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Major professor

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CONTINGENT-NEGATIVE VARIATION (CNV) IN AUTISTIC CHILDREN

By

Christel Beretta

A THESIS

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ABSTRACT

CONTINGENT-NEGATIVE VARIATION (CNV) IN AUTISTIC CHILDREN

By

Christel Beretta

To measure attention, three autistic subjects between the ages of 6 to 9 years with moderately-severe to severe autism were tested on six experimental tasks using the CNV (contingent-negative variation) paradigm. One methodological question and three clinical conceptual questions were addressed. The methodological question, whether autistic subjects were able to establish a CNV, was answered in the affirmative. One of the autistic subjects established a CNV while two autistic subjects produced large negative potential shifts.

Three conceptual questions addressed basic assumptions of the Affolter treatment paradigm. The first assumption is that the impaired child receives the input while being guided to perform a task. This assumption was investigated in two experimental tasks. It was found that one autistic subject established a CNV in both guided tasks, while two autistic subjects established large negative potential shifts (NPS). The difference between the two guided tasks was the novelty effect. The autistic subjects demonstrated a significantly longer duration and a significantly larger area of the CNV or largest NPS in the novel task as compared to the familiar task [T ($N = 5$) $= 0$, $p < .05$].

Affolter and colleagues' second assumption was that the input to the brain is the same in the guided and unguided conditions. Four experimental tasks were compared to test possible differences. For the novel task, no significant differences were found between the two conditions. However, the familiar task revealed more varied results. The Wilcoxon

matched pairs signed-ranks test did not find any significant differences for the duration and average amplitude of the CNV / largest NPS. However, significant differences were found for the area of the CNV or largest NPS and the overall area of negativities [$T (N = 5) = 0$, $p < .05$] suggesting that there was significantly more cognitive activity recorded in the unguided condition as compared to the guided condition.

Affolter and colleagues' third assumption was that changes of brain activity will be noticeable when the event stimuli vary in the amount of resistance. The effects of strong and weak resistance were investigated in two experimental tasks. Although the Wilcoxon matched pairs signed-ranks test did not reveal significant differences between the two conditions, some biases were observed. Two of the autistic subjects demonstrated greater amplitude shifts relative to the hard ball when the soft ball was squeezed (weak resistance). One autistic subject showed the same pattern in her second trial but not in her first trial.

When the area of the CNV or largest NPS was compared to the overall area of negativities recorded throughout the entire sampling time, significant differences were found for all tasks and conditions suggesting that there was more negative activity indicative of cognitive functioning outside the confines of the CNV or largest NPS than within the confines of the CNV or NPS. Hence, the measure of overall negativities recorded during the entire sampling time holds some promise as an indicator of cognitive activity.

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CHAPTER ONE

INTRODUCTION

In clinical praxis, speech-language pathologists encounter children with pervasive developmental delays who do not respond to traditional treatment methods. Such children show multiple impairments crossing verbal and nonverbal domains (Powell & Bishop, 1992; Scholl, 1981; Stark & Tallal, 1988; Swisher, 1994). These children may be nonverbal or echolalic, their motoric behavior may be abnormal, their sensory and perceptional systems may be strongly impaired, and their cognitive abilities may be very low. In the literature, these children are described as having pervasive developmental delay (PDD) or being autistic. Children along the autistic/PDD spectrum are considered to be more severely impaired than children along the specific language impairment (SLI) and specific learning disability (SLD) spectrum, who show more localized deficits.

Classic children with SLI show deficits in their oral language, whereas those diagnosed with learning disability (LD) show a deficit in learning one or more cognitive/linguistic skills required for academic success in school. For years, it was assumed that nonverbal performance was unimpaired in the latter two populations. The reason for this assumption was that the IQ tests used to evaluate nonverbal performance relied heavily, for instance, on simple visual-discrimination tasks, which can be accomplished by many children with developmental delays (Johnston, 1988). More recent research findings (Swisher et al., 1994) have indicated that typically developing children and those with SLI differ in their responses to test items on nonverbal instruments, even when the overall test result is in the average range for both groups.

Thus, not only do children along the PDD/autistic spectrum present an enigma to therapists, but children along the SLI/LD spectrum do so as well. Still, the latter group can respond with some success to traditional intervention approaches, which often require the processing of auditory and visual information. In contrast, children along the PDD/autistic spectrum exhibit verbal, nonverbal, motoric, and perceptual deficits when their impairments are severe. They represent the challenging cases in treatment because of their behaviors. One moment they withdraw from touch in displeasure (tactual defensiveness), and the next moment they might totally ignore being touched.

Similar phenomena have been observed when these children have been exposed to visual and auditory stimuli in their environment (Ayres, 1972; Fisher, Murray, & Bundy, 1991; Rutter & Schopler, 1987). These children, for instance, cover up their ears when the vacuum cleaner is switched on. However, when one speaks to them in a normal voice, they often fail to notice that they have been spoken to. Yet, when the children's hearing is tested, it is within normal limits. When their eyesight is checked, it is usually keen. This inconsistent reaction to sensory input has been puzzling to clinicians, parents, and researchers alike. Children with autism are also known for their stereotypies, such as hand or finger flapping, or walking on tiptoes. When they are examined, the pediatrician may not find any indication of physical handicaps. They also look normal. Consequently, the behaviors of these youngsters typically cannot be explained in terms of definite physical deficits. What theory could possibly account for the variety of deficits exhibited by this population?

Theoretical Explanations of Pathology

Contemporary theories regarding the cause of autism fall into two basic categories. The cause of autism is explained in terms of either physiological or psychological factors, processes, or mechanisms. For example, Singh and co-workers (Singh, 1996) focused on the cellular level by investigating the association between virus serology and autoimmune responses. Waterhouse, Fein, and Modahl (1996) attributed the etiology to dysfunctioning of neural mechanisms. The psychological theory put forward by Baron-Cohen (1995) explained autism by using a "theory of mind" model, whereas Affolter and colleagues (Affolter, 1987; Affolter & Bischofberger, 1993, 1996, in press; Affolter & Stricker, 1980) claimed that abnormal perceptual processing of nonverbal interaction experiences is the root of the problem.

Physiological Theories

Physiological explanations of autism are based on investigations of the organic structures that appear to be responsible for aberrant behavior. In other words, the functions of living organisms and the individual organs, tissues, and cells of which they are composed are the area of study (Purves et al., 1995).

Autoimmune Responses Causing Autistic Symptoms

The hypothesis that a virus-induced autoimmune response may play a causal role in the autistic syndrome has been put forth by Singh (1996), Warren et al. (1996), Warren and Singh (1996), Singh, Lin, and Yang (1998), and Warren et al. (1995). This means that there is reason to believe that autism is an autoimmune disease in which the body's immune system attacks its own cells instead of intruder cells (viruses and bacteria). Singh and coworkers reported an association between virus serology and brain autoantibodies in autism. They conducted the first serological study of the measles virus and herpes virus 6 (HHV-6) in autistic and normal subjects.

The researchers found that positive measles or HHV-6 titers were related autoantibodies -- in particular, to anti-MBP (an anti-myelin basic protein) in autistic children but not in normal controls (Singh, 1996). The authors pointed out that the measles virus and the HHV-6 virus were linked to demyelination. Myelin plays an important role in the transmission of neural impulses from the cell body of a neuron to its axon terminals, where a neurotransmitter substance is released. The axon carries action potentials. Myelin forms a sheath made of Schwann cells that is wrapped around an axon to insulate it electrically, thereby increasing its rate of transmission of neural impulses.

Another point worth considering is that environmental factors such as exposure to the measles virus or/and the HHV-6 virus should be considered as possible etiological agents linked to autoimmunity in autism (Singh, 1996). It is not known how the association between virous serology and autoantibodies might relate to the pathophysiology of the disorder.

Neuronal Organization in Brain Development

Whereas Singh and coworkers conducted their investigations at the cellular level, Waterhouse et al. (1996) looked at neuronal organization as a possible cause of autism. The researchers identified four major dysfunctions of neural mechanism that could account for the behaviors observed in autistic individuals: (a) canalesthesia, (b) impaired assignment of the affective significance of stimuli, (c) asociality, and (d) extended selective attention.

Under canalesthesia, the authors referred to fragmentation of cross-modal information processing for an ongoing event and long-term memory records for past events due to islandization of hippocampal system neurons. The dysfunction is caused by too great a cell-packing density that leads to component sensory records in the hippocampal system tissues to be canalized. Consequently, sensory information is not normal because hippocampal mossy fibers synapse on "islandized" cornu ammonis (CA3) pyramidal cells, and the incoming information is not coded adequately.

Waterhouse et al. (1996) defined impaired assignment of the affective significance of stimuli as an inability to judge actions by other people on a scale of important to unimportant (p. 458). This dysfunction is due to impaired amygdala function. The amygdala fails to develop due to overcrowding with immature cells. As a result, there is an inability to assign appropriate affective significance to incoming novel and social stimuli such as human faces, facial expressions, and nonverbal messages. The authors emphasized that the role of the amygdala is to integrate memory-modulating effects of neural hormone systems activated by learning experiences. Lesions of the amygdala in humans have been shown to result in abnormal affect, impaired face recognition, and impaired memory for the emotional content of stories.

Under asociality, Waterhouse et al. (1996) defined the dysfunction of social bonding due to aberrant functioning of the neuropeptide system involving oxytocin and vasopressin. The researchers stressed accumulating evidence suggesting that oxytocin and vasopressin participate in a mammalian neurophysiological network that regulates social affiliation and elaborated imprinting. The authors hypothesized that there might be two possible sources of oxytocin and vasopressin system dysfunction: (a) Impairment of oxytocin and vasopressin receptors in the amygdala and hippocampus following abnormal neuronal development in the medial temporal lobe, and (b) disruption of oxytocin- and vasopressin-releasing neurons early in development.

These assumptions have been supported by other researchers. Panksepp (1992) suggested that some motor stereotypies in autism may result from abnormal levels of oxytocin. Other researchers have stated that 25% of autistic individuals have elevated serotonin (5-HT) levels, which contribute to abnormalities in mood (Cook, 1990; Gillberg & Coleman, 1992; Waterhouse et al., 1996). According to Watherhouse et al., a certain number of autistic individuals demonstrate elevated beta endorphin levels, which reduce the reward value of sucking, satiety, and touch in nursing. These levels can also result in an abnormally high pain threshold.

The fourth dysfunction refers to the increased selective attention observed in autistic individuals. That is, they show decreased ability to shift attention (Waterhouse, et al, 1996). Inadequate temporal and parietal polysensory association cortex cells might trigger an extended selective attention loop in primary processing, according to the authors. Zeki (1993) provided evidence to support the hypothesis of extended selective attention in autism. He stated that properties of polysensory association cortex cells may be generated by local circuits or convergence. Zeki put forward the idea that the association cortex cells were new in evolutionary terms, fewer in number than the cells of the primary cortices, and more vulnerable. He pointed out that abnormally organized polysensory association cortex cells would disrupt formation of complex representations and increase reaction time to complex environmental stimuli.

Psychological Theories

Psychological theories of interest to this study have focused on explaining how the mind (our behaviors, experiences, personal identity) works and how it relates to the physical structure (the brain and the nervous system) that are ultimately responsible for many human behaviors observed in everyday life.

The Theory-of-Mind Model

Supporters of the theory-of-mind model have argued that a modular cognitive capacity underlies the ability to engage in complex social interactions. Baron-Cohen (1995) and Stone, Baron-Cohen, and Knight (1998) proposed that theory of mind is a complex, multicomponent, cognitive ability that is a distributed circuit involving many regions of the cortex rather than a unitary module localized in a small region of the cortex. The structures presumably involved in this circuit are amygdala, orbito-frontal cortex, and superior temporal sulcus. Baron-Cohen (1995) explained the autistic syndrome in terms of theory of mind, meaning that autistic individuals lacked the ability to make inferences about other people's mental states.

