frustrated, or demanding way. She did not grab and yank at the nipple, as ape infants sometimes do. Nor did she have a tantrum, as ape infants also sometimes do, and as N. herself had done recently. Instead, she strategized; she devised a calm action that had the potential to bring about her desired outcome. In fact, N.’s ploy failed. Her mother merely blinked her eye, and no nursing occurred.

Of course, we cannot know exactly what was in N.’s mind as this event unfolded. Perhaps she thought something along the lines of, “if my mother sleeps, maybe then I can nurse.” Or perhaps, “If I can cause my mother not to see me, maybe then I can nurse.” Or perhaps she thought something else altogether. Analyzing this event in the context of primate-behavior studies, it is nonetheless clear that N. was able to take the perspective of her mother into account, and to consider carefully how to try and bring about a desired result.

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<sup>1</sup>Thanks to Mary Kerr of SFZ and to Joanne Tanner for this anecdote.

For social event number two, we must follow anthropologist Richard Wrangham as he observes wild chimpanzees in Uganda. Wrangham (2000) notices eight-year-old male Kakama carrying around a small log. Tenderly, Kakama cares for the log; he retrieves it when it drops, even from high in a tree. At night, Kakama makes a nest for himself to sleep in as wild chimpanzees routinely do, then makes a toy-sized nest for the log; he even tries to squeeze in next to the log in the tiny nest.

That Kakama's mother is pregnant, apparently tired and not paying a great deal of attention to him, is likely no coincidence. Wrangham's interpretation of the log-nurturing behavior is that Kakama invented an imaginary companion to ease his loneliness.

Like N. in San Francisco, then, Kakama devised an imaginative way to try and satisfy an emotional need. Such needs are rooted in the intensely social nature of the African apes; wild chimpanzee and gorilla infants are dependent on their mothers for about four years in terms of nursing and close physical dependency; emotional dependency continues for much longer (and indeed, in some instances, for the span of the mother's life (Goodall, 1990).

Research suggests that as they develop, African ape infants and juveniles generally—not just N. and Kakama—are capable, at times, of bypassing their emotional reactivity by using their intelligence and imagination. Without language, but as intentional, conscious beings who increasingly participate in the social life of their family, they control their emotions as they learn to communicate with others in subtle and complex ways.

Since late 1999, my students and I have observed, filmed, and analyzed gorilla behavior at the National Zoological Park in Washington, DC.<sup>2</sup> The overall goal of my research involves analyzing the group's patterns of body movement and gesture, specifically the ontogeny of these forms of nonvocal communication. Here, I will focus on the emotional engagement within this family and how the infants and juveniles' developmental challenges concerning effective gestural communication can be understood within this context.

A social event I call "the fight" serves to introduce members of the family and to convey the depth of the emotional connection between them. In December 2000, the time of the fight, six gorillas comprised this family group, and I will refer to that time period in present tense. Adult female Mandara, a calm, nurturing mother, lives with biological sons Ktembe (age 3½) and Kwame (age 1) and adopted son Baraka, a subadult.<sup>3</sup> The group's silverback leader is Kuja, a large, heavy male who is also the biological father of Kwame.

On the morning in question, Kwame is my focal subject. As I film his behavior, screams pierce the calm and Kuja begins to chase Baraka aggressively. I did not witness any trigger for this conflict, but tensions between the two males had been increasing in recent months. At Baraka's age, male gorillas in the wild routinely emigrate from their natal groups in order to establish mating and breeding opportunities away from their relatives. Baraka could not, of course, do this at the zoo. His evident

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<sup>2</sup>For help with data collection and analysis I thank students Ann Hagan, Christy Hoffman, Margie Robinson, Rebecca Simmons, and Kendra Weber; NZP curator Lisa Stevens and her staff at the ape house; and Charles Hogg for technical help and for creating video presentations based on the data.

<sup>3</sup>Both Ktembe and Baraka have now been moved to a zoo in Omaha.

frustration at being subordinate to Kuja had at times brimmed over; he frequently threw objects and displayed at Kuja or otherwise challenged the silverback's authority. Zoo staff had even witnessed Baraka mating with his adoptive mother Mandara, though I had not.

When the fight breaks out, 1-year-old Kwame runs immediately to Mandara, his mother, for security and comfort, and clings to her body. As Kuja chases Baraka, Baraka's fear is evident from his screams, his tense body posture, his facial expression, and the fact that he experiences diarrhea. Into this tense encounter between the two older males runs the 3<sup>1/2</sup>-year-old juvenile Ktembe. He attempts to support his big brother Baraka, even as Kuja shoves him roughly away. Mandara, too, rushes in to support Baraka, with Kwame still clinging tightly to her.

As the fight continues, it becomes clear that Baraka is refusing to submit fully to Kuja. Though he is screaming, and at various points either running away or leaning away from Kuja, he does not adopt a fully subordinate posture. He remains standing or sitting when, judging from Kuja's actions, Kuja wants him to lower himself further. As zoo biologist Melanie Bond pointed out to me, Kuja's action of pulling repeatedly on Baraka's lower leg region probably indicated his desire that Baraka prostrate himself in full submission. Given Kuja's size and power, he could easily *force* Baraka down, or bodily pick him up and *put* him in the desired posture. Kuja, in other words, is not aggressing as fully as he might. Even as he chases Baraka, it is clear that he is not running "full speed ahead."

At one point, Baraka's family—his *social* family, given that this is his adoptive mother and sibs—literally lines up behind him. Mandara (with Kwame clinging on) and Ktembe face Kuja right along with Baraka. The gorillas' chosen deployment in space amounts to a beautiful metaphor to be appreciated by human observers: even though Kuja is much bigger, heavier, and more powerful than any individual member of the group, the family members stand together emotionally and physically during this conflict (Yamagiwa, 1987).

How does this conflict end? At one point, Kuja simply sits down. As the tension visibly drains from his body and he adopts a relaxed posture, the group's response is instant: everyone else relaxes too. There is no question that the fight is over.

Let's recap, then, the critical aspects of the fight:

- This family can be understood as an emotional system. An emotional change in one element of the system (a family member) produces, ripple-like, changes in the others. Because family members are connected in this way, a description of the fight as "between Baraka and Kuja" would be much too limited.
- Whereas juvenile Ktembe participates directly in the altercation, Kwame experiences it through his mother. Kwame not only witnesses the fight and its consequences from his vantage point on his mother's back or belly, but he must also *feel* his mother's responses viscerally—for example, her muscles tensing and relaxing as she approaches different group members.
- During the conflict, emotions sometimes, but not always, lead directly to forcible bodily action. Some moderation can be seen in Kuja's aggressiveness and in Baraka's refusal to totally submit despite his fear. It is highly probable, given what is known about ape intelligence (Rumbaugh & Washburn, 2003),

that this moderated behavior comes not from trial-and-error modification of response but from an ability to think through consequences of one's actions.

Reflecting on the fight years later, having read the books by Grandin and by Greenspan and Shanker, led me to some questions: When and how can young apes come to control the pathway of felt-emotion-to-forceful-action so common in primate infancy? How do ape infants come to negotiate with their social partners in getting their needs met, rather than simply using whole body force?

Some answers come to light through my focus on the development of Kwame's gesture requests, undertaken via the dynamic-systems theory (DST) perspective of behavioral analysis. The DST approach, grounded in an idea already presented, that of the family as an emotional system, has informed the work of a number of renowned psychiatrists and psychologists (e.g., Bowen, 1978; Fogel, 1993; Greenspan & Shanker, 2004). As we have seen, understanding of one ape's (or one person's) behavior emerges only from an understanding of how all the system's elements—all family members—affect one another. Thus the development of less emotionally reactive, potentially more symbolic thinking can only be fully grasped when studied in the context of unfolding family events.

Scrutiny of videotaped behavioral interactions involving Kwame and his older siblings and parents produces two broad results. Gestures that can be interpreted as requests develop from Kwame's limb and whole-body movements during early interactions located on his mother Mandara's body. These movements gradually become more consciously controlled by Kwame, and more coordinated with movements of his social partner, over time. From these movements emerge social-request gestures that enable negotiation rather than fixed action patterns, and that take on meaning only as the social event in question unfolds. Meaning, in other words, emerges within the social event which in turn is affected by the emotional system as a whole.

A powerful tool for behavioral analysis within DST is qualitative comparison of social events over time, in order to reveal and explain patterns of behavior. In Kwame's earliest months, his interactions with his mother and sibs tend to be marked by movements that are not well-controlled, and that he cannot bring into coordination with those of his partner. Over time, of course, this changes; *how* it changes and *how* Kwame begins to regulate his emotional needs is my interest. Let's sample some points along the continuum of Kwame's developmental trajectory during his first year of life.

*POINT #1. At five weeks of age, Kwame sits outdoors in Mandara's lap and reclines against her arm. He reaches for, and moves his head towards, Mandara's breast. He may suckle, but it is hard to know this for certain. Kwame then turns his head to the side, definitely not suckling now, and flails his arm. While looking elsewhere, he touches Mandara's breast in an uncontrolled way. Now Mandara withdraws her arm; lacking support, Kwame's head drops back.*

*Kwame tries to pull his head up, but Mandara's arm blocks him; he pulls on the arm; squirms; kicks out with his feet; continues to squirm; stretches out his body; and grips Mandara's fur. Now, with her other arm, Mandara reaches behind Kwame's head and pulls him in closer to her, positioning him so that he sits upright. Kwame nurses.*

Here, Mandara's and Kwame's actions are *co-regulated*, marked by moment-to-moment adjustment between the partners in a contingent, unpredictable dance of movement (Fogel, 1993). Co-regulation does not imply perfect coordination and certainly not perfect symmetry: "misreadings" of, or mismatches with, the partner may occur frequently, and the older or stronger partner may take the lead in a kind of behavioral asymmetry (Fogel, 1993). What co-regulation does imply is that Kwame's movements can only be understood in relation to Mandara's. Co-regulation is a key concept to the DST approach as I use it.

In retrospect it is clear to me that Mandara's behavior in this social event represents a pattern. Consistently (though not inevitably), Mandara lets Kwame move or try to reach a goal or solve a problem before stepping in, herself, to aid or comfort him; Kwame thus may learn that his moving or acting a certain way facilitates a desired result. Yet Mandara doesn't wait so long to respond to Kwame that he becomes overly frustrated or distressed.

In sum, co-regulation exists at this early point, but Kwame expresses his needs with whole-body actions and Mandara moderates them.

*POINT #2. Now almost 6 months of age, Kwame sits near his mother on the cage floor. Using Mandara's body as a bridge, Kwame climbs up the cage mesh. He puts one foot down on his mother's shoulder. Mandara opens her mouth (a mild threat), but Kwame is facing away and cannot see this. After some other contact between the two while Kwame is hanging on the mesh, Mandara shuffles a short distance away. As she moves, Kwame extends his hand, palm up, toward her, but she cannot see this. Kwame moves closer to her, still on the mesh, and touches her back several times. Whether he could now climb onto her body is not clear. Over the next few moments, Kwame reaches toward and touches Mandara some more, and stretches his body toward her. She looks over her shoulder at him, and raises one arm up a bit, and turns. As she does this, Kwame makes a distressed-face expression. (It is not clear whether this expression is visible to Mandara.) As Mandara completes her turn towards him, Kwame makes what seems to be a pout face, and reaches for his mother as she brings him in to her body.*

At this juncture, Kwame is beginning to figure out something about how to signal to his mother what he wants, *at a distance* as well as *on her body*. More able to control his own movements than at five weeks of age, he is able, too, to control his own distress to some degree. Note that the social communication in this event is far from perfectly executed; at times one partner is unable to perceive signals made by the other. Even so, Mandara acts in the balanced way identified above; she lets Kwame try different touches and gestures in expressing his desire to return to her, before she gathers him back in against her own body. Though some of Kwame's actions are not well-coordinated with hers, he is learning gradually that he can bring about a desired outcome in a gestural way.

*POINT #3. At around 8 months of age, Ktembe carries Kwame awkwardly across the cage (Ktembe is not all that much bigger than Kwame, and has little experience in transporting an infant). Kwame's body hits against hard objects as the pair moves along; Kwame makes a distressed face and screams quite loudly. Mandara moves calmly closer to the pair. She does not intervene directly but when Kwame breaks away from Ktembe, she stands quietly nearby so that Kwame may run to her for comfort. Later that same morning, Ktembe once again gathers up*

*Kwame, and holds his little brother against his chest. This time, when Ktembe begins to move away, Kwame quickly extends his arm in his mother's direction, palm down. Though he is close enough to touch Mandara, he does not. Seven seconds later, Mandara retrieves Kwame from Ktembe.*

It is unlikely that any juvenile ape, or for that matter an adult one, would fail to protest emotionally during an event such as the first “kidnapping” in which Kwame was physically banged around. Perhaps Kwame’s very rapid arm extension in the second “kidnapping” stemmed from his memory of what had happened earlier that morning, coupled with his wish for it not to be repeated. Even if his arm extension to Mandara was not intentional, however, it is still important; it gave Mandara a chance to respond *as if* it were intentional so that yet again, Kwame could learn something about the effects of his own movements. In any case, the two gorillas together negotiated a meaning for the arm extension and a behavioral outcome based on it.

At this point in his life, Kwame’s ability to request help, attention, or food develops not in a linear, progressive way, but in fits and starts. The same is true for the quality of his social requests vis-à-vis the partner:

*POINT #4. At around 10 months of age, Kwame makes a mix of requests, some well-coordinated with the orientation of his social partner and others not. In one event, Ktembe approaches Kwame as he sits near Mandara, then passes by a little ways with his back turned. As Ktembe moves by, Kwame reaches out his arm two times (first palm down then palm up) toward Ktembe, in a controlled way near Ktembe’s body—but he does it when Ktembe’s back is turned, either fully or partially. Ktembe does not respond. In another case, as Kwame sits with his mother in a tree as she eats browse, he raises a hand (in a loose fist) first to the branch Mandara holds and then to her mouth as she eats. His request matches a well-formed begging gesture used widely in apes, and was perfectly positioned vis-à-vis his social partner. In this case, this well-formedness makes no difference to the outcome, as Mandara shares no food with Kwame.*

These few points along the developmental trajectory in Kwame’s first year offer glimpses into what I believe to be patterns of change over time in this gorilla’s behavior,<sup>4</sup> patterns similar to those uncovered in my study of the gestural communication by a young bonobo female with her family members (King, 2002, 2004). Once again, key points can be highlighted:

- Co-regulation is frequently present from the beginning, in that mother and infant constantly adjust their movements to each other. The *quality and degree of coordination* between social partners increases over time, however, in a gradual, nonlinear way.
- Social requests are co-constructed with family members. While it is the individual ape who extends an arm, the *meaning* of that movement only emerges

<sup>4</sup>Currently underway is a formal study of social-request gestures by Kwame and his younger brother Kojo between months 6–18 years of age.

as the event unfolds, as the social partners adjust and readjust to each other, and as an outcome is negotiated.

- Intense embodied interaction gradually morphs into coordinated communication between social partners at a distance (with of course, mistakes in coordination or outright refusals to coordinate mixed in).
- Because the social events themselves are highly contingent and unpredictable, social partners must closely attend to each other and “read” subtle nuances of movement and expression. Ape social communication is highly complex. While some form of co-regulation may characterize many mammalian interactions, the unusual nature of ape intelligence (including the ability to take another’s perspective) underwrites what I suspect is, in fact, uniquely complex co-regulation, and as a result, uniquely complex social communication, in apes compared to other nonhuman primates.

Significant challenges exist for researchers who wish to describe and understand changes within an ape emotional family system. *The key process to look for is the mutual construction of meaning through contingent, unpredictable social interaction.* The longitudinal case study is the best vehicle for accomplishing this type of scientific analysis (Fogel, Greenspan, King, Lickliter, Shanker and Toren, in preparation). Change may be described qualitatively, or explained via statistical analysis, or some combination of the two may be attempted. In any case, the researcher looks at more than just the actions of individual ape A, or even ape A’s behavior together with ape B’s response in a back-and-forth exchange. Rather, the unit of analysis is, at one level, the social event, and at another, the social relationship. Tracking changes over time in the quality of co-regulation during social events leads to an understanding of the emergence of changes related to managing the emotions and acting with intelligence within social relationships.<sup>5</sup>

So far I have discussed only African apes living in captivity, but chimpanzees, bonobos and gorillas in the wild also come together with their social partners in a “dynamic dance” of meaning-making (King, 2004). An excellent example comes from the research of Japanese primatologist Kuroda (1984), who studied the rocking gesture among wild bonobos living in the Democratic Republic of Congo (formerly Zaire). Bonobos rock the upper body and head: back and forth or side to side, to different degrees, sometimes accompanied by gestures such as arm raises or by an erect penis in the males; contexts in which rocking occurs vary from sex and courtship, to aggression, to play and mother-infant behavior. Kuroda stresses that the rocking behavior alone carries no meaning; rather, the meaning emerges from the constellation of factors in play at the moment, involving the social partners’ identities and histories. “If the rocking male’s penis is not erect,” he writes, “the meaning of the interaction changes depending on the group situation and the intensity of the rocking” (Kuroda, 1984).

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<sup>5</sup>On this point I am indebted to participants in the dynamic-systems workshop that I organized, and that was funded by the Wenner-Gren Foundation for Anthropological Research, in April 2004: Alan Fogel, Charles Goodwin, Christine Johnson, Kathleen Kerr, Barbara Smuts and Stuart Shanker.

What Kuroda describes is an avenue, similar to the social-request behavior in gorillas, available to infant and juvenile bonobos as they start to express their desires in non-forceful ways. Though Kuroda does not use the language of DST, nor did he study development specifically, his study resonates with the approach described here. DST-oriented research on the ontogeny of the bonobo rocking gesture, and of other co-regulated gestures in African apes, would add much to our overall understanding of ape infants' ability to act, and to think, in ways that are intelligent and imaginative rather than fixed or forceful.

African apes, then, during spontaneous interactions in the wild and captivity, use gestures to negotiate outcomes during co-regulated interactions. Infants and juveniles, as they interact with their family members, gradually learn the skills related to this negotiating. Ape language researchers report that apes raised in highly enriched conditions use human symbols in an accelerated and heightened version of this same process (Savage-Rumbaugh, Shanker & Taylor, 1998; Segerdahl, Fields & Savage-Rumbaugh, 2005). The message for the evolution of the human family system is clear.

As Temple Grandin reminds us, we have evolved from other creatures who are conscious and who can think. As Stanley Greenspan and Stuart Shanker tell us, we have evolved from primates who were able, via ever more complex emotional signaling with their partners, to channel their emotions into productive actions. As they put it, “[a]t each stage, new cognitive skills are learned from emotional experiences” (2004). And as my work with African apes underscores, humans have evolved over millions of years to be emotionally connected within their family and social groups, and to make meaning together through co-regulated interaction. It is in this context that infants and juveniles make strides in regulating their emotions and beginning to negotiate strategically for desired outcomes.

The lessons for parents, clinicians, and educators is a hopeful one. Evolution has prepared our children to be attuned to our feelings and thoughts, to be ready to adjust their own actions to ours, and to develop their cognitive powers through emotional connection with those around them. In interacting with children, we adults have a very deep substrate to tap into, for humans have evolved to co-construct our lives using a powerful blend of emotion and cognition.

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# EVALUATING CENTRAL AUDITORY FUNCTION IN AUTISM:

## New Approaches in Clinical Practice

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**Abstract:** *The clinical evaluation of auditory function in children with autism spectrum disorders (ASD) has traditionally been limited to tests of hearing. However, recent studies have suggested that children with ASD may have impaired listening abilities despite normal hearing. Listening abilities are associated with the central auditory system and, in particular, auditory cortex. Recent advances in brain mapping methods, including neuroimaging and electrophysiology, provide new tools for probing cortical auditory function in ASD. In this article, we discuss how these brain mapping methods can be combined with behavioral measures in clinical practice to evaluate listening abilities in children with ASD.*

## INTRODUCTION

Children with autism spectrum disorders (ASD) routinely undergo hearing tests to rule-out hearing loss as a risk factor for speech-language delays and disorders. These tests probe the functional integrity of the peripheral auditory system to determine whether a child can detect sounds at normal intensity levels. This is accomplished by establishing hearing thresholds across a range of frequencies (250–8000 Hz) for each ear and by testing middle ear function to rule out the presence of fluid or other abnormalities that can interfere with hearing. These tests can be supplemented with objective measures, including otoacoustic emissions, auditory brainstem responses, and, more recently, auditory steady-state responses, to provide additional information about the hearing abilities of children with ASD.