Baron-Cohen (1995) tried to discover why, in particular, autistic children have extreme difficulties forming mental representations. He described the autistic deficits in terms of "mindblindness." Hypothesizing that mindreading is enabled by the language faculty. The drive to inform, to exchange information, to persuade, or to find out about other people's thoughts, is based principally on mindreading. Unless language is linked to the mindreading system, language may be seldom used -- at least, not for social purposes. It is well known that autistic children are unable to make the associations necessary for normal social and language development.

Stone et al. (1998) provided evidence for Baron-Cohen's theory. Their analysis of various lesion studies indicated that damage in the orbito-frontal cortex, superior temporal sulcus, and amygdala causes symptoms very similar to the ones observed in autism. Baron-

Cohen and coworkers compared patients with bilateral orbito-frontal lesions to individuals with Asperger's syndrome (a mild form of autism) on a series of advanced theory-of-mind tasks, such as first- and second-order make-believe tasks and faux pas tasks.

The researchers found that the patients with bilateral orbito-frontal lesions performed similarly to individuals with Asperger's syndrome. They performed well on simpler tests such as first- and second-order false-belief tasks, but they encountered difficulties with higher level tasks, such as recognizing a faux pas, which required more subtle social reasoning. According to Stone et al. (1998), two things are necessary for an individual to detect a faux pas:

1. He or she has to understand that one person has knowledge that another person is unaware of or that an individual has a mistaken belief.

2. He or she needs to have an empathic understanding about what kinds of things another person would find upsetting or insulting.

Individuals with autism can understand other people's emotions, provided those emotions are caused by situations or desires (Baron-Cohen, 1991). However, emotions that are caused by beliefs are incomprehensible even for high-functioning autistic individuals. This deficit may be due to problems connecting mental inferences with an understanding of emotion. These assumptions have been supported by research conducted in patients with orbito-frontal and ventromedial brain damage. Brothers and Ring (1992) found that the amygdala and orbito-frontal cortex are essential brain structures for theory of mind as they are involved in interpreting the valence and significance of other people's actions and intentions.

Abnormal Perceptual Processing of Nonverbal Interaction Experiences

Verbal and nonverbal deficits in children along the PDD/autistic spectrum and the SLI spectrum have been explained in terms of abnormal processing of perceptual information at the nonverbal level. Affolter and coworkers (Affolter, 1987; Affolter & Bischofberger, 1993, 1996, in press; Affolter & Stricker, 1980) assumed that nonverbal interaction with the physical environment in daily problem-solving events is the root of cognitive and linguistic development.

Theoretical and clinical assumptions. In theoretical terms, Affolter and colleagues assumed that a baby's nonverbal interaction with the environment is the foundation on which perceptual organization and knowledge of the world rest. Nonverbal interaction occurs when one's action changes some aspect of the physical environment and, in turn, causes an adaptive response by the actor or agent in response to the change in the environment. For example, one may have to change body posture to accommodate to the new situation. Thus, interaction is reciprocal; it alters the person and his or her environment simultaneously. Thus, one comes to experience that "there is a world that resists the body when it is touched" (Affolter et al., 1996, p. 2).

When the body touches its environment and the various objects, people, and animals in it, the nervous system is assumed to register changes in resistance. The infant's adaptations to new situations are also experienced in the form of changes in resistance. From interaction experiences, the nervous system knows, for instance, how hard or soft a ball can be. This kind of tactual information is presumed to have been coded on a scale of maximal to minimal resistance.

Affolter and colleagues concluded from these observations that the nervous system stored tactile information in the form of changes in resistance offered by the various objects and people in the environment. They assumed that the nervous system created a scale of resistance that would allow the individual to relate patterns of resistance to certain tactual experiences. In child development, these tactual explorations are observed early, long before the child starts to speak

The following example explains the notion of interaction as described by Affolter and colleagues. A 5-month-old baby is sitting in his high chair, and an orange is on the support. The baby (actor) reaches out to touch the orange, and the orange moves around in response to the baby's touching and exploring. The orange rolls farther away from the baby. The baby has to adjust his own posture to the new situation in order to keep track of the orange. The baby accommodates to the new situation. Then the infant rolls the orange over the edge of the support. The orange falls to the ground and is out of the baby's sight. The baby interacted with his environment and achieved a topological change (which means a change of the baby's body in relation to the objects that form his environment). Grasping, taking off, and putting on, for instance, are topological changes. Once the orange was gone, the child related to the new situation.

The interaction event has all of the primitives for organizing a perceptual system, as assumed by Affolter and colleagues. When interacting with the environment, the baby receives tactual input (Primitive 1) that is coordinated with other sensory systems, such as vision, audition, taste, and smell. During an interaction event, the sensory systems can be correlated so that the tactual input is connected to other systems. Thus, multimodal connections (Primitive 2) of perceptual information can be established. When a baby performs an interaction, there will be a sequence in which the individual actions take place. The event sequence will enable the child to organize the perceptual information serially (serial organization – Primitive 3). In solving daily life problems, the child will be exposed to all necessary sources of perceptual information, and that is where learning takes place.

Another important consequence or effect of interaction -- apart from its role in perceptual organization -- is knowledge about causes and effects. To give an example, the baby rolled the orange over the edge of the support (cause), and the fruit disappeared (effect). By having a multitude of these interaction experiences, the baby gains knowledge about its own body and about the physical world around it. Knowledge of causes and effects supports conceptual development, which frames the semantic foundation of language and adaptive problem solving in daily-life events.

In clinical terms, Affolter and colleagues applied their interaction hypothesis to diagnosis and intervention. They believed that severe developmental problems result from abnormal interaction experiences. These abnormalities are assumed to be rooted in central nervous system pathology that prevents the child from sensing enough input, connecting the input with the modalities, or organizing it serially. Hence, there are three diagnostic groups:

1. Children who are unable to interact with their environment to extract the necessary information due to Tactile-Kinesthetic (T-K) deficits. This group of children typically learns best when the environment is changed so that they can receive adequate T-K input by feeling more resistance. Stockman (in press) suggested that these children behave like those in the United States who receive a diagnosis of PPD or high-functioning autistic children.

2. Children who can extract the necessary information from the environment but who are unable to process more than one modality at a time. These youngsters fail to make intermodal connections. Stockman's (in press) review of the literature indicated that children with classic autistic symptoms show intermodal difficulties.

3. Children who can perceive tactual, multistimuli and, as far as serial and temporal aspects are concerned, can process more than one modality at a time, but who fail at sequencing the information. This group of children is unable to serially organize the input they perceive. As a result of this deficit, these children face storage and recognition problems. According to Stockman (in press), this subgroup behaves like children in the United States who are diagnosed with SLI.

The subgroups stated under items 1 and 2, above, children with problems extracting the necessary tactile information from their environment and coordinating their intermodal information, were of particular interest in this study. These groups are the most severely impaired, in clinical terms.

If failure to interact is the cause of the deficits due to a perceptual problem, then treatment must facilitate interaction. To help the impaired child interact with the environment, Affolter and colleagues recommended guiding the child through a problem-solving event that is meaningful to the child. In other words, a clinician moves the child's body with him or her, not for him or her. They hypothesized that the input to the brain is the same when the child is manually led to solve a problem as when the child solves the problem independently. The focus on facilitating nonverbal interaction experiences in problem-solving situations is assumed to be relevant to both nonverbal and verbal development.

Affolter and colleagues' theory is also based on functionality. They assumed that while the child is being guided (hand over hand), the child will make some of the necessary associations required for concept formation. They claimed that the input will get to the brain whether the child effects the interaction on his or her own or is being guided to do so. They stressed that one moves the child's body with him or her and not for him or her.

Just touching objects is not necessarily beneficial to learning. Severely impaired autistic children can often be seen running around a room and touching everything they can get their hands on, but the children will not interact with the touched objects or people in any way. Affolter and colleagues pointed out that these children need to be guided to perform a functional goal-directed task. A functional goal-directed task would be, for instance, opening a milk carton. A cause-effect relationship is preserved in this task (you open the milk carton and you can drink milk).

The child will sit down at a table with good support (feet touching the ground, arms lying on a firm surface). The therapist will help the child open the milk carton, find the straw, put it in the carton, and drink the milk. This activity is meaningful to the child. There is a beginning, middle, and end to this particular task. The random touching seen before has been converted into goal-directed touching and learning, such that concept formation (open, drink) can take place.

<u>Behavioral and physiological evidence for the interaction hypothesis.</u> Support for the guided-interaction framework comes from Affolter's own behavioral research and other supportive studies. As summarized in Affolter and Bischofberger (in press), this research has involved several comparative behavioral studies of normal children and children with severe developmental disorders, including autism. They compared sensory-deprived (blind or deaf) subjects, language-impaired (including autistic) subjects, and normal control subjects in cross-sectional studies of ages ranging from 4 to 21 years, on form and pattern-recognition tasks, serial tasks, and classic problem-solving tasks. All tasks allowed them to compare tactual, visual, and auditory input (Affolter & Bischofberger, in press; Affolter & Stricker, 1980).

The learning and visually impaired groups were able to develop cognitively after showing initial developmental delays. The language-delayed group and the autistically impaired subjects, on the other hand, failed to show the same developmental pattern as the sensory-deprived subjects. They continued to fall behind in their cognitive development. In particular, subjects with severe impairments did more poorly on tactual tasks than did normal children and those with sensory deficits. Based on these findings, the authors suggested that tactual input was basic to perceptual organization and development.

In a longitudinal study (Affolter & Bischofberger, in press; Affolter & Stricker, 1980), the researchers found that language-impaired subjects (autistic subjects included) did not demonstrate nonverbal interaction performances in daily problem-solving activities as comparable to the sensory-deprived and normal groups. The language-impaired as well as the autistic subjects interacted with their environment to a lesser degree than the sensory-deprived groups. If problem solving occurred in the language-impaired group, it was done in a peculiar way. Usually it was not done at all.

The most striking finding was that "event representation" had to be established before true language would emerge. Consequently, Affolter and coworkers assumed that the common link between verbal and nonverbal performance was successful problem solving at the nonverbal level.

The theory stated by Affolter and colleagues was strongly influenced by Affolter's mentor, Jean Piaget, who often is considered to be the first contemporary scholar to focus on physical interaction as an important construct in developing cognition. Piaget considered assimilation and accommodation to be reciprocal mechanisms of developmental change that resulted in a cause-effect understanding of the world. This basic understanding would form the basis for cognition. In his writings, Piaget (1977) emphasized the importance of these early interactions with the environment in the "sensory-motor stage" of development. Piaget proposed that the child had to acquire a number of sensory-motor skills before language could develop.

Evidence in the literature supports some of the assumptions made by Affolter and colleagues about T-K deficits in children with developmental delays. Stockman (in press) cited studies that have shown a relationship between sensory-motor deficits and cognitive-linguistic delays. Grandin (1995) described in her book her own autistic sensory problems as a child and the remedies she created herself. Grandin would crawl into a cattle chute at her aunt's ranch to relax by feeling more pressure against her sides and neck. Later she built her own machine to experience more pressure. Affolter and colleagues believe that individuals with perceptual disturbances need to feel more resistance than those without such disturbance.