In contrast, auditory functions associated with the central auditory system are rarely evaluated clinically in children with ASD. The central auditory system begins

at the level of the brainstem and includes other subcortical auditory structures, such as the inferior colliculus and the medial geniculate of the thalamus, as well as cortical primary and association auditory areas in temporal lobes. Auditory functions associated with the central auditory system include the ability to analyze and integrate spectral and temporal features of auditory objects in the environment, discriminate and identify speech sounds, process speech under different listening conditions, sequence auditory events, and selectively attend to auditory information. Collectively these functions are referred to as listening abilities and they interface between the peripheral hearing system and higher-level language systems, including the lexical-semantic system, involved in the comprehension of spoken speech. A deficiency in one or more of these listening abilities is considered a risk factor for speech-language impairments and poor academic performance (ASHA, 1996).

Behavioral research suggests that listening abilities and, by implication, central auditory functions may be impaired in otherwise normal-hearing children with ASD. An early study of listening preferences in children with ASD showed abnormal responses to speech with a preference for non-speech sounds (Klin, 1991). This finding is consistent with reports of abnormal and inconsistent responses to voices in children with ASD (Gervais et al., 2004). It has also been observed that high-functioning individuals with autism or Asperger syndrome have difficulty with speech recognition in the presence of background noise. A recent study confirmed this observation reporting higher (i.e. worse) speech reception thresholds in temporally and spectrally modulated speech-shaped background noise compared to normal controls (Alcantara, Weisblatt, Moore, & Bolton, 2004). These findings suggest that high-functioning individuals with autism or Asperger syndrome have difficulty with speech recognition when the background noise is composed of or resembles speech. Other studies, including our own, have found evidence for impaired speech recognition abilities when the speech signal itself is degraded or masked to simulate the effects of everyday adverse listening conditions, including background noise (Boatman, 2003). There is also evidence that ASD individuals process sounds differently than normal subjects, focusing on sound features (local processing) while normal subjects process sounds more globally, consistent with the view that ASD individuals have difficulty integrating and interpreting sound features into coherent auditory objects (Foxton et al., 2003). Interestingly, it has also been shown that although children with ASD perform more poorly than normal controls when information is presented in auditory or visual modalities alone, they show normal integration of auditory-visual information (Williams, Massaro, Peel, Bosseler, & Suddendorf, 2004).

Taken together, these findings indicate that listening abilities are impaired in children with ASD. Although behavioral studies can identify and characterize central auditory impairments in children with ASD, they do not provide information about the underlying neural bases of these impairments. With recent advances in brain mapping methods, new insights have emerged into the neural bases of central auditory dysfunction in ASD. In the next section, we review a number of these findings and their potential clinical implications.

## **BRAIN MAPPING STUDIES OF AUDITORY FUNCTION IN ASD**

Brain mapping studies, using neuroimaging or electrophysiological methods, have focused largely on the cortical level of the auditory system. These studies provide exciting new insights into the neurological bases of auditory dysfunction in ASD. Moreover, they attest to the feasibility of combining behavioral and brain mapping methods for the clinical evaluation of auditory function in children with ASD. In this section, we discuss recent brain mapping findings related to the issue of central auditory function in ASD. This is not meant to be an exhaustive historical review, but rather a brief overview to provide a framework for discussing the potential implementation of brain mapping methods in clinical practice.

### **Neuroimaging Studies**

Neuroimaging methods provide a non-invasive means of visualizing the central auditory system *in vivo*, both functionally and structurally. A growing number of studies are using neuroimaging methods to investigate the integrity of central nervous functions in individuals with ASD. A subset of these studies focus on the auditory system. In this section, we discuss recent findings from functional and structural neuroimaging studies of auditory function in ASD.

#### Functional Neuroimaging

Functional neuroimaging methods are used to identify brain regions associated with task performance. The two main approaches to functional neuroimaging are functional MRI (fMRI) and Positron Emission Tomography (PET). PET is used more rarely in studies of children with ASD because it involves a radioactive tracer. For fMRI, the signal is a blood oxygen level dependent (BOLD) signal. Task-specific regional increases in blood oxygen levels increase the strength of the MRI signal detected. Abnormal cortical patterns of fMRI activation have been reported for autistic subjects on tasks of face processing (Adolphs, Sears, & Piven, 2001; Critchley et al., 2000), semantic processing (Dunn, Vaughan, Kreuzer, & Kurtzberg, 1999), and eye gaze (Pelphrey, Morris, & McCarthy, 2005; Ring et al., 1999). Studies using fMRI have also reported abnormal auditory processing in autism. A recent fMRI study found that ASD subjects showed reduced activation of temporal lobe voice processing regions, including the superior temporal sulcus, compared to normal listeners (Gervais et al., 2004). PET studies have also yielded interesting findings. A PET study of school-age children with ASD showed bilateral hypoperfusion in temporal lobe auditory areas (Zilbovicius et al., 2000). More recently, another PET study of children with ASD also reported less activation of language-related areas in the left hemisphere than in normal controls (Boddaert et al., 2004).

## Structural Neuroimaging

Structural MRI studies have revealed abnormalities in auditory cortical areas in individuals with autism. There are currently two main types of structural neuroimaging studies: volumetric studies and diffusion tensor imaging (DTI) studies. Volumetric studies use size (volume) measurements to quantify regions of interest from MRI scans. Volumetric studies of auditory cortex have shown atypical patterns of brain growth in ASD, with larger brain regions early in development (Courchesne et al., 2001). There is also evidence for atypical hemispheric asymmetries in ASD, including auditory areas such as the planum temporale (Herbert et al., 2003; 2005). Both increased volume and abnormal auditory processing might result from increased numbers of cortical processing units that have been described as minicolumns (Casanova, Buxhoeveden, & Brown, 2002). Abnormal white matter volumes have also been identified. The corpus callosum, a large white matter tract connecting the two hemispheres, is reportedly smaller in ASD (Eras, Couches & Sutor, 1995; Harden, Minshew & Keshavan, 2005), consistent with behavioral studies showing impaired transfer of information between the two hemispheres (Gunter, Ghaziuddin & Ellis, 2002). Similarly, abnormal cerebellar and subcortical white matter volumes have also been reported (Akshoomoff et al., 2004; Aylward, Minshew, Field, Sparks & Singh, 2002; Sparks et al., 2002). Taken together, these volumetric studies provide evidence for abnormal brain growth patterns, atypical hemispheric asymmetries, abnormal subcortical white matter volumes, and smaller corpus callosum volumes in ASD.

Diffusion Tensor Imaging (DTI) probes the microstructural integrity of white matter pathways by quantifying the diffusion of water in brain tissue (Le Bihan et al., 2001). Water diffusion in white matter is normally anisotropic because it occurs more rapidly in parallel than perpendicular to axonal fibers due to myelination. White matter abnormalities manifest as decreased anisotropic values. DTI studies in autism are just beginning to emerge. A recent study reported below normal fractional anisotropy values in the white matter pathways underlying auditory areas in the superior temporal gyri of autistic subjects (Barnea-Goraly, Kwon, Menon, Eliez, Lotspeich & Reiss, 2004). Because changes in white matter integrity may precede the onset of clinical symptoms, DTI offers a potentially useful clinical tool for early diagnosis of autism.

## **Electrophysiological Studies**

Electrophysiological studies of central auditory function in ASD have focused on the brainstem or cortex. Auditory brainstem response (ABR) studies have yielded inconsistent findings with some studies reporting abnormalities (Rosenhall, Nordin, Brantberg, & Gillberg, 2003) and others reporting normal findings (Grillon, Courchesne, & Akshoomoff, 1989). In contrast, scalp recordings of cortical auditory potentials have consistently reported abnormalities in ASD, as recently discussed (Rapin & Dunn, 2003). Early cortical response latencies associated with primary auditory areas, including the N100, appear to be prolonged (Klein et al., 1995), as are later

cortical auditory responses (Bruneau, Roux, Adrien & Bathelemy, 1999). Although early cortical responses to non-speech auditory information, such as tones, may be normal, cortical responses to speech (words) in ASD subjects are prolonged (Dunn et al., 1999). A recent electrophysiological study of speech sound processing in children with high-functioning autism found evidence of a selective impairment in attention orienting to vowel sounds, with otherwise normal sensory processing of vowels and acoustically matched complex sounds (Ceponiene et al., 2003).

Studies using magnetoencephalography (MEG) have also reported abnormal cortical auditory responses in ASD. Using a passive listening paradigm with children and adults with ASD, a recent MEG study reported abnormal M100 responses to a series of tones in children with language impairments suggesting auditory temporal processing deficiencies (Oram Cardy, Flagg, Roberts, Brian, & Roberts, 2005).

The growing number of brain mapping studies of ASD attest to the feasibility of using neuroimaging and electrophysiology methods to probe the functional and structural integrity of the central auditory system in this population. In the next section, we discuss how these methods can be implemented in clinical practice, in combination with established behavioral measures, to evaluate the listening abilities of children with ASD.

## **CLINICAL EVALUATION OF CENTRAL AUDITORY FUNCTIONS IN AUTISM**

### **Behavioral Testing**

Behavioral tests of central auditory function have traditionally been used to diagnose or rule-out central auditory disorders in children. Strictly defined, a central auditory disorder is a modality-specific impairment in the ability to process auditory information in the context of otherwise normal hearing, language and cognitive abilities (Jerger & Musiek, 2000). Although the finding of a central auditory disorder is important to identify children who have no other neurodevelopmental disorders and who would benefit from remediation and educational services, the diagnosis may be less useful in children who have already been diagnosed with a neurodevelopmental disorder, including ASD. Moreover, children with ASD often have multi-sensory disorders in addition to language and cognitive impairment and may vary greatly in their abilities from other children with language disorders (Greenspan & Wieder, 2002). The central auditory evaluation may be more useful for identifying and characterizing relative strengths and weaknesses in the auditory processing abilities of the individual child with ASD. By profiling their listening abilities, it is possible to provide parents, teachers, and other clinicians with a comprehensive basis for identifying particular areas to be targeted for remediation and/or medical therapies and to monitor changes in those areas over time.

In testing children with suspected central auditory dysfunction, regardless of the etiology, it is important to administer a battery of tests because no single test covers all central auditory functions. Standardized tests are available to probe multiple aspects of central auditory function including auditory spectral and temporal process-

ing, speech sound (phoneme) awareness, speech recognition under different listening conditions, auditory sequencing abilities, auditory attention, and auditory verbal working memory. Many of the tests use single word repetition as the response format. Single-word repetition is generally feasible for children with high functioning autism or Asperger syndrome. We have found that children with ASD who have reduced language skills and have echolalia can be tested using the single word repetition format since they will repeat words regardless of whether they comprehend task directions. Central auditory tests that use short phrases and sentences may be useful only for testing children with high-functioning autism.

Recent research findings can be used to guide the selection of tests to be administered. Because multiple studies have shown impairments in speech recognition under adverse listening conditions, tests of word recognition in background noise and filtered word recognition are likely to be useful. Similarly, a number of studies have pointed to atypical lateralization of speech and language functions in individuals with ASD. Dichotic listening tests provide behavioral measures of lateralization and, therefore, may be useful. Measures of auditory temporal processing may be helpful in identifying deficiencies that can affect speech processing. Although a number of central auditory tests do not have norms for children younger than 6 years, there are several tests that provide younger norms (e.g. SSW test, SCAN-C Test, Phoneme Synthesis Test).

Although most children with ASD who are referred for central auditory evaluations have confirmed normal hearing, we routinely do otoacoustic emissions screening which can be done in less than 2 minutes and does not require a behavioral response from the child. The presence of otoacoustic emissions suggests normal cochlear function in the speech frequency range (500–4000 Hz) and ensures that there is no middle ear pathology. Minimal requirements for behavioral central auditory testing include the ability to wear headphones or insert earphones (some tests can be played through speakers) and the ability to repeat single words. The equipment used to administer behavioral tests includes a clinically calibrated two-channel sound presentation system (audiometer, computer), inserts or headphone, and quiet listening conditions (i.e. ambient noise levels  $\leq 45$  dB SPL). The use of insert earphones or headphones varies from clinic to clinic. We have found that headphones are often not tolerated as well as insert earphones perhaps because of the additional pressure on the head from the headphone headband and/or discomfort from having the ears entirely covered.

## **Neuroimaging**

The growing number of functional and structural neuroimaging studies of ASD challenges previous concerns about feasibility. Moreover, recent advances in MRI technology including event-related protocols, that allow auditory stimuli to be presented in the absence of scanner noise, are making it more feasible to conduct neuroimaging studies in children with ASD. A number of issues remain to be addressed before neuroimaging studies become routine in the clinical evaluation of central auditory function in children with ASD. One issue concerns behavioral compliance. Most neuroimaging studies in autism have focused on adults with ASD or children

with high-functioning autism or Asperger syndrome because they are more likely to be behaviorally compliant. A related issue concerns task requirements. Auditory neuroimaging studies of children with ASD have chosen a passive listening task to reduce the behavioral compliance requirements. If a behavioral response is elicited, practice sessions are recommended before the child enters the scanner. A number of programs have mock scanners that enable children to go through practice sessions to acclimate to the scanner. Movement artifact continues to be a limitation in most pediatric neuroimaging studies. This may be more problematic for children with ASD who have repetitive motor behaviors. Limiting time in the scanner is also helpful whenever possible. Although numerous centers have successfully scanned ASD subjects for as long as 2 hours, 30–50 minutes is more standard. Structural neuroimaging studies typically take less time (~ 30 min–1 hour) and, therefore, may be more feasible than functional neuroimaging. Similarly, although very young children with ASD have been scanned successfully, in our experience a lower age limit of 6–8 years is common.

Despite the growth of neuroimaging studies, no reliable clinical markers have been identified for the diagnosis of autism. Consequently, it has been recommended that neuroimaging not be used routinely in the clinical work-up for the diagnosis of autism (Sokol & Edwards-Brown, 2004). Neuroimaging may be useful in the clinical evaluation of auditory functions in ASD. By comparing patterns of task-related activation elicited from ASD subjects to appropriately matched normal controls, it may be possible to identify differences associated with behavioral abnormalities in central auditory function. The next 5–10 years are likely to bring advances in neuroimaging methods to further facilitate the evaluation of central auditory function in children with ASD.

## **Electrophysiological Testing**

Different implementation and interpretive issues face clinicians wishing to include electrophysiological testing in the evaluation of central auditory function in children with ASD. An advantage of electrophysiological testing is that it offers an objective measure of auditory function and, therefore, is useful when behavioral testing yields inconsistent or unreliable responses. Auditory brainstem response testing is done in many clinics to evaluate hearing thresholds in children with ASD to confirm behavioral threshold results or to evaluate the status of brainstem auditory pathways. Testing requires placement of a minimum of 4 electrodes (one behind each ear, a ground, and a high forehead or vertex recording electrode). Insert earphones or headphones are used to present clicks to each ear. A recording system collects and averages the responses for each ear. The peak latencies of waves I–V are recorded and compared for each ear with established clinical norms. Recently, researchers have begun to use speech stimuli to investigate temporal aspects of transmission of auditory information in the brainstem. Children with language disabilities and evidence of cortical auditory dysfunction also show abnormalities in the neural transmission of speech information through the brainstem (Wible, Nicol, & Kraus, 2005). This testing can be accomplished without eliciting behavioral responses and, therefore, is well suited for evaluating auditory processing in children with ASD.

Later auditory evoked potentials associated with cortical auditory processing are also used to evaluate central auditory function. They can be implemented using the same recording equipment used to elicit brainstem auditory responses with additional electrodes and different paradigms and stimuli. One popular auditory evoked potential paradigm for testing children with ASD is the passive oddball paradigm used to elicit the N1-P2 complex and the mismatch negativity (MMN). The N1-P2 complex is one of the earliest cortical responses and reflects the brain's automatic detection of the presence of a sound. The MMN is a computed waveform representing a pre-attentive response to the detection of a deviant acoustic stimulus in a series of standard stimuli (Naatanen, 1995). A passive oddball paradigm is useful for testing children with ASD because it is not attention or response dependent and is elicited in the context of a visual distracter (e.g. cartoon, video). We use this protocol routinely in our clinic and have found that the visual distracter is also helpful for electrode placement. An active version of the oddball paradigm, requiring the child to press a button or keep track of the number of deviant stimuli, is used to elicit the P300 response that reflects auditory attention and higher-level cognitive functions. Because the active oddball paradigm requires a behavioral response, the compliance requirements are greater and may not be feasible for some children. Two case presentations illustrate the utility of implementing electrophysiological measures to supplement behavioral testing of central auditory functions in children with ASD.

#### CASE 1

A 9-year-old, right-handed boy diagnosed with high-functioning autism was referred for central auditory testing by a pediatric neurologist. Developmental history included speech-language and motor delays. An attention disorder was diagnosed at age 5 years; no medications had been tried. Previous hearing tests were normal. Behavioral central auditory testing yielded inconsistent findings unrelated to task difficulty across the test session. Otoacoustic emissions confirmed normal cochlear function bilaterally (500–6000 Hz). Auditory brainstem responses showed normal absolute peak and inter-aural latencies and for waves I-V. Cortical auditory evoked responses, elicited with a passive oddball paradigm, showed normal N100 latencies for pure tones (standard: 1000 Hz; deviant: 1100 Hz) and speech (standard: ba; deviant: da) and MMN latencies for tones and speech (234–257 ms), suggesting normal pre-attentive cortical auditory processing. An active oddball paradigm yielded inconsistent behavioral responses and delayed P300 latencies. Electrophysiological results indicated normal central auditory function on response-independent measures. Although the behavioral results were largely un-interpretable, the electrophysiology findings suggested normal central auditory function.

#### CASE 2

A 14-year-old, right-handed boy diagnosed with Asperger Syndrome was seen for central auditory testing at the request of his parents. Medical history included chronic ear infections. Previous hearing tests were normal. There was no history of speech-language delays. Decreased speech understanding was reported under ad-

verse listening conditions. On behavioral tests of speech sound awareness, he performed 2–3 standard deviations below the mean for his age. Speech recognition in moderate-high levels of background noise was impaired, as was recognition of filtered words. Discrimination of pure tone pairs was normal; discrimination of speech syllables (e.g. ba-da) and frequency-modulated tones was impaired. Otoacoustic emissions and auditory brainstem responses were normal. Cortical auditory evoked responses, elicited with a passive oddball paradigm, showed normal N100 latencies for pure tones (standard: 1000 Hz; deviant: 1100 Hz) and speech (standard: ba; deviant: da). MMN latencies were prolonged for tones and speech. Test results suggest impaired cortical processing of auditory spectral and temporal information associated with speech sound perception. Preferential classroom seating and remediation to improve speech sound awareness skills was recommended.

Analysis of auditory brainstem responses and later auditory evoked responses is based on published and/or clinical norms. A minimum of 20 normal subjects is recommended for development of clinical norms for adolescents and adults. Because auditory evoked responses are subject to developmental effects, it is important to elicit age-specific norms for younger children.

## SUMMARY

In summary, non-invasive brain mapping methods, used in combination with established behavioral measures, offer clinicians new tools for probing and visualizing the functional and structural integrity of the central auditory system, and associated listening abilities, in children with ASD. In addition to providing diagnostic information, these tools can also be used to monitor effects of medication, therapy, or other interventions.

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# CAN CHILDREN WITH AUTISM MASTER THE CORE DEFICITS AND BECOME EMPATHETIC, CREATIVE, AND REFLECTIVE?

A Ten to Fifteen Year Follow-Up of a Subgroup of Children with Autism Spectrum Disorders (ASD) Who Received a Comprehensive Developmental, Individual-Difference, Relationship-Based (DIR) Approach

**Serena Wieder, Ph.D. and Stanley Greenspan, M.D.**

**Abstract:** *A follow-up study of 16 children diagnosed with an autistic spectrum disorder (ASD) revealed that with the DIR/Floortime approach, a subgroup of children with ASD can become empathetic, creative, and reflective, with healthy peer relationships and solid academic skills. This suggests that some children with ASD can master the core deficits and reach levels of development formerly thought unattainable with a family-oriented approach that focuses on the building blocks of relating, communicating, and thinking.*

There is mounting evidence that emotional processes, such as engagement, joint attention affective reciprocity, and creative play are associated with healthy social, language, and intellectual functioning (Greenspan, 2004; Mundy, 1993; Sigman, & Kasari, 1990; Siller & Sigman, 2002). Therefore, we raise the following question: Can these processes be harnessed in children with autism spectrum disorders (ASD) to enable them to make more progress than formerly thought possible? It has been believed that children with ASD are incapable of higher levels of empathy and creative and reflective thinking, no matter how much progress they make academically or with language.

In this paper, we report on a follow-up study of 16 children and families who engaged in the Developmental, Individual-Difference, Relationship-Based (DIR/

Floortime) comprehensive intervention program that focused on the building blocks of relating, communicating, and thinking. The DIR/Floortime assessment and intervention program also addresses the individual variations in sensory processing (auditory and visual-spatial processing), sensory discrimination and modulation (including tactile, sound, vestibular, proprioceptive, olfactory, taste, pain, and sight), and motor planning and sequencing (including muscle tone, and coordination), as well as family interactive patterns (Greenspan & Wieder, 1999; 1998; Interdisciplinary Council on Developmental and Learning Disorders Clinical Practice Guidelines Workgroup, 2000).