There is also evidence in the literature that children with severe developmental delays may have intermodal-processing deficits, as Affolter and colleagues have claimed. When Frith and Baron-Cohen (1987) reviewed a variety of studies that compared autistic children to mentally retarded and normal children, they concluded that at the sensory, lower processing levels, no deficit in any modality appeared to be specific to autism. The autistic subjects showed insufficient coordination with other senses in time and space. This observation was supported in a 1969 study by Frith and Hermeline (as cited in Stockman, in press). The researchers demonstrated that autistic subjects performed as well as normals when they just visually tracked a display and even better than normals when they just tracked from feeling. These children were less successful when they had to look and feel at the same time. Such findings support the assumption made by Affolter and colleagues that autistic children have problems on the intermodal level of organization.

There is a rich body of contemporary literature describing how the normal child learns. Part of learning is concept formation. Medin (as cited in Booth, 1998) suggested that concepts and categories serve as building blocks for human thought and behavior. Booth investigated the role of functional information in the development of object concepts in infancy. She tested 14-month-old infants by applying, among other things, the operant-discrimination learning paradigm. Infants were given either static, dynamic, or functional experience with exemplars. Infants in the static condition observed stationary pairs of exemplars. In the dynamic condition, they observed the exemplars moving in category-specific ways. In the functional condition, the infants produced the motions themselves. The operant-discrimination learning paradigm revealed that infants in the functional condition not only were more likely to learn, but also they learned faster than they did in the static or dynamic conditions.

Besides behavioral evidence for the claims of Affolter and colleagues, there is a physiological basis for them as well. In traditional intervention paradigms, T-K input as a possible source of learning has been widely neglected. One reason for this is that research in exploring the senses has focused primarily on vision, the auditory system, taste and smell. Affolter and colleagues are among the few contemporary scholars who have placed importance on T-K input for development. The nervous system of a new-born child is still immature in many ways; various processes and neurological mechanisms need to be established before, among other things, normal language development can be triggered.

Because the nervous systems of mammals are very similar to that of humans, a study by Wallace et al. (1997) is of interest. They investigated the development of multisensory neurons and the multisensory integration in the superior colliculus of cats. They found that although a high proportion of multisensory neurons and a high level of multisensory integration were found in the deep layers of the superior colliculus of adult cats, there were no such neurons during the first period of postnatal life in kittens. All sensory-responsive neurons were unimodal. This means that experiences and a functioning nervous system are necessary to establish the connections that enable adult cats to be successful as a species. One can assume that human infants explore their environments with the help of their senses. A well-functioning nervous system will form intramodal and intermodal connections that are necessary for development.

The roles of active touch and perception in one's exploration of the environment have not been fully explored. Bonda et al. (1996) investigated the neural systems involving memory processing of experiences through touch. The researchers found that a ventrally directed parietoinsular pathway, leading to the posteroventral insula and perirhinal cortex, constitutes a system by which long-lasting representations of tactual experiences are formed. The perirhinal cortex was found to be further involved in the integration of long-lasting representations of somatosensory experiences. This study indicated that certain pathways and brain areas are allocated to somatosensory experiences and representations.

Carvell and Simon (1996) investigated abnormal tactile experiences early in life in rats by trimming their whiskers. They found that the deprived rats were severely impaired in their ability to distinguish between smooth and rough surfaces. The rats' sensorimotor integration underlying active touch was substantially and perhaps permanently impaired.

Klatzky (1987) looked into the salience of object attributes for haptics with and without vision. The results of her study supported the contention that haptic and visual systems have distinct encoding pathways, with haptics oriented toward the encoding of substance rather than shape. This may reflect a direct influence of haptic exploratory procedures.

Evaluation of the Four Theoretical Perspectives

Theory should account for behaviors in normal and impaired populations so that a better understanding of developmental principles of human learning can be achieved and intervention principles formulated. To account for the behavior of children with autism, one needs to look at how theory can account for both nonverbal and verbal cognition, inclusive of social/pragmatic deficits.

Physiological theories have been formulated to explain the cause of autism by pointing to neurological structures that may be involved in the behaviors exhibited by autistic persons. These theories fall short in that they are not aimed at capturing broad developmental principles of human learning. It is not clear whether treatment strategies can result from the findings of research based on such theories. Singh's (1966, 1997, 1998) work at the cellular level might pave the way for the development of some future drug or vaccine. His line of thinking is clearly promising with regard to treatment outcomes in the future, although it leaves the clinician empty handed for the time being. Waterhouse et al. (1996) focused on identifying structural and organizational differences that might explain the deficits observed in autism. Their findings on vasopressin and oxytocin might lead to medical intervention at some time when neurotransmitters and hormones, such as vasopressin and oxytocin, are better understood. Again there is some promise for the future. For the time being, though, their theory also will leave the clinician empty handed.

Both psychological theories have shortcomings, as well. Baron-Cohen's theory-of-mind model pertains to a specific deficit (lack of mindreading ability) that, in turn, is responsible for language deficits. He asked relevant questions and looked for answers to them. He did not investigate perceptual mechanisms specifically, nor did he explore the issue of verbal and nonverbal performances. His theory does not provide any direction for intervention, rather it is a theoretical model looking at autism primarily from a theory-of-mind perspective while touching only up on the mind-brain relationship. In addition, by reducing the autistic deficit to a lack of mindreading ability, researchers using this theory address only a mild form of autism such as Asperger's syndrome. Supporters of a theory-of-mind model have not offered any explanations for the pervasive developmental deficits that more often characterize children with autism.

The theory stated by Affolter and colleagues, on the other hand, is the only one that casts a broad explanatory net in ways that connect to more general principles of learning and normal development. Diagnostic and treatment practices follow directly from their theoretical assumptions. Still, this theory is not well known, and its basic tenets go against the grain of most existing treatment frameworks. This is because the focus of their theory and treatment principles on physical interaction with the environment implies a sensory-motor orientation to therapy. Sensory-motor approaches developed by occupational and physical therapists have emerged, but these approaches remain an undercurrent in rehabilitation (Stockman, in press). In addition, there is no evidence that the few sensory-motor approaches that have been developed by occupational and physical therapists actually work.

One reason why sensory-motor approaches are missing in contemporary treatment is the waning influence of Piaget's theory on cognitive development, in which sensory-motor performance is foundational. Although some assumptions remain that do support Piaget's theory and reemerged in the new wave of cognitive constructionism (Langer, 1994; Nelson, 1986; Thelen, 1995), it is generally neither understood nor accepted that tactual input is important to essential aspects of cognitive and linguistic development. A lack of knowledge about the tactual system as compared to audition and vision is another reason why any paradigm involving sensory-motor mechanisms is not well received.

Documentation and/or testing of the efficacy of the guided-interaction treatment paradigm developed by Affolter and colleagues is needed. Until now, a major source of support for this treatment paradigm has been clinical observations substantiated by video archives. Children and brain-injured patients are videotaped when therapy is initiated, and patients' progress is documented in the course of treatment. For instance, at the School for Perceptually Disturbed Children in St. Gallen, Switzerland, clinicians are required to write down their observations during treatment. During a guided-interaction task, the child's behaviors are documented. For example, the clinician writes down when the child is attentive, and the conditions under which attention is sustained. The clinician notes progress in solving problems of daily life -- for instance, if the child anticipates the next step in the task, if the child takes over and continues performing the task independently, how often the clinician has to redirect the child's attention to the task, and so on.

It is well established that clinical efficacy studies, the approach by Affolter and colleagues included, are plagued by a lack of control. There are many variables that affect the internal and external validity of such research. These include clinician bias and maturation effects. In view of these difficulties with documenting progress and establishing valid criteria, support for treatment outcomes from a variety of different sources is desirable.

Encephalographic studies are a valuable addition to traditional empirical investigations in the field of speech-language pathology. Over the past decades, the number of electrophysiological studies conducted to investigate physiology and human behavior has increased considerably. These studies allow researchers to correlate brain activity with cognitive functioning, and they have the potential to be a valuable additional tool in assessing treatment efficacy for reasons stated earlier.

Another important factor influencing the present researcher to undertake this study is that the premises by Affolter and colleagues are not well accepted (for reasons described later). By measuring actual brain activity while testing Affolter and colleagues' assumptions, this investigator might be able to shed some light on the validity of their theory with a different kind of measurement than solely video observations.

Statement of the Problem

The present investigation was motivated by the advantages of studying mental processing in relationship to measures of brain activity. Neuropsychological research that involves relationships between mental processing and brain activity is potentially useful for informing both physiological and behavioral theories of causation for two reasons. The first one is obvious; it allows the investigator to combine physiology with psychological behaviors — something that is missing in contemporary psychological and physiological theories of autism, which concentrate on one dimension or the other. Although brain/behavior studies cannot yield theory in and of themselves, they can provide some support for or refute critical assumptions on which a physiological or psychological theory is based.

The second reason is that measures of brain activity appear to be less sensitive to cultural differences as cognition is being measured in the form of electrical activity and not with formal or rigidly standardized test instruments, which often are culturally biased. The kinds of mental processes that can be measured, are considered.

Attention is a prerequisite for learning. That is, if a child can pay attention for a certain period of time, he or she has a chance to learn some aspect of a task. When a child is unable to pay attention, it is important to enable him or her to do so. Getting the child's attention is an important goal when treating youngsters with severe deficits along the

PDD/autistic spectrum. Hence, one criterion for evaluating the efficacy of any treatment paradigm is its capacity to motivate attention to the task. In the guided-interaction paradigm designed by Affolter and colleagues, attention is the consequence of information received by the child. For impaired persons within this framework, the type of input needed to get the attention of the nervous system is anchored by tactual input.

On the one hand, the investigator focused on finding an electrophysiological measurement that would give some indication of whether a child is attentive or inattentive; on the other hand, the investigator wanted to observe brain activity in different conditions while sensory input was given involving the tactual system. Another consideration was to find an electrophysiological measurement that normal and autistic children could tolerate. Electroencephalography (EEG) turned out to be the measurement of preference for the present study.

Description of Electroencephalography

The EEG is composed of electrical rhythms and transient discharges, which may be distinguished from one another on the basis of location (brain region), frequency, and functional properties. The alpha band has a range of 8 to 13 cps, and the beta band's range is 14 cps. and above. The theta band ranges from 4 and 8 cps, and the delta band's range is 0.5 to 3 cps. Wavelength is employed to indicate the duration of a single event. Functional properties of cerebral electrical events are those variations that occur in relation to a shift in the level of consciousness (change in the type of mental activity).

The ongoing EEG records spontaneous brain activity driven by internal subject responses. Historically, ongoing EEGs have been used to compare normal with abnormal brain activity, as will be described later. To record brain activity in response to specific stimuli, the evoked-response paradigm was developed. These stimuli are associated with changes in the EEG that are called event-related potentials (ERP). Evoked potentials (EP) are signals that are generated by neural populations that become active when timelocked to the stimulus. This signal is summed to the ongoing EEG activity (Lopes da Silva, 1993). Time analysis of the EP is based on two assumptions:

1. The electrical response evoked from the brain is invariably delayed relative to the stimulus.
2. The ongoing activity is a stationary noise. The detection of the EP becomes a question of improving the signal-to-noise ratio.

One extensively studied ERP is the contingent-negative variation (CNV), first described by Walter (1964). The CNV is picked up from a background of raw EEG activity. It consists of slow surface negativity that depends on the association of two successive stimuli. A first stimulus (S1) serves as a preparatory signal for an "imperative" stimulus (S2), to which a motor response is made. The time interval between S1 and S2 is usually 1 to 2 s (Tecce & Cattanach, 1993). Present responses are recorded and averaged. Positive and negative components make up the evoked response, whereas the negative component is indicative of cognitive/mental activity. McCallum (1988) and Tecce and Cattanach (1982) suggested that the CNV is a potentially useful measure of brain-behavior functions, particularly psychological processes.

A sawtooth waveform is typical of the CNV that rises steadily until the termination takes place during the positive phase of the evoked potential to the imperative stimulus (Reneau & Hnatiow, 1975). Cohen (1969) indicated that 40% of the adults he tested produced CNVs having a ramp shape and 33% produced rectangular CNVs. The remaining subjects produced mixed and atypical CNVs. The shape of the CNV depended on the subject's uncertainty with the prediction. If the subject was certain when the response stimulus would occur, the CNV showed a ramp-like form. If the uncertainty was total, the CNV showed a square form. If uncertainty was reduced, the CNV showed reduced amplitude (Reneau & Hnatiow, 1975).

Ongoing EEG measurements to study attention in normals. In whole-scalp EEG studies, brain activities in the various bandwidths (such as alpha, beta, theta, and delta) have been related to cognitive processes such as attention. The studies discussed in the following paragraphs have demonstrated a relationship between electrical activity in the various bandwidths and cognitive functioning and, in particular, attention.

Researchers in Austria (Klimesch et al., 1996) used EEG and evoked potentials to study attention and memory in a normal population. Klimesch et al. demonstrated that the upper alpha band is sensitive to semantic memory, whereas the lower alpha band seems to reflect attentional processes. The authors assumed that EEG frequencies from the alpha bands originate from the thalamus and that activity of thalamocortical networks reflects processes that are related to searching, accessing, and retrieving information from long-term memory.

In general, the beta bands in the range of 20 to 40 Hz are linked to diffuse arousal and focused attention (Steriade, 1993). The fast-frequency bands have been observed, for instance, in the occipital cortex of a dog while the animal paid intense attention to a visual stimulus (Lopes da Silva, 1970). Sheer (1984) observed the same waves in humans during focused arousal before they performed a complex task. These particular beta bands are linked to the arousal system of the reticular formation that projects to the thalamus, where axons are found that directly innervate the cerebral cortex (Saper, 1987). The beta bands were also the focus of research by Pfurtscheller, Stancak, and Edlinger (1997). They recorded from sensorimotor areas during unilateral self-paced brisk and slow finger movements. The researchers found two different beta-components, whose function they believed to be a correlate of active inhibition of idling of the primary motor area following movement execution. The fact that the primary motor cortex is inhibited after execution of a motor task suggests that the resources allocated to one task can be transferred to another task. As will be described later, cognitive processes, such as paying attention, are possible only when certain areas of the brain are inactivated and the freed capacity is allocated to the task. If certain sensory and perceptual inputs cannot be blocked out, the system will overload and cease to function adequately.

Harmony et al. (1996) investigated whether an increase in delta EEG activity during mental tasks was related to an increase in the subjects' attention to internal processing. The researchers showed an increase in delta power from 1.56 to 3.90 Hz only during the difficult mental-calculation task, not during the control task. On the basis of these findings, they found evidence for their hypothesis.

Klimesch, Doppelmayr, Russegger, and Pachinger (1996) investigated the role of theta bands during an encoding task. The researchers found that theta power increased during successful encoding of new information, whereas alpha power decreased during encoding. Significantly higher theta power was noted during the encoding of words that could be remembered in the later recall task, compared to those words that the subjects failed to remember in the later recall task (Klimesch, Doppelmayr, Schimke, & Ripper, 1997). The researchers believed that theta power was induced in the cortex through hippocampo-cortical feedback loops. Theta power traditionally has been viewed as "noise" in the system. However, the finding that alpha power decreased while theta power increased at a time when words were learned might suggest a reciprocal relationship between the two band widths.

This reciprocal relationship might be indicative of cognitive processing and of attention. No learning can take place without attention.

Burgess and Gruzelier (1997) looked at changes in human theta rhythm during a word-recognition memory task. Their results confirmed that short-duration changes in human theta rhythm were associated with recognition memory. Verbal versus visuo-spatial recognition tasks were examined by Dujardin et al. (1995) and Rugg and Dickens (1982). The researchers found that alpha power was significantly lower during performance of both tasks as compared to the rest condition. Theta power, however, was significantly higher in epochs recorded during the visuo-spatial as opposed to the verbal task.

Weiss et al. (1995) examined EEG parameters that can be attributed to movements performed with maximal subjective effort. They found that theta decrease possibly reflected a down-regulation of a posterior attention system in order to minimize the influences of external stimuli during the preparation for voluntary isometric contractions.

CNV as an investigative tool to study attention in normals. CNV has been used to study cognitive functioning in normal adult subjects. It is generally accepted that larger CNV amplitudes are correlated with attention to a task procedure. Differences in CNV amplitude, on the other hand, may reflect changes in attention and sensitivity. McAdam (1969) investigated the relationship between learning how to estimate a short interval of time and the CNV. He found that an increase in CNV amplitude paralleled the actual learning of the experimental task.

Tecce and Scheff (as cited in Reneau & Hnatiow, 1975) found greater amplitude of the CNV when reaction times of subjects were faster. They concluded that the CNV and reaction times were manifestations of attention. On the basis of his own findings, Donald (1970) hypothesized that the CNV is a phenomenon that occurs during intense concentration.

EEG and Attention

Ongoing EEG-studies in impaired subjects. The ongoing EEG has been used as an investigative tool since the beginning of the century. The studies discussed in this section used ongoing EEG recordings of spontaneous brain activity in impaired subjects and compared them to those of normal controls. The impaired group demonstrated reduced activity in the alpha bands that are indicative of cognitive functioning, as described earlier. Cantor, Thatcher, Hrybyk, and Kaye (1986) measured brain activity in low-functioning autistic children with age-matched mentally retarded and normal subjects. The researchers found that the autistic subjects exhibited significantly more slow wave activity and less alpha activity than the normal or mentally retarded children did.

Dawson, Klinger, Panagiotides, Lewy, and Castelloe (1995) investigated subgroups of autistic children based on social behavior display and patterns of brain activity. Compared to normally developing youngsters, the autistic children showed reduced EEG power in the frontal and temporal regions, but not in the parietal region. Differences in the left hemisphere were more prominent than in the right hemisphere. The researchers were able to establish distinct patterns of brain activity of the children in the subgroups of autism. The subgroup of "passive" children exhibited reduced alpha EEG power in the frontal region.

Gorbachevskaya et al. (1992) studied, among other syndromes, infantile autism by using EEG mapping. The Russian researchers included in this group infantile schizophrenia, Rett's syndrome and fragile x syndrome. Their reason for including these three syndromes in the infantile autism group was that they showed similar clinical pictures. The investigators found three distinct patterns of brain activity among these three syndromes. The fragile x group showed marked reductions of the alpha rhythm and predominance of a theta rhythm with a frequency of 6 to 9 Hz and with maximal amplitude in the parieto-central region.

In the schizophrenic group, a reduction in amplitude of the EEG waves was noted, with a very small increase in diffuse slow-wave activity and with inadequate representation of the alpha rhythm. In the early stage of Rett's syndrome, a decrease in amplitude of the waves and of a fragmentary alpha rhythm with a frequency of 8 to 11 Hz was noted. Through the course of the disease, the abundance of the alpha rhythm decreased, foci of epileptoid activity appeared, and the theta rhythm was considerably intensified.

Schneble (1984) compared the EEGs of autistic children and adolescents with those of age-matched mentally retarded patients. The most striking finding of Schneble's study was that the majority of the autistic population (67.5%) showed an abnormally accelerated background activity. A mixture of fast alpha frequencies (11 to 12 s.) was found to be dominant in the parieto-occipital regions bilaterally. Almost the same pattern was found in the medial and frontal regions, with the only difference that the frequencies were more widespread. On average, the autistic group showed less synchronization than the control group.

As these studies have indicated, the impaired population shows reduced alpha amplitude and/or inadequate representation of the alpha rhythm compared to the alpha representation in normals. Of the autistic population tested by Schneble (1984), 67.5% showed abnormally accelerated background activity.

CNV in impaired subjects. Only a few researchers have looked at the CNV in clinical populations. Gloning, Burian, Gestring, and Haider (1970) studied the CNV with aphasic adults. Some severe aphasics had test results similar to those of the control group, and other severe aphasics had results that differed from those of the control group.

Walter (1966) found that it was difficult for patients suffering from chronic anxiety to develop a CNV. The same results were found when psychotic individuals were tested. They had great difficulty establishing a CNV (Reneau & Hnatiow, 1975). Rugg et al., (1989) recorded event-related potentials in a Go/No-Go reaction-time task from patients with closed head injuries and normal controls. The researchers found abnormalities in those of the clinical group but not those of the control group.

Cohen and Offner (1967) observed CNVs in children as young as 6 years. Prevec and Ribaric (1986) recorded a reliable CNV even in children as young as 3 years. Low, Coats, Rettig, and McSherry (1967) found that CNVs in children do not return to the baseline abruptly after the child makes a response. Their duration and amplitude are increased as compared to those of adults. Cohen and Offner used the CNV paradigm to test children with learning disabilities. The children in their study could not form CNVs.

Based on these studies, one can expect a more pronounced CNV in normal children as compared to normal adults. There is also the possibility that the impaired population might fail to establish a CNV.

Application of ERP/CNV to the Affolter Guided-Interaction Paradigm

The questions for the present investigation were motivated by methodological and theoretical considerations. With regard to methodology, there is some doubt that CNVs can be established in impaired children (as described earlier). In addition, even the literature on CNVs in normal children is scarce, so there is a need to explore methodological consequences of using the CNV in normal and clinical groups to gather further evidence.

With regard to theory, there appear to be four fundamental assumptions of the framework put forward by Affolter and colleagues that can be tested using simple tasks in the CNV paradigm. However, these assumptions are contentious on several fronts, and answering questions pertaining to them would validate or invalidate the theoretical framework that guides treatment.

The first assumption is that the brain gets information during guiding. Although the existence of the sensory system cannot be denied, there is a strong bias that guiding will not stimulate the nervous system because it is allegedly passive.

Detecting a CNV, or negative potential shift (NPS) in the autistic subjects when they are manually guided to perform a task would provide additional evidence for Affolter and colleagues' hypothesis that the input under guiding is received by the brain and actively processed, although the subject is not performing the task independently. If increased brain activity in the form of negative shifts or CNV is documented during guiding, Affolter and colleagues' hypothesis of working at the nonverbal level would also receive some support, and clinicians who use the guided-interaction paradigm to enable severely impaired children to interact with their environment and to solve functional tasks would have another piece of evidence to demonstrate the efficacy of this type of intervention.

The second assumption is that an individual will receive the same input in both the guided and unguided conditions. This is contended for the same reasons as the ones stated above. Independent volitional movements are thought to provide the best source of input for learning. This traditional view received support from the study by Carr et al., (1996).

Not many researchers have investigated guided versus unguided performance and the resulting brain activity. Carr et al. (1996) examined somatosensory activity associated specifically with motor control using functional magnetic resonance imaging (fMRI). The researchers compared an active performance condition in which the subject moved his hand independently with a passive sensory baseline condition in which the same movement was produced by the experimenter manipulating the subject's hand. The active performance condition and the passive sensory baseline condition were compared to find some evidence for processes associated with endogenous motor control and motor execution.

Differences in the extent of magnitude of activity in the somatosensory cortex due to somatosensory feedback were of particular interest to the investigators. They measured activity in the somatosensory cortex, proximate parietal association areas, and motor cortex during a task requiring cyclic flexion and extension of the four fingers of the right hand. The subject himself carried out this movement, and then the experimenter moved the subject's fingers in the same pattern and at the same pace.