In this study, we attempted to answer the question of whether or not a subgroup of children diagnosed with ASD could go beyond expectations for high-functioning ASD and learn to be related, empathetic, creative, and reflective thinkers. This report is not intended to be an outcome study of the DIR/Floortime model, but only to answer the specific question raised above. Observing if a subgroup of children with ASD can achieve levels of functioning formerly thought unattainable is especially significant in light of the different intervention approaches now being offered. Some approaches focus more on surface behavioral changes and academic skills and others, such as the DIR/Floortime model, focus more on the developmental processes leading to relating, communicating, and thinking. Looking at the upper limits attainable by a subgroup of children with a good prognosis, who had access to an optimal developmentally-based program, can therefore shed light on both the mechanisms involved in helping children with ASD grow psychologically and intellectually and the potential of some children in an optimal intervention program.

In an earlier paper reviewing 200 cases of children with ASD followed 2–8 years after the start of intervention (Greenspan & Wieder, 1997), we reported that a subgroup we treated did exceptionally well, learning to engage, communicate, and think creatively and reflectively with high levels of emotional understanding and empathy. Although in this chart review (summarized on the following page), 58% showed these optimal patterns, the 200 cases reviewed were not a representative population of children with ASD. Therefore, the true size of the subgroup is not known.

Before we present the current study, it will be useful to briefly present an overview of the earlier review to create the context for the current follow-up. Table 1 summarizes the presenting problems of the children and Table 2 the DIR/Floortime Intervention outcomes.

In the 1997 study, the authors looked more closely at 20 children in the good to outstanding outcome group in two ways (Greenspan & Wieder, 1997). We used the Functional Emotional Assessment Scale (FEAS; Greenspan, DeGangi, & Wieder, 2001), a reliable and validated instrument which measures emotional, social, and intellectual functioning, to compare these 20 children to an age and socioeconomic status-matched group of peers with no history of developmental challenges, as well as a group of children with ASD who had continuing challenges. We found there were no differences between the DIR/Floortime intervention group and the “typical” peer comparison group in terms of emotional, social, and intellectual functioning, but significant differences with the group that had continuing difficulties. See Table 3. We also assessed the group of twenty with the Vineland Adaptive Behavior Scale which measures three domains. As can be seen in Table 4, the group of twenty scored higher than age level in all domains, especially in communication and socialization (Sparrow, Balla, & Cicchetti, 1984).

**Table 1—Chart Review of 200 Cases**

Developmental Patterns*	
Presenting Patterns	
Engagement	<ul style="list-style-type: none"> <li>• 5%—no affective engagement</li> <li>• 31%—only intermittent engagement</li> <li>• 40%—intermittent engagement and some reciprocity</li> <li>• 24%—intermittent engagement and reciprocity and islands of symbolic capacity</li> <li>• 100%—lacking long chains of reciprocal interactions</li> </ul>
Auditory Processing Problems	<ul style="list-style-type: none"> <li>• 100%</li> </ul>
Motor Planning Dysfunction	<ul style="list-style-type: none"> <li>• 100%</li> </ul>
Reactivity to Sensation	<ul style="list-style-type: none"> <li>• 39%—Underreactive</li> <li>• 19%—Hyperreactive</li> <li>• 36%—Mixed</li> </ul>

\*Journal of Developmental and Learning Disorders, 1997

**Table 2—DIR/Floortime Intervention Outcomes**

All Degrees of Implementation of Recommended Program N=200	
Good to Outstanding	58%
Medium	25%
Ongoing Difficulties	17%

**Table 3—FEAS Outcomes**

	N	Mean FEAS	Range
DIR/Floortime Intervention Group	20	74.8	70–76
Normal Comparison Group	14	74.9	65–76
Continuing Significant Difficulties	12	23.7	10–40

**Table 4—Vineland Outcomes**

Sample of Children with Good to Outstanding Outcomes N=15	
Higher than age levels in communication	93%
Higher than age levels in socialization	87%
Higher than age levels in daily living skills	53%

## LONG-TERM OUTCOMES

In this presentation, we report on a ten to fifteen-year follow-up (since the start of treatment) of 16 of the children for whom we were able to obtain follow-up data. See Table 5.<sup>6</sup> The children were all boys, ranged in age between 12 and 17, with a mean of 13.9 years. This follow-up was exceptional in its comprehensiveness and provides one of the most complete pictures of the development of children diagnosed on the autism spectrum. The follow-up addressed the full range of emotional, social and sensory processing variables in addition to traditional cognitive and academic outcomes. We found this group developed high levels of empathy (very advanced on theory of mind tasks) and were often more empathetic than their peers. Some became very talented in music and writing and some developed into wonderful poets. Most were outstanding students, excelling in many academic areas, while others were average students, while a few struggled academically with learning disabilities because of executive functioning and sequencing problems. As a group, they showed the expected range of mental health problems, often depending upon family circumstances, and a few were anxious or depressed as adolescents. Importantly, however, they coped with the stresses of puberty, family conflicts (including divorce), parent illness (cancer) and maintained their core gains in relating, communicating, and reflective thinking. Since this was the second follow-up of this group, it is also noteworthy that they not only maintained their initial gains (Greenspan & Wieder, 1997), but made further progress and were overall equipped to handle the stressors of adolescence and life events.

**Table 5—Follow-Up of Long Term Outcomes**

Report on cases originally used to validate outcomes with the Vineland and FEAS in our 1997 Chart Review of 200 Cases
<ul style="list-style-type: none"> <li>• Current Ages—12 to 17 years</li> <li>• 16 boys</li> <li>• First concerns between 12 and 24 months</li> <li>• All diagnosed with PDD or Autistic Spectrum between 24 and 30 months by others</li> </ul>

### Excerpts from Interviews with Four Boys in Follow-Up Study

Before we describe these children in more detail, let's look at a few excerpts from recent videotaped interviews. Two interviews were conducted by parents in their home and two by interviewers (first author and research assistant).

<sup>6</sup>Fourteen of these children were in the validating group identified in Table 4 (with Vineland) and two more were in the group for whom the FEAS was completed.

## DAVID, AGE 12½, EIGHTH GRADE

David is a warm, friendly, confident youngster with curly hair, a big metallic smile, and impish gleam in his eyes. He is both amused and awkward in creating the videotaped vignettes of his life but cooperates as the camera follows him. The video starts with David lounging on a sunny deck in the back of his home as he spontaneously reports on all the activities he is enjoying now, exuding considerable self confidence and pausing to directly look at the camera to convey a message of appreciation.

Parent: So, tell us what you are doing these days, David.

David: Right now I'm playing the sax, the piano, and I've got lots of good friends, and I'm getting really good grades. And I'm also in the jazz band at school and I'm getting ready for my bar mitzvah now and I'm almost ready. Last summer I went to \_\_\_\_ Camp and I had a great time. I took up water skiing. Right now I'm learning to slalom on one ski and I'm just having a great time lately. And I owe it to you.

As the tape continues, we see scenes where David is meeting with his basketball team and playing video games with his friend. Later, we hear him say, "All right, I'll clean up the room, I'll clean up the room, just stop bugging me!" We also see him helping his sister with her homework. The tape is an impressive compilation of different scenes from this child's life, reflecting the range of his self-confident functioning.

## ADAM, AGE 14, NINTH GRADE

The second child, Adam, was taped late at night by his mother and was being pushed to do the interview. Adam is seen lying semi-curved up on the couch, eyes half-closed, complaining about doing homework. He drags out each word, giving half-answers, with a "get me" gleam in his eye letting his mother know she will have to work for his answers, yet warm and humorous. Here we will see a young adolescent reflecting off an internal standard as he discovers himself as a person who likes to learn. Although it started with "pulling teeth," as one would expect of an adolescent, and initially he couldn't admit that he liked school, Adam actually went on to talk about how much he liked school and the assignments that interested him. As a younger adolescent he also knows how to goad his mother into saying "no" enjoying how well he can predict her behavior!

Parent: Who forces you to do homework?

Adam: Take a guess.

Parent: Me?

Adam: Take another guess.

Parent: Dad.

Adam: Take another guess.

Parent: Miss \_\_\_\_?

Adam: Well, the whole school.

Parent: So, do you like school?

- Adam: It's okay, yeah.
- Parent: Are you happy at school?
- Adam: Yeah.
- Parent: Adam, why are you sitting like that?
- Adam: I'm tired.
- Parent: Why are you tired?
- Adam: Because I'm sleepy.
- Parent: What time did you get up?
- Adam: Basically the time I get up every day: 6:45.
- Parent: That's so early. So, do you feel tired at school?
- Adam: Yeah, I want to fall asleep but I know I can't. And even if I could, probably couldn't.
- Parent: It sounds to me, just hearing this snippet of conversation for the last 15 minutes we've had, that you don't like school. Is that true? It just sounds as if you think school's kind of boring.
- Adam: No, I think . . . I like it, it's just I don't really want to say it because I'm tired.
- Parent: So, did I get you at a bad moment tonight because you're tired?
- Adam: I'm tired and I didn't realize it would take this long.
- Parent: Oh, should I get you at quarter of seven in the morning instead?
- Adam: Can I watch my big television now?
- Parent: No!!!

The whole tape is a wonderful, lazy flow of a typical adolescent boy being pushed to do an interview when he'd rather be doing something else.

### SAM, AGE 16, TENTH GRADE

Sam is a tall, handsome disheveled teenager with long dark hair who chats spontaneously and confidently, conveying "I know about life now!" He enjoys his mature status and has an opinion about everything. In the next clip we will see Sam reflect on the elections which just finished.

- Interviewer: Any other topics to explore? You shared a lot of good stuff and your opinions, which is what we wanted to hear, how you feel about things—so what do you think about yesterday's events and the way this election turned out?
- Sam: I didn't like how it turned out.
- Interviewer: Yeah, yeah.
- Sam: I don't know. I saw a really, really dumb commercial. It was about this woman saying she lost her sister or something and she looks at George Bush and George Bush knew about it, and he hugged her, and her saying, you know, Bush is so caring. And, I mean, in public everyone's going to do that for a photo op. I mean, just because Bush hugged a little girl in public doesn't mean you should vote for him just because you think he's compassionate. You know, we attacked Iraq with no good

reason. We found Saddam Hussein in a hole. We haven't found the weapons of mass destruction for the simple reason there are none there. And they never really attacked us unless you count the time a long time ago. They had nothing to do with it. They had nothing to do with 9/11.