The results showed that in the contralateral primary and supplementary motor areas, larger numbers of activated pixels were found during the active performance task than during the passive sensory baseline. A larger signal change occurred during active performance (9% versus 5%) than during the passive sensory baseline condition. Increased somatosensory activation was observed when endogenous control and active movement were required. Increased sensory feedback and increased attention to sensory feedback were noted during active performance. These findings suggest that independent task performance requires more mental activation than the passive baseline condition. That is, there was a difference between the guided and unguided conditions in the normal subject. The activation patterns were stronger in the unguided condition.

However, what the activation patterns of an autistically impaired subject would look like is still a question that needs to be answered. If an impaired child has to learn how to organize the perceptual information during guiding, it is not unreasonable to assume that the NPS would be even stronger under the guided condition as compared to the unguided condition. If more CNVs or negative shifts are recorded in this study when the impaired subject is manually guided to perform a novel task as compared to the condition where the impaired subject performs the task independently, additional evidence will be provided in favor of guiding.

A third assumption has to do with the role of resistance in tactual representation in the nervous system. Affolter and colleagues asserted that the most elementary kind of information needed to interact is the change of resistance one feels when touching objects in the environment. In her view, then the child searches for resistance to organize the T-K input.

To cite Affolter's Oyer Lecture (1996),

> "When I peel an orange, I know that the orange changes. I get information about these changes. I assimilate them. At the same time I also change or I have to accommodate my own movements in order to hold the orange and continue to peel it. While touching the orange and moving my own body through space, I also perceive the resistance offered by the environment. Judging from the degrees of resistance experienced, for instance, I know how much effort I have to use to grasp an object, or to push something out of my way."

Hence, guided-interaction treatment places emphasis on resistance. If resistance is a critical source of input, one should be able to detect changes in NPS on the EEG recordings. These changes should be observable when changes in topological relationships are correlated with changes in resistance.

Affolter and colleagues assumed that the various degrees of resistance play a key role in coding T-K information. This hypothesis is also addressed in this study. Affolter and colleagues believed that the nervous system has to exert more effort when an object is grasped that offers weak resistance than when an object is grasped that offers strong resistance. If a CNV of longer duration and higher amplitude is recorded in a condition where a soft ball is squeezed (rather than a hard ball), this is evidence that more mental energy is exerted to complete this experimental task. The individual has to search harder to perceive the T-K feedback resulting from touching the soft ball as compared to the hard ball.

The implications for therapy are that children with perceptual disturbances would be seated in such a way that they know where they are in space. This can be achieved by having them sit on a solid surface, feet placed on the floor and hands on a table offering a solid surface as well. Wherever and whenever possible, the objects used for intervention should be solid, too. Instead of using a plastic spoon, where the impaired child cannot feel much when he or she touches it, a metal spoon would be preferable. These accommodations would make it easier for the child to orient himself or herself in space and to the functional task he or she is about to tackle.

Positive research findings would also have implications for children with specific language impairment (SLI). Completion of problem-solving functional tasks would help them develop the sequencing skills very much needed in daily life and in a school setting. Metalinguistic performance (retelling stories, summarizing events, and so on) will be impaired unless the child with SLI acquires sequencing skills.

As the studies on CNVs in autistic and normal children are scarce or nonexistent, the results of this study will increase understanding of CNV measurement and the kind of information we might get from it.

The present study is pioneering work. To date, no studies have been conducted testing fairly complex segments of human behavior or, in Affolter and coworkers' terminology, "topological changes." The results will shed light on the feasibility of this kind of endeavor.

Research Questions

The following research questions were posed to guide the collection of data for this study:

1. Is it possible to elicit CNVs in autistic children?

2. Is it possible to elicit a CNV when the autistic subject is manually guided to do an event?

3. Is there a difference between the CNV elicited when the autistic subject is manually guided and unguided to do an event?

4. Is there a difference between the CNV elicited from autistic subjects when the event stimuli vary in the amount of resistance?

CHAPTER TWO

EXPERIMENTAL METHODS AND PROCEDURES

In this study, brain electrical potential shifts occurring between paired auditory stimuli were measured. The formation of the contingent negative variation (CNV) was of particular interest as it is indicative of attention/cognitive functioning. Two independent variables were manipulated: (a) guided versus unguided condition, and (b) changes in the resistance of stimulus material. The four dependent measures of brain wave activity included:

1. The duration in ms of the CNV or the largest negative potential shift (NPS).
2. The average amplitude in volts of the CNV or the largest NPS.
3. The extent of the area as a function of both duration and average amplitude of the CNV or the largest NPS.
4. The overall extent of the area as a function of both duration and average amplitude of the negativities recorded during the entire sampling time.

Subjects

Three autistic subjects were selected. They included two boys and one girl, all ranging in age from 6 to 10 years. They had been diagnosed with autism in the range from moderately severe to severe in accordance with the criteria stated in DSM-IV.

Subject-Inclusion Criteria

The autistic subjects were diagnosed with autism in accordance with the criteria stated in DSM-IV (fourth edition) of the American Psychiatric Association by a qualified professional (psychiatrist, psychologist, or physician) (see Appendix A). In addition to meeting DSM-IV criteria, subjects also met the following criteria for inclusion in the study:

1. They had no known cause of brain damage, such as infantile stroke.
2. They had no further medical conditions such as diabetes, or seizures.
3. They had not been born prematurely, and therefore the clinical profile was not assumed to be the result of slow maturation.
4. They had no additional syndrome such as Fragile X.
5. They had normal hearing and vision, as confirmed by teacher report.
6. They were native speakers of American English.
7. They had no physical impairments that might have decreased their agility and independent mobility.
8. They were unmedicated: One subject used Ritalin irregularly but was free of medication on the days of testing.

The investigator knew the autistic subjects from working with them regularly in the autistically impaired resource room in the Lansing School District. Permission was granted to visit the autistically impaired resource room to interact with the children. The investigator relied on psychological and teacher reports to ascertain that the subjects were autistic. The investigator relied also on her own observations made in the autistically impaired classroom to determine handedness of the subjects while working with them. All autistic subjects were right-handed.

Procedures for Subject Recruitment and Selection

Subjects were recruited from the Lansing Public Schools, using guidelines specified by the MSU Committee on Research Involving Human Subjects (UCRIHS). They were recruited from the special education autistically impaired program. Only three of the five students in the Autistically-Impaired Resource room met the inclusion criteria. Parental consent was obtained for each subject who was tested (see consent form in Appendix B).

Human Subjects Considerations

UCRIHS reviewed and approved this project and also the consent form to be used (see Appendix B). Each subject was paid an honorarium of $25 after each testing session at the Neuro-Audiologic Laboratory, Department of Audiology and Speech Sciences, MSU.

Data Collection

Description of Tasks

The experimental tasks were developed and pilot tested. More than 30 hours of actual observation time were invested in getting the most reliable results possible within the constraints of the laboratory equipment available to the investigator. Approximately 10 graduate and undergraduate students served as pilot subjects on a voluntary basis to assist with developing the experimental protocols, including the tasks and instrumental settings.

The subjects were presented with six experimental tasks. In addition to the tasks, the subjects' auditory brain-stem responses (ABR) were recorded.

Task 1 -- Push Button Task

The subject sat at a table with the left hand resting in the lap and the right hand resting on the table next to the response box. The subject heard white noise and a click delivered over headphones. The noise was stimulus one (S1) and the click was stimulus two (S2). The 2 stimuli were presented at a preset interval of 2 seconds. When the subject heard the noise (S1), a green light was displayed on the response box, and when the click (S2) was presented, a red light was displayed on the response box. The subject was prepared to push the button when the noise was heard and the green light was observed. After the click was presented and the red light was displayed, the subject immediately pushed a button on the response box. Six cycles of S1 and S2 presentations were delivered and averaged over time.

The Push Button task had been used in the Neuro-Audiologic Laboratory at MSU in previous experiments and was known to produce a CNV in unimpaired adult subjects. However, the light stimuli were added to the Push Button task to make it more interesting for the autistic subjects. The Push Button task was selected to answer the question of whether autistically impaired children could establish a CNV. Consequently, the feasibility of the CNV paradigm for this population was investigated.

Task 2 (Squeezing a Soft Ball -- Unguided) and Task 3 (Squeezing a Hard Ball -- Unguided)

For each task, the subject sat at a table with the left hand resting in the lap, and the right hand resting on the table. A ball (23 cm circumference) was placed next to the subject's right hand. White noise and click were presented at 2-second intervals as described previously for Task 1. When the noise (S1) was heard, the subject prepared to perform the task. After the click (S2) was perceived, the subject squeezed a ball. Six cycles of S1 and S2 were presented and averaged over time.

In Task 2, the subject squeezed a soft ball. It was made of foam and had a circumference of 23 cm. In Task 3, the subject squeezed a hard ball. It was made of Styrofoam and had a circumference of 23 cm. These tasks were designed to investigate whether negative potential shifts were altered by changes in resistance.

Task 4 -- Squeezing a Soft Ball, Guided

The subject sat at a table with the left hand resting in the lap and the right hand resting on the table. The same soft ball (made of foam, circumference of 23 cm) that was used in Task 2 was placed next to the subject's hand. The investigator sat next to the subject and listened for the same stimuli presented to the subject over a second set of headphones. When the investigator and subject perceived the noise (S1), they waited for the click (S2). As soon as the click was delivered, the investigator took the subject's hand and placed it around the ball. Then the ball was squeezed. When the investigator guided (hand-over-hand) the subject, the investigator's fingers were on top of the subject's fingers, and the investigator's palm rested on the back of the subject's hand so that both hands could move together simultaneously. Six cycles of S1 and S2 were presented and averaged over time.

This task was designed to determine possible differences in brain activity as related to the CNV or large NPS between Task 2 -- where the subject squeezed the soft ball independently -- and Task 4 -- where the subject was led manually (hand-over-hand) to perform the same task.

Experimental Task 5 - Picking up Light Glass, Guided

The subject sat at a table with the left hand resting in the lap and the right hand resting on the table. A glass (made of plastic, height = 14 cm, diameter of the glass at the bottom =

5.5 cm, diameter of the glass at the top = 8.5 cm, weight = 75 g) was placed next to the subject's hand. The investigator sat next to the subject. As with other tasks, signals for the subject and investigator were delivered through headphones. The white noise and the click were delivered at preset 2-second intervals. When noise (S1) was presented, the investigator and subject waited for the click (S2). As soon as the click was presented, the investigator guided the subject to grasp the glass, and to pick it up and put it down manually. Six cycles of S1 and S2 were presented and averaged over time.

Unlike Task 4, in which subjects were guided to perform a task they had done previously, Task 5 involved guiding the subjects in an unfamiliar event. Task 5 was designed to control for the order effect as compared to Task 4 (Squeezing a Soft Ball – Guided). In addition, this task was used to investigate the guided condition in a different task.

Task 6 - Picking Up a Heavy Glass, Unguided

The subject sat at a table with the left hand resting in the lap, and the right hand resting on the table. A glass, identical to the one used in Task 5, was used. The only difference was that the glass in Task 6 was filled with sand. The weight difference made the task more interesting for the subjects because it added novelty, and it also added resistance. The glass (made of plastic, height = 14 cm, diameter at the bottom of the glass = 5.5 cm, diameter at the top of the glass = 8.5 cm, weight = 575 g) was placed next to the subject's hand. The white noise (S1) and a click (S2) were delivered in sets of 2-second intervals. S1 was the warning signal. As soon as S2 was heard, the subject grasped and picked up the glass, and put it back down. Six cycles of S1 and S2 were presented and averaged over time.

Tasks 5 and 6 were designed to compare task performances in the guided and unguided conditions and to reveal possible differences in CNV or NPS. In addition, Tasks 5 and 6 were designed to be identical except for the aspect of weight. The glass used for Task 6 was 500 g heavier than the one used for Task 5. This aspect was changed to add novelty to Task 6 so that the subjects would not lose interest.

Auditory Brainstem Response (ABR)

An ABR recording was obtained for each subject. As the subjects did not undergo formal hearing evaluations, an ABR recording was obtained from each subject to determine that the auditory system was functioning normally. This non-volitional procedure required the subject to lie back in the chair, close his or her eyes, and relax. The subject was presented with 1,024 clicks 200 micros in duration at a repetition rate of 11.1/s.

An ABR recording provides information about the functioning of the auditory system, and the auditory nerve in particular. The classic ABR response consists of five positive principal peaks. Wave I is generated in the eighth nerve, and Waves III to V are generated in the brainstem. All other aspects of the waves (their sources and what they reflect) are still under discussion. The diagnostic power of brain stem auditory evoked potentials relies on the interpeak latency of Waves I to V, which represents brainstem transmission time and therefore brainstem auditory processing (Celesia & Brigell, 1993).

Administration of Tasks

Data collection took place in the Neuro-Audiologic Laboratory in the Department of Audiology and Speech Sciences at MSU. The investigator picked up the autistic subjects from school and drove them to the Neuro-Audiologic Laboratory during school hours. They were accompanied by their school aide.

Each subject was subjected to a standard protocol of tasks in the S1-S2 CNV response paradigm as described above. The investigator administered the tasks. Additional personnel provided support, as needed, to operate the computer or to monitor subjects' responses during tasks.

Each subject came to the laboratory twice. The same tasks were administered in the same sequence a second time to ensure reliability of results. The second testing took place within a month of the first testing.

Preparation of Subjects for Tasks

The subjects were prepared for the experiments in one room of the laboratory. In this room three electrodes were applied to the subject's scalp in accordance with the International 10-20 system. One electrode was placed in the Fz position. A second electrode was clipped on the subject's left ear to serve as a ground, and a third electrode was placed on the subject's right ear to serve as a reference. The impedance of all electrodes was kept below 5k ohms throughout the recordings, in accordance with the standard procedures used in the Neuro-Audiologic Laboratory at MSU, and as used in research reports on eliciting EEG responses (Dawson, Klinger, Panagiotides, Lewy, & Castelloe, 1995; Pfurtscheller, Stancák, & Neuper, 1996).

Once the electrodes were placed, the subject was led into a sound-proof room of the laboratory. It contained a table, a chair, and instruments for receiving and monitoring auditory signals, namely a preamplifier box, headphones, and so on. There was another chair 1.5 m away from the subject, where an aide could sit and observe the child.

Before each experimental task, the investigator gave nonverbal instructions. Intention implies that this was not always done. The investigator often took the subject's hand and guided him or her to perform the task after the imperative stimulus (S2) had occurred.

Order of Task Administration

The subjects were tested individually. They performed the tasks in the same order, which was as follows:

1. Push Button Task
2. Squeezing a Soft Ball -- Unguided
3. Squeezing a Hard Ball -- Unguided
4. Squeezing a Soft Ball -- Guided
5. Picking Up a Light Glass -- Unguided
6. Picking Up a Heavy Glass -- Guided
7. ABR

Recording of Data

Instrumental Recording of Subjects' Responses to Tasks

A signal generator (MI 2xx) was triggered by a custom-written program to produce S1 and S2. The subject's electrodes were connected to the preamplifier box that allowed for the stimuli to be amplified (MI 2xx) and attenuated (MI 2xx). CNV data were filtered with a high-frequency cut-off of 10 Hz and a low-frequency cutoff of 1 Hz. The preamplifier (Grass sss) gain was set at 30K x 6. The signal was fed to computer memory, which was connected to an oscilloscope and a computer monitor so that the investigator could observe the wave configuration on line. Electrophysiological activity was averaged on-line with signal averaging software (MI 2xx) on an IBM-XT computer. One channel was used. Sampling time was 2,499.71 ms, and sampling frequency was 3.02 KHz. Responses were generated across six trials for each experimental task.

The number of cycles for each subject in every experimental task was determined on the basis of extensive testing. The pilot subjects were asked to perform the experimental tasks in cycles varying from 4 to 30. It was observed that the number of cycles coincided with findings stated by Walter (1965), whose pilot testing showed also that the CNV was observed best after only a few cycles of presentations had been given.

As far as the interference of eye movements with the CNV was concerned, Low et al. (1966) found that horizontal eye movements were not significant but that upward eye movements were associated with a positive potential shift. As an evaluation of positive potential shifts was not of interest in the present study, the effect of eye movements could be ignored. The CNV occurs only in the form of NPS.

The ABRs were recorded with the same equipment, and the computer software program "dacpulse" (MI 2xx). The number of trials of each ABR was 1,024. Sampling frequency was 100.0 KHz, and sampling time was 10.0 ms.

The CNV experimental parameters were as follows:

Interstimulus interval (ISI)	= 2000 ms
Alternating polarity	= A
Click and noise stimuli used	= C and N
Click duration	= 2 ms
Noise-masking duration	= 50 ms
Rise/fall duration	= 10 ms
Delta T	= 500 ms

Behavioral Observations

In addition to measures of brain activity, the investigator also made behavioral observations. She noted whether the subject seemed attentive or inattentive to the tasks. She wrote down, for instance, whether the subject switched hands during an experimental event.

Data Analysis

A CNV is a slow, protracted potential (Walter, 1965). Grünewald (1979) applied the term CNV to cerebral NPS occurring in the interval between a warning stimulus (S1) and an imperative or otherwise significant stimulus (S2). The CNV takes into account the measurements of average amplitude and duration of the NPS.

In this study, an NPS was defined as a CNV whose duration extended over a period of 400 ms and whose average amplitude reached a value of –0.500 volts/division. Values less than 400 ms and less than -0.500 volts/division were regarded simply as NPS.

Previous researchers have reported CNV criteria for durations ranging from 200 ms to 1,000 ms. Rebert and Knott (1970) concluded from their investigations that the average time for onset of the CNV was 467 ms. As far as the duration of the CNV is concerned, Walter (1965) observed that the response to the first stimulus always contained a small negative variation, with a duration of about 200 ms equal in amplitude to the negative component of the second response. Walter (1964) also showed data where the CNV between two stimuli (click and flashes) was recorded over a time interval of 1 second. In general, the duration of the CNV varies and the length of the interstimulus interval varies too, depending on the test equipment available to the investigator.

Walter (1964) stated that the CNV usually has an amplitude of less than 20 microvolts, but Low et al. (1966) reported it to be as high as 50 microvolts in subjects younger than 12 years of age. As described earlier, the criteria for defining a CNV took into account the 2-second interstimulus interval, placement of the electrode in the Fz position, and the findings of Walter (1964) and Low et al. (1966).

For the present study, all NPS with a duration of 400 ms and an average amplitude of -0.500 volts were characterized as a CNV. Values below 400 ms and -0.500 volts were characterized as NPS.

Dependent and Independent Variables

The four dependent variables that were used to interpret the influence of the independent variables were:

1. The measured duration of the CNV or the largest NPS as identified by the investigator's visual inspection (Klimesch et al., 1996); the negative depression from the onset to the offset of the NPS was measured in ms along the x-axes.

2. The measured average amplitude of the CNV or the largest NPS as calculated by finding the sum of all amplitudes in the region of interest (NPS) and dividing the obtained value by the number of data points for that particular region (NPS).

Average amplitude = Σ (v/V), where v = amplitude in volts, and V = all the data points.

3. The measured area of NPS between the two stimuli (S1 and S2); the area was approximated as a sum of consecutive rectangles, with one side being the time interval and the other side the amplitude. The formula was as follows:

Area = $\Sigma (t \cdot v)$, where t = the time interval of 0.331 ms, and where v = the amplitude for each individual data point.

4. The measured overall area of negativities of the entire sampling time, as obtained by going through the raw data and adding the individual negative areas below the baseline. Overall area = the product of the time interval (0.331 ms) and the sum of the negative areas.

The four dependent variables were analyzed to test each of the experimental hypotheses. Waveforms for each task and each subject were plotted from the raw data. Afterwards, the dependent variables were identified by using the mathematical operations described above. For each analysis, data were pooled across the subjects and trials to obtain the best possible estimate of the parameters under study.

The two independent variables used in the study were (a) guided versus unguided condition and (b) changes in resistance. The independent variables pertained to Research Questions 3 and 4. The obtained values for the guided and unguided conditions were compared in Tasks 2 versus Task 4, and Task 5 versus Task 6. Changes in resistance were obtained by comparing the values recorded for Task 2 versus Task 3.

Possible Differences Between Guided and Unguided Conditions

To determine whether there was a difference between the CNV elicited when the autistic subject was manually guided and unguided to do an event, Task 2 (Squeezing a Soft Ball – Unguided) was compared to Task 4 (Squeezing a Soft Ball – Guided). Also, Task 5 (Picking Up a Light Glass – Guided) was compared to Task 6 (Picking Up a Heavy Glass – Unguided).

Possible Differences Between Stimuli Varying in the Amount of Resistance

To determine whether there was a difference between the CNV elicited from autistic subjects when the event stimuli varied in the amount of resistance, Task 2 (Squeezing a Soft

Ball – Unguided) was compared to Task 3 (Squeezing a Hard Ball – Unguided). Consequently, the researcher determined possible changes in resistance.

Research Questions

Elicitation of CNV in Autistic Subjects

To answer Research Question 1, regarding whether autistic subjects were able to establish a CNV, the EEG recordings of Task 1 (Push Button) were analyzed. Then the values obtained for duration and average amplitude were compared to the criteria defined for a CNV.

Elicitation of CNV in the Guided Condition

To answer Research Question 2, concerning whether autistic subjects were able to establish a CNV when they were manually led to do an event, the EEG recordings of Tasks 4 (Squeezing a Soft Ball – Guided) and Task 5 (Picking Up a Light Glass – Guided) were analyzed and compared to the criteria described above. Consequently, the researcher determined the absence or presence of a CNV.

Possible Differences Between the Guided and Unguided Conditions

To answer Research Question 3, regarding whether there was a difference between the CNV elicited when the autistic subject was manually guided and unguided to do an event, Task 2 (Squeezing a Soft Ball – Unguided) was compared to Task 4 (Squeezing a Soft Ball – Guided). Also, Task 5 (Picking Up a Light Glass – Guided) was compared to Task 6 (Picking Up a Heavy Glass —Unguided).

Possible Differences When the Event Stimuli Vary in the Amount of Resistance

Research Question 4 concerned whether there was a difference between the CNV elicited from autistic subjects when the event stimuli varied in the amount of resistance. To answer this question, Task 2 (Squeezing a Soft Ball – Unguided) was compared to Task 3 (Squeezing a Hard Ball – Unguided).

Statistical Analyses

After recording the data, the researcher converted the data points from the DOS program to Excel to calculate the measures for the dependent variables. The Wilcoxon matched pairs signed-ranks test was used to test for significant differences between responses and conditions. The data were pooled across two trials for each subject. This amounted to a maximum of six data points to analyze each experimental variable.

CHAPTER THREE

RESULTS

In this study, EEG recordings were analyzed with regard to NPS and the possible formation of CNV. A CNV is an NPS extending over a certain period of time and reaching a certain amplitude. According to the literature (Low et al., 1966; Prevec & Beric, 1990: Ikeda, 1997; Walter, 1964), the exact values for determining a CNV vary depending on the length of the interstimulus interval, the kind of task to be performed, and the location of the electrodes.