Interviewer: Have you seen the Michael Moore movie?

Sam: Yes, I have. I liked it.

Interviewer: Yeah, what'd you think of that?

Sam: He over-exaggerated a few things, but there were a few things I didn't know about. I did not know how many of those . . .

Sam went on for quite a while and had something to say about everything. He was not only interested in his own life, but was quite a student of the world, politics, and people. It was striking how he was now thinking and empathizing with others, no longer at the center of his own universe. He enjoyed a rich extra-curricular life, had many friends, and excelled at school.

#### JACK, AGE 17, HIGH SCHOOL SENIOR

Another boy, Jack, a tall lanky adolescent, appeared more serious and thoughtful. He was one of our oldest teenagers in the outcome study. He was an outstanding student, continued to enjoy a team sport he had started playing as a kid, and volunteered to help the poor. Jack was a senior in high school applying to colleges and was asked what he might like to study. In this clip he reflects on journalism and an interest he developed during his senior year in high school.

Jack: This (journalism) is my favorite thing to do.

Interviewer: What do you write about?

Jack: A bunch of things—I write for my newspaper, I write about history, I write about theology. My favorite subjects are theology, history, and English. They're analytical subjects.

Interviewer: They sure are. How did you get interested in theology?

Jack: I didn't even know what it was till this year, but I had taken a class this year and it just really interested me—the different views that people have of God. It's very interesting, because there're so many different ways to look at it.

Interviewer: What do you think? What is your view?

Jack: I honestly am not sure. But it's definitely something I want to continue studying.

Interviewer: Why does it interest you?

Jack: Because it's more analyzing. Anything like philosophy and theology you can analyze what life is, what the meaning of life is—it's very interesting to be able to do that!

Jack was intrigued with the meaning of life at this stage as he was about to embark on a life away from home. As a student he had relied upon structure and good grades to define himself. As will be seen when we discuss the academic outcomes,

many of the children in the follow-up study not only took regular high-level academic courses in school, but took some Advanced Placement and honors courses as well. These children were capable of multi-causal thinking and were very interested in reflecting on what things meant to them. They saw things in “shades of gray.” In other words, they had reflective thinking capacities.

The major findings of this follow-up are illustrated by these four clips showing engaging adolescents who could relate with warmth and empathy, express their opinions, give to others, and reflect on the world around them as they grew older. They were doing the hard work of adolescence in all respects as they studied hard, played hard, and related to others with openness and confidence they could hold their own. Speaking with them, it was hard to remember that they were all children once diagnosed with ASD between two and three years of age. The intensive DIR based interventions which allowed them to change and develop will be described below. What is noteworthy is that for this subgroup of children the core deficits appear to be reversible. Furthermore, in this follow-up study we saw that even after the intervention was completed, the children in this subgroup continued to hold their gains and continue to develop in a healthy way.

## **Parents Perspectives**

The children in this subgroup are now 12 to 18 years of age. When we reported on their cases in the 1997 study, they were between four and eight years old. Considerable time had passed and we were interested in hearing the parents’ perspectives of how their children were functioning at the present time.

Our first query to the parents was open-ended: “Tell us how your child is doing” and these are some of their first words:

“Amazing when I think about who he was.”

“A miracle child.”

“He’s doing great.”

“He’s happy.”

“I’m not parenting a child with special needs, just an adolescent boy.”

Other parents reported:

“He is sweet, empathic, accommodating, and earnest.”

“So caring and observant, so humorous.”

“He is in touch with himself and others.”

We were struck by how the parents first described the emotional qualities they valued in their children rather than their academic achievements and the lingering awe they felt that the children they were told were autistic had become such wonderful, well grounded kids. Their comments reflected upon a group of very empathic, compassionate young men who were caring, funny, and observant of others. Some were still working hard, struggling with some academic areas and other challenges, but all had become part of life in all its dimensions.

## Information Collected for the Follow-Up Study

We conducted parent interviews and asked parents to complete a functional emotional developmental questionnaire (FEDQ) (Greenspan & Greenspan, 2002) which provided their ratings of various domains described below. We also rated our impressions of the children independently based on the interviews. For some, we used videotapes made by parents or our direct interviews with the children, and with others audiotapes recorded via telephone. These provided the basis for the independent clinician ratings that were conducted separately from the parent ratings which were mailed in. We collected school reports and obtained IQ tests when available. It is interesting to note that very few of the children were tested for IQ. Most parents indicated there was no need to have their children tested. We also administered the Achenbach Scales (Achenbach, 1991), a child behavior checklist (CBCL) that rates competence and clinical syndromes, to provide an objective assessment. See Table 6.

**Table 6—Current Study**

*Follow-up study included:*

- Parent Interviews and FEDQ Ratings
- Clinician FEDL Ratings Independent of Parent Ratings
- Child Interviews (videotaped)
- School and Cognitive Reports
- Child Behavior Check List—Achenbach Scales (CBCL)

## THE DIR/FLOORTIME INTERVENTION PROGRAM

The DIR/Floortime approach provides a comprehensive framework for understanding and treating children challenged by autism spectrum and related disorders. It focuses on helping children master the building blocks of relating, communicating and thinking, rather than on symptoms alone. As can be seen in the Tables on the next page, all the children received comprehensive intervention programs, including five to thirteen different types of interventions depending on their individual needs. An average of eight specific interventions were implemented between ages two and eight and a half. All the children received DIR/Floortime consultations from one of the authors and all did Floortime at home. Fifty-six percent of children had additional Floortime therapy. The emphasis, however, was on the home program. Seventy-five percent implemented a very serious play date program we recommended—at two, have two play dates a week, at three have three play dates, etc. through kindergarten and then to maintain as many as possible during school years. In addition, all the children received speech and language therapy and many continued these therapies for a few years after preschool. All children received clinic based occupational therapy with sensory integration, in addition to their home program. All also received auditory integration therapy. When asked which interventions were

most effective, parents reported that Floortime at home, Floortime therapy with their child and a therapist, and playmates were the most significant interventions.

Other therapies varied quite a bit. Some of these therapies have become more popular now, but were not so at the time (e.g., casein/gluten-free diets). At school age a small number continued Floortime therapy, two started psychotherapy during adolescence, and four children received educational therapy. Several children also received tutoring for specific school subjects when needed.

**Table 7–Comprehensive Intervention Profiles**

Average number of different interventions:	8
Range of interventions:	5–13
Ages:	2–8.5 years
Duration of intensive interventions:	2–5 years

**Table 8–Comprehensive Intervention Profiles**

N=16	
DIR Consultation	100%
Floortime at Home	100%
Floortime Therapy	56%
Play Dates	75%
Speech and Language Therapy	100%+
Occupational Therapy	100%+
AIT/Tomatis	100%
Visual Spatial Therapy	19%
Biomedical	38%
Cognitive/Ed Therapy	13%/13%
Nutrition	44%+
Diet	13%/25%
Meds at School Age	25%
Family Therapy at School Age	13%
Adolescent Psychotherapy	19%
Other	19%

= Parents report most efficacy; + = also helpful

## **Parent Ratings of Functional Emotional Developmental Capacities**

We asked the parents to rate their children on items organized around the six core developmental capacities and three higher order abstract capacities using the Functional Emotional Developmental Questionnaire (Greenspan & Greenspan, 2001). The questions are based on the Functional Emotional Developmental Levels (FEDL). See Table 9. Parents were very familiar with these levels as they provided the fundamental concepts and goals for the early intervention.

**Table 9—Functional Emotional Development Levels (FEDL)**

Functional Emotional Developmental Level	Emotional, Social and Intellectual Capacities
I. Shared attention and regulation	Experiencing affective interest in sights, sound, touch, movement and other sensory experiences. Modulating affects (i.e., calming down).
II. Engagement and relating	Experiencing pleasurable affects and growing feelings of intimacy in the context of primary relationships.
III. Two-way intentional affective signaling and communication	Using a range of affects in back-and-forth affective signaling to convey intentions (i.e., reading and responding to affective signals).
IV. Long chains of co-regulated emotional signaling and shared social problem solving	<p>Organizing affective interactions into behavioral patterns to express wishes and needs and to solve problems (e.g., showing someone what one wants with a pattern of actions rather than words or pictures).</p> <ol style="list-style-type: none"> <li>1. Fragmented level: little islands of intentional problem-solving behavior.</li> <li>2. Polarized level: organized patterns of behavior expressing only one or another feeling state, e.g., organized aggression and impulsivity or organized clinging, needy, dependent behavior, or organized fearful patterns.</li> <li>3. Integrated level: different emotional patterns—dependency, assertiveness, pleasure, etc.—organized into integrated, problem-solving affective interactions (e.g., flirting, seeking closeness, and then getting help to find a needed object).</li> </ol>
V. Creating symbols or ideas	<ol style="list-style-type: none"> <li>1. Using words and actions together (ideas are acted out in action, but words are also used to signify the action).</li> <li>2. Conveying feelings as real rather than as signals (“I’m mad,” “Hungry,” “Need a hug” as compared with “I feel mad” or “I feel hungry” or “I feel like I need a hug”). In the first instance, the feeling state demands action and is very close to action; in the second, it is more a signal for something going on inside that leads to a consideration of many possible thoughts and actions.</li> <li>3. Using somatic or physical words to convey feeling states (“My muscles are exploding,” “Head is aching”).</li> <li>4. Using action words instead of actions to convey intent (“Hit you!”).</li> <li>5. Expressing global feeling states (“I feel awful,” “I feel OK,” etc.).</li> <li>6. Expressing polarized feeling states (feelings tend to be characterized as all good or all bad).</li> </ol>
VI. Building Bridges between Ideas: Logical Thinking	<ol style="list-style-type: none"> <li>1. Expressing differentiated feelings (gradually there are more and more subtle descriptions of feeling states, such as loneliness, sadness, annoyance, anger, delight, and happiness).</li> <li>2. Creating connections between differentiated feeling states (“I feel angry when you are mad at me”).</li> </ol>

The FEDQ parallels the FEDL and is designed to assess the emotional, social and intellectual capacities of the child. It asks the parent to rate each of the capacities from 1–7, with the highest rating a parent could give his or her child is a 7. The results are described on page 51 and summarized in Table 10. As will be seen, the ratings were very consistent, with only small variations until questioned about future plans where the ratings of younger children who did not have defined thoughts yet lowered the average.

### Regulation and Shared Attention

We asked parents whether or not their child could stay focused and calm when doing what he wanted to do (mean=6.9) and also if he was able to remain focused and calm when asked to do something that was not necessarily what he wanted to do, such as homework or chores (mean=6.5). In both cases, parents rated their children as having excellent regulation and shared attention.