The criteria for defining a CNV in this study took into account the 2-second interstimulus interval, placement of the electrode in the Fz position, and the findings of Walter (1964), and Low et al. (1966). An NPS was defined as a CNV whose duration extended over a period of 400 ms, and whose average amplitude reached a value of -0.500 volts/division. Values less than 400 ms, and less than -0.500 volts/division were regarded simply as NPS.

A CNV in a S1-S2 response paradigm contains two basic components (Grünewald, 1979; Ikeda, 1997) -- an early component of the CNV that is called Bereitschaftspotential (BP), and a late component that occurs before S2. In the present study, the components of the CNV were not separated because there is evidence in the literature that both are indicative of attention (Walter, 1965), although the two components might be generated in different areas of the brain (Ikeda, 1997).

In the present study, three autistic subjects (two boys, one girl) varying in age from 6 to 9 years were tested twice on six experimental tasks as described earlier. In the data analysis, the autistic boys were referred to as Subjects 1 and 2, and the autistic girl was referred to as Subject 3.

In the ABR (Auditory Brainstem Responses) recordings the 5 expected peaks were visible. Consequently, it was assumed that there was no gross abnormality of the auditory system that would have excluded the subjects from participating in the experiments.

The results of the study on experimental tasks are displayed and described below for each of the questions posed for investigation. Data analyses for each question involved an analysis of each of the following dependent variables:

1. average amplitude of CNV or largest NPS
2. duration of CNV or largest NPS
3. area of negativity of CNV or largest NPS
4. area of negativities for the entire sampling time

The Wilcoxon matched pairs signed-ranks test was used to test for significant differences between responses and conditions. The results for the three subjects were pooled across five or six trials for each of the four dependent variables.

To answer each research question, the averaged wave forms generated during each task were inspected to determine whether the amplitude and duration criteria for a CNV were met for each subject in each trial, as described above. In addition, the values for the area of the CNV or the largest NPS and the overall area of negativities for the entire sampling time were calculated.

Research Question 1

Is it possible to elicit CNVs in autistic children?

The first question addressed a methodological issue -- that is, whether an autistic subject can establish a CNV. A Push-Button task similar to Task 1 had been used in the Neuro-Audiologic Laboratory at MSU in the past and had produced CNVs in unimpaired adult subjects. Hence, the investigator assumed that this kind of task was suitable to address the question. Only Task 1 was selected to investigate whether the autistic subjects could establish a CNV.

On Experimental Task 1 (Push Button), Subjects 1, 2, and 3 were tested twice. The results for the three subjects pooled across six trials for each of the four dependent variables are displayed in Table 1. Figure 1 displays a CNV for subject 1, and Figures 2 and 3 display large NPS on Task 1, for Subjects 2 and 3, respectively

Duration and Average Amplitude of the CNV or Largest NPS (Push Button)

As is shown in Figures 1, 2, and 3, the duration of an NPS serves as a measure of the length of time that attention can be sustained, and the average amplitude of the NPS serves as a measure of the magnitude of the brain response as judged by the steepness of the negative wave. The group's mean value for the duration of the CNV/largest NPS was 321.100 ms (SD = 124.3), and the average amplitude was -0.891 volts (SD = -0.421). The group's mean value for average amplitude exceeded the CNV criterion of –0.500 volts by -0.391 volts. But the group's mean value for duration did not exceed the preset CNV criterion of 400 ms. On average, the group did not meet both criteria defined for duration and average amplitude.

The group's trend did not reflect individual subject data. The criterion for duration was met only by Subject 1, Trial 1. However, the two large NPS observed for Subject 1, Trial

Table 1. Dependent Measures of Largest NPS on Experimental Task 1 (Push Button – Unguided).

		Largest NPS for Each Subject in Each Trial With an Indication Which NPS Meets CNV-Defined Criteria			
Trial	Subjects	Duration (ms) (CNV >400 ms)	Avg. Amplitude (volts) (CNV >.500 volts)	Area (volts*ms)	Overall Area (volts*ms)
1*	1	**540.192**[a]	**-1.639**[b]	886.413	1,193.640
1	2	191.980	**-0.9672**[b]	185.993	709.439
1	3	279.364	**-0.962**[b]	268.949	790.612
2	1	331.331	-0.416	137.953	607.528
2	2	358.877	**-0.711**[b]	255.263	422.184
2	3	224.749	**-0.873**[b]	196.399	687.232
Mean		321.100	-0.891	322.000	735.000
SD		124.300	-0.421	281.000	257.000

* Contingent Negative Variation (CNV).
[a] Shows that CNV criterion for duration was met.
[b] Shows that CNV criterion for average amplitude was met.

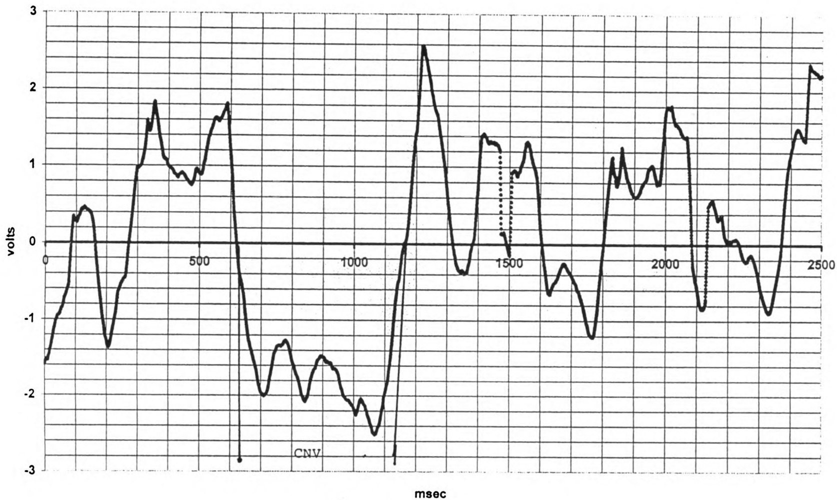

Figure 1. CS051399, Event 4, Experimental Task 1, Push Button, Unguided, Autistic Subject 1, Trial 1.

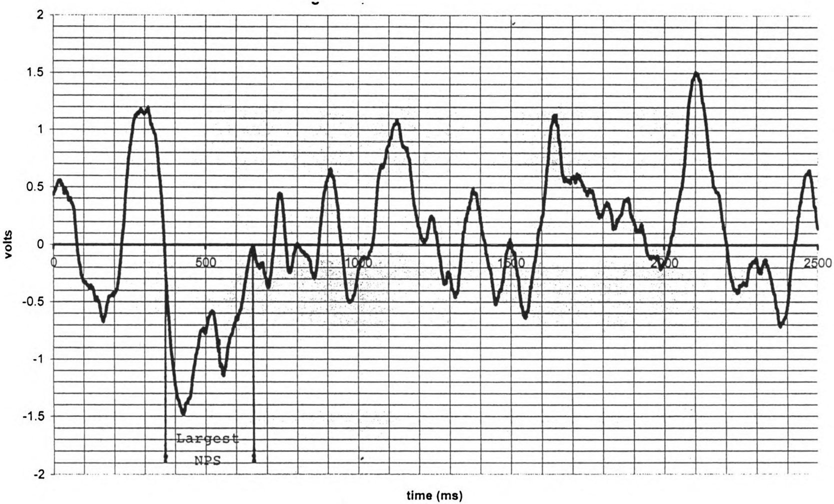

Figure 2. DB061199, Event 3, Experimental Task 1, Push Button, Unguided, Autistic Subject 2, Trial 2.

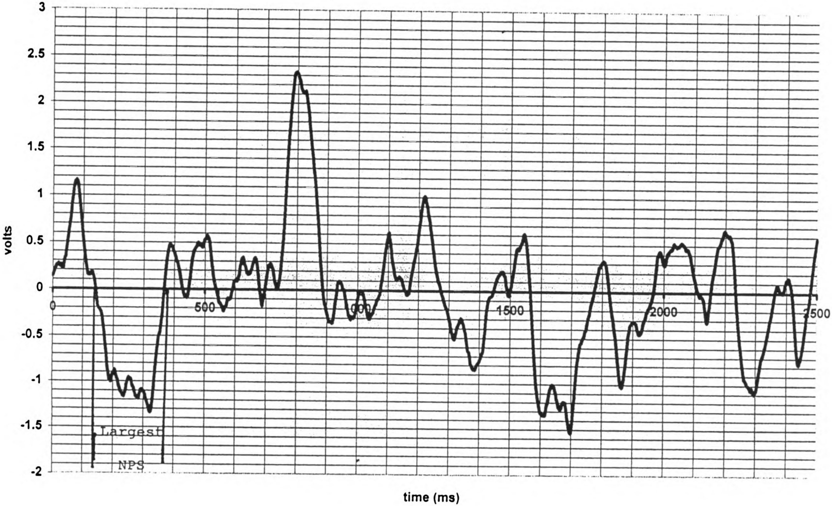

Figure 3 CM061199, Event 3, Experimental Task 1, Push Button, Unguided, Autistic Subject 3, Trial 2.

2, and Subject 2, Trial 2, came close to the criterion. Thus, only Subject 1, Trial 1, displayed a CNV (see Figure 1) with a duration of 540.192 ms and an average amplitude of -1.639 volts. Its duration and average amplitude were more than 1.5 SD above the mean. However, Subject 2, Trial 2, established a large NPS (see Figure 2) that displayed a duration of 358.877 ms, falling short of the defined criterion by 41.123 ms, and an average amplitude of -0.711 volts exceeding the criterion. Altogether, Subject 2, Trial 2, met 89.7% of the criterion for duration and 142% of the criterion for average amplitude. Subject 3's largest NPS was very similar in shape to a CNV, which is defined as a depression, displaced in the negative area of the curve, and terminated by the points where the onset trough-like and offset of the depression cross the baseline. However, Subject 3's largest NPS lacked the necessary dimensions. It gave the impression of a "depressed CNV" as compared to the CNV displayed by Subject 1 (see Figure 1).

Area of the CNV/Largest NPS and Overall Negativities of Entire Sampling Time (Push Button Task)

The area of the CNV/largest NPS is a combined measure of duration and average amplitude, and so is the measure of overall area of negativities extending across the entire sampling time of a task. Area and overall area of negativities represent measures of cognitive functioning as described earlier.

The restricted area of the CNV was compared to the entire area of negativities. The group's mean for the area of the CNV/NPS was 322 (SD = 281), and the group's mean for overall negativities of the entire sampling time was 735.0 (SD = 257.0). The Wilcoxon matched pairs signed-ranks test pooled across subjects and trials (N = 6) revealed a significant difference between the area of the CNV/largest NPS and the overall area of negativities of the entire sampling time [T (N = 6) = 0, p < .05]. To be statistically significant, the T-value had to be less than or equal to 1 for the present sample size. This comparison showed that there was a great amount of negativity outside the area of the CNV/ largest NPS while the subjects were performing the tasks.

Subject 1, Trial 1, not only established a CNV representing the largest area of all measured trials in Task 1, but he also established the largest area of negativities for the overall area. The largest negative area measured 886.413 volts*ms, which was more than 2 SD above the mean. The area of overall negativities for the entire sampling time was 1.193.64 volts*ms (1.5 SD above the group' s mean).

The value for the area of the largest NPS (255.263 volts*ms) was within 1 SD of the group's mean for Subject 2, Trial 2. Subject 2 showed an overall area of negativities (422.184 volts*ms) that was more than 1 SD below the group's mean. Subject 3's values for area of the largest NPS and overall area of negativities were within 1 SD of the mean.

Research Question 2: Eliciting the CNV in the Guided Condition

Is it possible to elicit a CNV when the autistic subject is manually guided to do an event?