### Engagement

When asked if the children were engaged overall and the parents reported a 6.9 average. When asked if they stayed engaged when they were upset, angry, or disappointed, the average rating of engagement under emotional stress was 6.1.

### Two-Way Intentional Affective Signaling and Communication

We asked parents if their children could show their emotions in more gestural ways and if they could get an interactive flow of communication and interaction going and sustain it. The parents reported that the children could, with an average 6.9 rating.

### Social Problem Solving

The children's abilities to engage in complex, shared, social problem solving also got very high ratings (mean=6.8). The youngsters were all able to sustain the back-and-forth interactions and could have very long conversations. They could not only say what they wanted, but also what they thought and what they thought of "you."

### Creating Symbols and Ideas

In terms of emotional ideas, the parents reported that the children could express their feelings and ideas (mean=6.6). What was most striking is that most of these children went from playing "on the floor" to being wonderful, creative writers and dramatists. As the parents saw them—the children in the follow-up study could express both feelings and motives and demonstrated understanding and "theory of mind" capacities at the highest levels.

### Higher Order Thinking

When we looked at higher levels of thinking, we saw a little variation because the children ranged in ages from 12 to 18 years. When it came to understanding multiple causes of behavior in themselves and others; understanding when they felt dif-

ferent in different situations and why they felt that way; judging their own and others' emotional reactions; being able to reflect on their own internal standards; and being aware of their bodies and the impact of the change on them (these were adolescents going through puberty), the results showed ratings above 6 in all these areas. The children's plans for the future were a little less clear, as seen with the mean = 4.4 rating. However, those who were older than 16 years of age were much more defined in their thoughts of the future. Questions about independence regarding important decisions also received slightly lower scores, which is to be expected. These children were aware that big life decisions were going to be made with their families.

**Table 10—Parent Rating—Functional Emotional Developmental Levels\***

Derived from FEDQ	Mean
<b>Regulation and Shared Attention</b>	
1a—Calm/focus/able to perform task of choice	6.9
1b—Calm/focus/able to perform requested tasks	6.5
<b>Forming Attachments and Engaging in Relationships</b> with warmth, trust, and intimacy across full range of emotions	
2a—Stay engaged when upset	6.1
2b—Typical engagement/warmth	6.9
<b>Intentional Two-Way Affective Communication</b> —purposeful continuous flow of interactions with gestures and affective reciprocal interactions	
3—Response to emotional gestures	6.9
<b>Complex Social Problem Solving</b> —able to problem solve through social interactions in a continuous flow using long sequences	
4a—Length of sustained back/forth interaction	6.8
4b—Communicating needs	6.8
<b>Emotional Ideas</b> —able to represent or symbolize intentions, feelings and ideas in imaginative play or language using words and symbols (representational capacities and elaboration)	
5a—Expressing range of feelings	6.6
5b—Create story line with motives and emotions	6.6
<b>Emotional Thinking</b> —bridges and combines ideas to become logical and abstract feelings	
6—Explains complex feelings	6.6
<b>Higher Level Capacities</b> —	
7—Understanding multiple causes of others' behavior	5.3
8—Varying feelings for one situation (13/16)	6.1
9—Judging own emotional reactions (13/16)	6.4
10a—Internal standard for self re education	6.1
10b—Role in peer relationships	6.1
10c—Bodily changes-awareness	6.4
11—Plans for future	4.4
12—Independent judgement re important decisions	5.2

\*On a scale of 1–7 with 1 being the lowest score and 7 being the highest score.

## Clinician Ratings of Functional Emotional Developmental Capacities

When the clinicians (the authors and research assistant) rated the same children, whether through videotapes, verbal interviews, or recordings, their ratings were very close to the parent responses for all the core capacities. It is important to note that the clinicians rated the children separately from the parents using parallel rating scales. See Table 10.

**Table 11—Clinician and Parent Independent Ratings\***

Functional Emotional Developmental Levels		
	Clinician Mean	Parent Mean
Self Regulation	6.7	6.7
Relationships	6.9	6.5
Purposeful Communication	6.8	6.9
Complex Sense of Self	6.4	6.8
Representational	6.4	6.6
Emotional Thinking	6.4	6.4

\*On a scale of 1–7 with 1 being the lowest score and 7 being the highest score.

We also had the clinicians rate (based on the interviews) the level of empathy (whether it was compared to peers or to siblings), creativity, and talent. This provides a picture of the full range of competencies of these children.

**Table 12—Additional Clinician Scales**

N=16	Mean
Empathic (compared to peers)	6.4
Empathic (compared to siblings) (n=15)	6.1
Creativity (compared to peers)	6.0
Talents (compared to peers)	5.7

## Achenbach Scales (CBCL)

To obtain an independent measure of functioning, we asked the parents to complete the Achenbach Scales (Achenbach, 1991). Three measures of competence are examined. See Table 13. On the social competence scales, 94% were in the normal range; 88% were in the normal range for activities; and for school competence, results were similar with 88% in the normal range. Two children in this group had learning disabilities (LD) (one was in an LD school and the other home-schooled). The overall competence ratings were 82% with only 18% presenting some variations.

**Table 13—Achenbach CBCL T-Scores—Competence Scales (N = 16)**

	Normal	Borderline	Clinical
Social Competence	94%	6%	
Activities	88%		12%
School	88%	6%	6%
Overall Competence	82%	12%	6%

When we looked at the CBCL syndrome scales, see Table 13—clinical signs of anxiety, depression, withdrawal, socially acting out, or aggression—we found, by parent report that 75% fell into the normal range. Thirteen percent were in the borderline clinical range and 12% in the clinical range. However, children showing anxiety and depression, or slight withdrawal from activities and depression are typical of many adolescents during their teenage years. In our study, those who evidenced anxiety and depression, however, were very verbal and creative. The symptoms were circumscribed and easily managed.

The vast majority of adolescents in the follow-up study showed very good scores in the normal range. One of the children had somatic complaints and seemed to feel somewhat insecure about his changing body. Seventy-five percent showed no social problems, with the rest showing some, and two showing more significant problems.

**Table 14—Achenbach CBCL T-Scores—Syndrome Scales**

	Normal	Borderline	Clinical
Anxiety/Depression	75% (12)*	13% (2)	12% (2)
Withdrawal/Depression	82% (13)	12% (2)	6% (1)
Somatic Complaints	94% (15)	6% (1)	
Social Problems	75% (12)	12% (2)	12% (2)

\*The numbers in parentheses show how many children under 16 that we had the data set on were involved.

Thought problems were reported for three children. (For a full explanation of these thought problems please refer to the Achenbach scale.) With regard to other challenges: ninety-four percent showed no difficulties in attention. Perhaps it's because of those long back-and-forth conversations that are emphasized in the DIR program. There were no indications of rule breaking, aggression, or other problems.

**Table 15—Achenbach CBCL T-Scores—Syndrome Scales**

Challenge	% in Normal Range	% in Problem Range
Thought Problems	82% (13 children)	18% (3 children)
Attention Problems	94% (15 children)	6% (1 child)
Rule Breaking Behavior	100%	0%
Aggressive Behavior	100%	0%
Other Problems	100%	0%

## EARLY AND LATER MOTOR AND SENSORY PROCESSING PATTERNS

It is now well known that children on the spectrum experience significant sensory processing and motor planning difficulties. These challenges can significantly affect self-regulation, purposeful behavior and adaptation to the environment as well as relating and communicating. Table 16 highlights the high incidence and pervasiveness of these challenges in the 200 cases. As can be seen, all the children in the original study had significant problems with motor or sensory processing and all had some motor planning challenges. We later found that only 18% of the “very good to outstanding” outcome group had significant motor planning problems and that they tended to have more hyper or mixed reactivity to sensation and a lower incidence of under-reactivity compared to the poor outcome group. This finding suggested that children in the better outcome group were more purposeful and capable of planning and executing (sequencing) ideas, and perhaps more likely to react or respond to the environment.

**Table 16—Muscle Tone, Motor Planning, and Sensory Reactivity**

N=200 Chart Review (1997)	<i>All Groups</i> Presenting Patterns N=200	<i>Outcome Group</i> Good to Outstanding (58% of N=200)	<i>Outcome Group</i> Poor (17% of N=200)
Low muscle tone	17%	12.5%	23.5%
Significant motor planning problems	100%	18%	78%
Underreactive to sensation with patterns of:	99%	30%	48%
Craving/Stimulus Seeking	11%	7%	15%
Self Absorption	28%	23%	33%
Hyperreactive to sensation	19%	25%	15%
Mixed patterns of reactivity to sensation (hyper- in some areas like sound and hypo- in other areas like pain or touch)	36%	45%	37%

We were very interested in finding out what happened to these patterns 10 to 15 years later to learn more about the residuals of these early challenges as the children matured. We asked parents to rate their children using the Sensory Motor Questionnaire (Greenspan & Greenspan, 2001) and they reported that most of the sensory reactivity challenges resolved. Continuing sensitivities were reported regarding pain (47% were still hypersensitive); smell (33%); and taste (50%). But only some of the children, many of whom had been very picky eaters as young children, were still picky eaters. See Table 17.

## Follow-Up Profiles

**Table 17—Sensory Motor Profiles—Sensory Domains**

N=16			
Outcomes for Follow-Up Group	Normal	Hypersensitive	Sensory-Seeking (Craving Sensory Input)
Sounds	87%	13%	20% at times
Visual Sensation	80%	20%	13% at times
Tactile Stimulation	93%	7%	33% at times
Pain Sensation	53%	47%	
Smell Sensation	67%	33%	
Taste Sensation	50%	50%	14%
Motion (Vestibular)	93%	7%	29%

Overall, an impressive 88% resolved auditory, visual, tactile, and vestibular hypersensitivities with the benefit of maturation, treatment, and activities. Of those with mixed profiles, we saw 22% still sensory seeking. These children also tended to be more active athletically, which seemed to be a good solution.

Motor planning or sequencing is very much at the core of many of the deficits children with ASD show and may remain a challenging area for children who show the remarkable development this follow-up group did. On follow-up, parents reported 40% were still below average on gross motor skills. They preferred playing individual sports and played tennis and/or enjoyed swimming or track. Others with better motor planning were able to do more team sports. Some children with better visual-spatial than visual-motor processing capacities preferred strategy games, such as chess.

The challenges with fine motor planning were manifest in part with difficulties in executive functioning. Some children had better ways of compensating than others. Sixty percent had poor handwriting but they learned to type very well. They also had difficulties managing time (related to sequencing) and the ability to follow multiple complex directions still remained an issue for some. However, they had greater strength in verbal sequencing, or the ability to organize and elaborate on verbal ideas (in contrast to motor execution). Memory was an important asset and most were very good at visualizing their families, searching for what they wanted, orienting in space and attending to details. More than half (60%) were described as big picture thinkers and able to maintain long logical sequences. Overall, we still saw affect (i.e. emotional interests), driving improved sequencing capacities and attention to details. Tables 18–21 summarize the findings.

**Table 18—Summary of Sensory Reactivity**

N=16	
Resolved auditory, visual, tactile, and vestibular hypersensitivities	88%
Continued to be hypersensitive to pain and taste	49%
Continued to be hypersensitive to smell	33%
Evidenced some sensory seeking	22%

**Table 19–Sensory Motor Profiles–Sequencing**

N=16			
	Average +	Below Average	Very Poor
Gross Motor Skills: The 40% who were below average on gross motor preferred individual sports and strategy board games			
	60%	40%	
Fine Motor Skills: The 60% rating below average and very poor on fine motor skills, e.g., handwriting			
	40%	40%	20%

**Table 20–Summary of Sequencing Related Functions**

N=16	
	Average and Above
Verbal Elaboration and Abstraction	73%
Multiple Directions	60%
Orientation in Space	80%
Visualize Family	92%

**Table 21–Summary of Sequencing Related Functions**

N=16			
	Mostly	Sometimes	Rarely
Multiple Directions	60%	34%	6%
Logical Arguments	60%	40%	
Main and Sub Points	60%	40%	
Wide Range Elaboration	87%	7%	6%
Visualize Family	92%	8%	
Systematic Search	80%	20%	
Big Picture Thinking	66%	27%	8%
Good with Details	93%	7%	

## Academics and School Report Cards

Parents reported that this group of wonderful young individuals were gifted in math, science, and music. They were very creative and enjoyed a wide range of activities at school. See Table 22. When asked what the challenges were in language arts, the parents were able to tell us that at first many of the children had to work a little harder on getting hidden meanings and making inferences, but were able to master these reflective thinking skills. Two children had difficulty learning to read. But, as can be seen, they progressed in language arts, with 83% average or above av-

erage. With respect to math and science, parents reported greater strengths with 62% performing in the superior and gifted range. Similarly, they reported 62% performing in the superior range in social studies and history. See Table 22. Overall, parents reported very high performance in all academic areas.

We also reviewed school report cards obtained from nine of the children.<sup>7</sup> We found that 83% of this group were receiving all A's and B's in programs which included honors and advanced placement (AP) classes. On the 9 complete reports, there were only two C grades. Sometimes the children were good both in math and English and other times they were stronger in one than the other. Many got A's and B's in science, history, social studies, and languages (some were even studying Latin). See Table 23.

**Table 22—Academics: School Reports 8th–12th Grades**

Parent Reports on Entire Group (N=16)	
Math and Science	23%—Gifted 39%—Superior 38%—Average
Social Studies—History	62%—Superior 38%—Average
Language Arts	30%—Superior 53%—Average 15%—Below Average* 46%—Truly love reading 46%—Creative Writers

\*Reading comprehension—“getting hidden meanings,” making inferences relatively weaker; reading mechanics still hard for two with learning disabilities.

**Table 23—Academics: School Reports 8th–12th Grades**

Fourteen (of 16) were attending high level public and private academic programs. One was in school for LD-Dyslexia. One was home-schooled. N=9	
Independent School Reports (n=9)	
Receiving all A's and B's in programs including honors and AP classes (only 2 C grades in this group)	77%
A's in Math	89%
A's in English, Language, Creative Writing	89%
A's and B's in Science	89%
A's and B's in History and Social Studies	89%
A's and B's in Foreign Languages, including Latin	89%

<sup>7</sup>This is a preliminary report and follow-up will attempt to complete this information.

Only one-third of the children underwent IQ testing and those had average to superior scores. Most of the scores were balanced between verbal and performance areas, but a few showed large discrepancies with higher verbal and lower performance scores (i.e., lower on motor planning and visual-spatial processing).

## **Family Stress and Coping**

The parents told us there had been stress in their marriages and families. They had to work hard and often needed to be reminded that they were a couple, apart from their child, and needed to take care of themselves. Most marriages did stay together and in some cases relationships improved as couples mobilized to take care of their child's special needs. The early stressors had to do with, "Did I find the right school?" "Did I have the right program?" Parents said that what helped them most in the early years was learning how to be an advocate for their children—being able to speak up and get the educational programs and services needed. Siblings often expressed a concern early on about what they were going to have to do for their little sisters or brothers and needed reassurance. Within the DIR model of family intervention, siblings were usually seen and parents, siblings and the challenged children were all encouraged to express and reflect on their feelings.

## **Looking Back at "Life on the Floor"**

What is it like looking back at life "on the floor?" Families polled said that they did an average of nine hours of Floortime each week. The range went from two to sixteen hours per week and as the children got older, that amount of time diminished. The average number of years they "lived on the floor" was almost five (2.5 to 10.4 years). When we asked, "How well did you actually do it?" and "Did you really do it?" on a scale of 1–7 (1 being the least and 7 being the most), self-reports averaged 5.75. When we asked how helpful it was, especially compared to all the interventions they tried or were doing, 88% reported that it was the most helpful.

## **THE FUTURE**

In considering the future, parents felt their children would be able to make the best decisions for themselves. What was most important to all these families was how happy, related, and fully involved in life their children were. The parents weren't thinking about what profession their children would have or what they would do in life; they were most interested in the fact that their children would have relationships, families, and friends, and be able to cope with whatever might come. For example, parents stated:

"I think he will find something he likes to do and will stick with it."

"When he wants something he usually finds a way to get it."

In terms of future hopes, one parent stated, “he’s happy and confident; his social skills are in place, academics are strong. He can be whatever he wants to be.” Another said: “I believe the future is open and I believe he will be able to do it all.” These parents were optimistic about the future because their children had exceeded their expectations given what they were told they could expect when their children were first diagnosed with ASD.

## DISCUSSION AND CONCLUSIONS

The children in our follow-up study progressed out of their core symptoms and, more importantly, their core deficits. They became warm, related, and sensitive young people who have the foundations for an optimistic future. They demonstrated competence in a full range of activities. Like other adolescents, however, they were not immune to mental health problems. Some showed anxiety and depression. However, they did not evidence the deficits or symptoms of ASD. While some residual sensory challenges lingered, these did not derail their relating, communicating and thinking abilities. Their progress illustrates the crucial importance of comprehensive and intensive intervention during the early years provided by the DIR model and how a certain group of children can become empathetic, creative, and reflective, with healthy peer relationships and solid academic skills. These children mastered the core deficits and reached levels of development formerly thought unattainable with a family-oriented approach that focuses on the building blocks of relating, communicating, and thinking.

The DIR model provides the framework for implementing such a focus through daily floortime sessions supporting the continuous flow of engagement, symbolic play and higher order thinking, as well as ongoing problem solving and reality based logical conversations, and reflective “talk time,” play dates and friendships. Parents validated these mechanisms as the most responsible for their children’s improvement. In addition, a wide range of individualized activities and therapies address the critical underlying regulatory and sensory processing challenges. For this group of children the most intensive interventions were provided during early childhood and the benefits continued long after the specific therapies ceased with the building blocks were established. The comprehensive nature of the intervention and the intensive level of daily interactions integrated relating, communicating and thinking into the fabric of every child’s and family’s life.

We will continue to follow this group and also conduct follow-ups with additional children who have done very well. Furthermore, we will be conducting follow-ups with children who have made slower progress. In many respects, their gains are even more remarkable because of the greater hurdles they have had to overcome.

It is important to emphasize that whenever we report on a subgroup of children that did outstandingly well, it is always with trepidation, knowing that there are many families who are working hard with their children and not seeing the kind of progress that this subgroup experienced. And, again, we don’t know how representational this population of children with ASD is and how many others share the characteristics of this group. We can note that children with slower or less progress, as reported in our 1997 study of 200 cases, are also making gains in their core

deficits. They are learning to become engaged, interactive and communicative, but with more limitations in their language and reflective thinking capacities. We have also worked with adolescents and middle aged adults with ASD and observed progress (Greenspan & Mann, ICDL guidelines, 2000).

The most important lesson is that progress can continue into the adolescent years and further. Therefore, it is most important to continue to try to work with the child and his or her family on these most essential capacities for relating, communicating, and thinking. When we observe that a subgroup can make these kinds of gains it is encouraging. Such observations suggest that we are harnessing the essential developmental processes in using the DIR/Floortime model. The fact that a subgroup can move to a level of creative and abstract thinking thought unattainable even by “high-functioning” children with ASD suggests that we are mobilizing critical aspects of emotional and intellectual growth.

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### *Manuscript Preparation:*

*Text:* **Double spaced**; typed on heavy bond paper; 1.5 inch margins on all four sides. **Note:** All materials submitted must be **double spaced**-block quotations, text, footnotes, references, extracts from case material, and tables. Pages must be number sequentially.

*Abstract:* All papers and case presentations should begin with a brief, **double spaced** description of the material, approximately 150 words.

*Art:* (includes charts, tables, figures, drawings, photographs) is to be submitted to the publisher camera ready.

*Dimensions of artwork:* 4.25 inches wide by 7 inches high.

Cost of alterations to artwork to be borne by author.

*Tables:* should be **double spaced**, rules kept to a minimum-head, foot, saddle-no vertical rules.

Footnotes: Numbered sequentially and **double spaced**: should appear at the foot of the page where cited; footnote numbers should be typed one space above line without punctuation or parentheses. A corresponding number should appear in the text. **Note:** Initial footnotes referring to the title of the paper, acknowledgements, bios, or the author do not carry a number.

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*Books:* Author. (date). Title. Place: Publisher. (Original date of publication [if different from cited date]). When referring to the writings of Sigmund Freud, cite only the Standard Edition.

*Chapter in Edited Volume:* Author (date). Title of chapter. In J. Smith & B. Jones (Eds.), Title of Book ((pp. 111–135). Place: Publisher.

*Journal Articles:* Author. (date). Title of paper. Journal Title in Full, volume number, inclusive page numbers.

*Text citations:* Provide author(s) name(s) followed by date. Jones (1918), or (Jones 1918). Multiple text citations are listed in alphabetical order (i.e., Abraham, 1966; Jones, 1950). Use of et al.: Six or fewer must list every author in the text at first mention, thereafter et al. is used. More than six authors is et al., at first and subsequent mentions.

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