Table 2 contains the results for Experimental Tasks 4 (Squeezing a Soft Ball) and 5 (Picking Up a Light Glass) in the guided condition. Subject 2, Trial 2, established two CNVs in the guided condition. One CNV was produced in Experimental Task 4 (Squeezing a Soft Ball -- Guided), and a second CNV was produced in Experimental Task 5. As mentioned earlier, the basic difference between these tasks was a potential novelty effect.

Table 2. Dependent Measures of Largest NPS on Experimental Task 4 (Squeezing a Soft Ball – Guided) Versus Experimental Task 5 (Picking Up a Light Glass – Guided).

			Largest NPS for Each Subject in Each Trial With an Indication Which NPS Meets CNV-Defined Criteria			
Trial	Subjects	Condition	Duration (ms) (CNV >400 ms)	Avg. Amplitude (volts) CNV >0.500 volts	Area (volts*ms)	Overall Area (volts*ms)
1	1	Guided	-	-	-	-
1	2	Guided (Ball)	209.192	**-0.635**[b]	133.060	517.140
1	2	Guided (Glass)	277.709	**-0.684**[b]	190.070	518.570
1	3	Guided (Ball)	236.003	**-0.883**[b]	208.798	375.453
1	3	Guided (Glass)	322.725	**-0.814**[b]	263.067	790.045
2	1	Guided (Ball)	208.199	**-0.989**[b]	206.327	713.960
2	1	Guided (Glass)	367.079	**-0.588**[b]	216.114	483.661
2*	2	Guided (Ball)	**417.476**[a]	**-0.548**[b]	228.856	548.472
2*	2	Guided (Glass)	**430.631**[a]	**-0.744**[b]	320.598	688.234
2	3	Guided (Ball)	189.663	**-0.718**[b]	136.466	636.476
2	3	Guided (Glass)	201.910	**-1.084**[b]	219.297	628.602
	Mean	Guided (Ball)	252.100	-0.755	182.700	558.300
	Mean	Guided (Glass)	320.000	-0.823	241.800	621.800
	SD	Guided (Ball)	93.900	-0.180	44.600	128.000
	SD	Guided (Glass)	86.900	-0.154	51.200	125.000

* Contingent Negative Variation (CNV).
[a] Shows that CNV criterion for duration was met.
[b] Shows that CNV criterion for average amplitude was met.

Task 4 (Squeezing a Soft Ball – Guided)

On Task 4, subjects were tested twice. The results for the three subjects pooled across 5 trials for each of the dependent variables are displayed in Table 2. Figure 4 displays a CNV for Task 4.

Duration and Average Amplitude of the CNV/Largest NPS for Task 4 (Squeezing a Soft Ball)

The group's mean for the duration of the CNV/largest NPS in Experimental Task 4 (Squeezing a Soft Ball) was 252.100 ms (SD = 93.9), and the mean for average amplitude was -0.755 volts (SD = 0.180). The mean value for average amplitude exceeded the minimum -0.500 voltage requirement by 0.255 volts. All subjects met the minimum requirement for average amplitude in every trial for this particular task, but not the duration criterion. Consequently, when individual subject data were examined, just one subject met both CNV criteria. The CNV established by Subject 2, Trial 2, in Task 4 (Squeezing a Soft Ball) had a duration of 417.476 ms and an average amplitude of -0.548 volts (see Figure 4). It was more than 1.5 SD above the mean for duration and within 1 SD of the mean for average amplitude.

Area of the CNV/Largest NPS and Overall Negativities of the Entire Sampling Time for Task 4 (Squeezing a Soft Ball)

The group's mean for the area of the CNV /largest NPS was 182.700 volts*ms (SD = 44.6). The group's mean for the overall area of negativities was 558.300 volts*ms (SD = 128.0). In Trial 2, Subject 2's value for the area of his CNV was 1 SD above the mean, and his value for the overall area of negativities was within 1 SD of the mean.

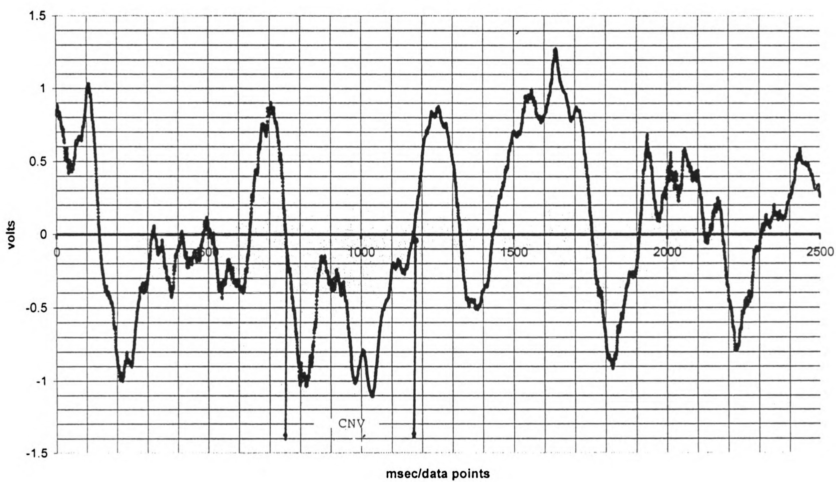

Figure 4. DB061199, Event 9, Experimental Task 4, Squeezing a Soft Ball, Guided, Autistic Subject 2, Trial 2.

The group's mean for the overall area of negativities during the entire sampling time was 558.300 volts*ms (SD = 128.0). A Wilcoxon matched pairs signed-ranks test was used to compare the negativity of the area of the largest shift to the area of overall negativities of the entire sampling time. The result showed a significant difference [T (N = 5) = 0, $p < .05$] between the two dependent variables. The value for T had to be below or equal to 1 to be statistically significant. This comparison showed that there was significantly more negative activity during the entire sampling time than during the recording of the CNV/largest NPS.

<u>Task 5 (Picking Up a Light Glass – Guided)</u>

On Task 5, Subjects 1, 2, and 3 were tested twice. The results for the three subjects, pooled across five trials for each of the four dependent variables, are displayed in Table 2. Figure 5 displays a CNV for this task. Figures 6 and 7 display large NPS meeting between 80% and 90% of criterion for duration and exceeding criterion for average amplitude.

<u>Duration and Average Amplitude of the CNV/Largest NPS for Task 5 (Picking Up a Light Glass)</u>

Table 2 also shows that the group's mean for duration of the CNV/largest NPS for this guided task condition was 320.000 ms (SD = 86.9). On the whole, the group met 80% of the criterion for duration of the CNV. The group's mean average amplitude was -0.823 volts (SD = 0.154). The amplitude value exceeded the minimal required voltage of -0.500 volts for a CNV by -0.323 volts. However, the group's mean values did not meet the CNV criteria for both measures (duration and average amplitude).

Individual subject data revealed the following: The same subject who established a CNV in the guided condition on Task 4 (Squeezing a Soft Ball) produced a CNV in the

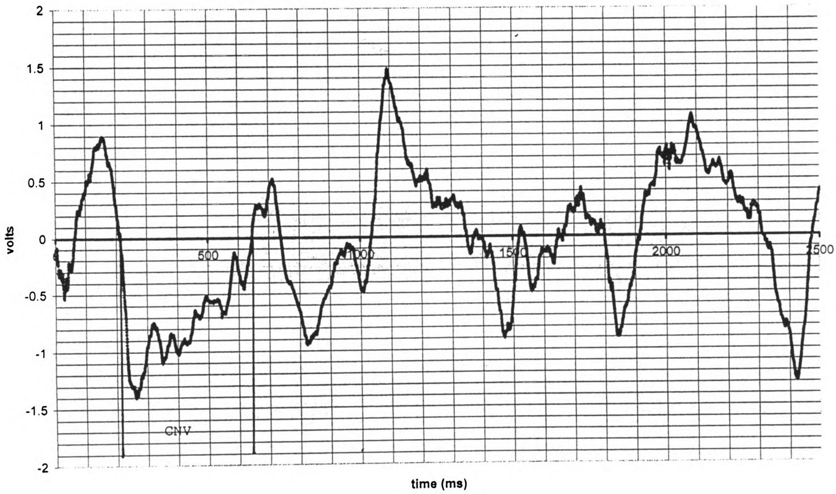

Figure 5. DB061199, Event 11, Experimental Task 5, Picking Up a Light Glass, Guided, Autistic Subject 2, Trial 2.

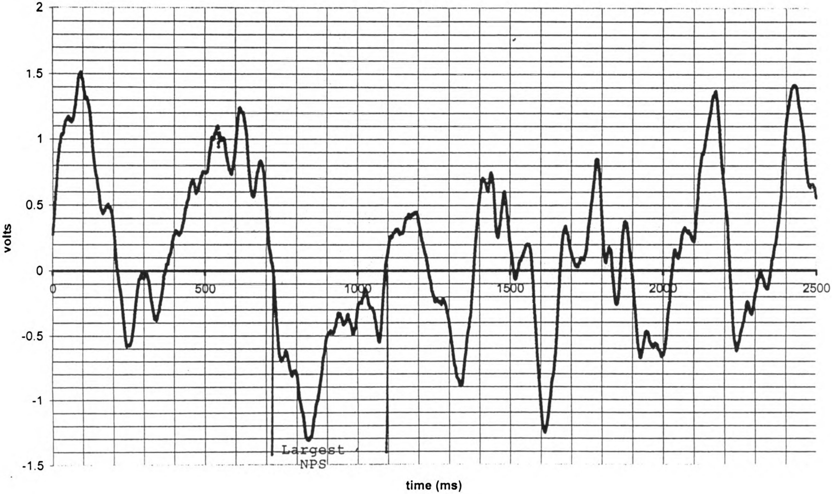

Figure 6. CS061199, Event 13, Experimental Task 5, Picking Up a Light Glass, Guided, Autistic Subject 1, Trial 2.

guided condition on Task 5 (Picking Up a Light Glass); see Subject 2, Trial 2. His CNV had a duration of 430.631 ms and an average amplitude of -0.744 volts (see Figure 5). Subject 2's CNV was more than 1 SD above the mean for duration, and it was within 1 SD of the mean for average amplitude.

Although subjects 2 established only one CNV in the guided condition, in trial 2, Subjects 1 and 3 established large NPS, meeting between 80% and 90% of the criterion for duration while exceeding the criteron for average amplitude. Subject 1, Trial 2, showed a large NPS (meeting 91.8% of the criterion) on Experimental Task 5 (Picking Up a Light Glass), with a duration of 367.079 ms and an average amplitude of -0.588 volts (see Figure 6). Subject 3, Trial 2, established a large NPS, meeting 80% of the criterion for duration (see Figure 7) and achieving the highest value for average amplitude of all subjects in the guided conditions.

Area of the CNV/Largest NPS and Overall Negativities of the Entire Sampling Time for Task 5 (Picking Up a Light Glass)

The group's mean for the area of the CNV/largest NPS was 241.800 volts*ms ($\underline{SD}$ = 51.200). The group's mean value for overall negativities recorded throughout the entire sampling time was 621.800 volts*ms ($\underline{SD}$ = 125.00). The Wilcoxon matched pairs signed-ranks test was used to compare the area of the CNV/largest NPS with the overall area of negativities. The test revealed a significant difference [$\underline{T}$ ($\underline{N}$ = 5) = 0, $\underline{p}$ < .05] between the two dependent variables. To be significantly different, $\underline{T}$ had to be below or less than 1. This finding demonstrated significantly more negative activity outside the area of the CNV or largest NPS than within the area defined as CNV or largest NPS.

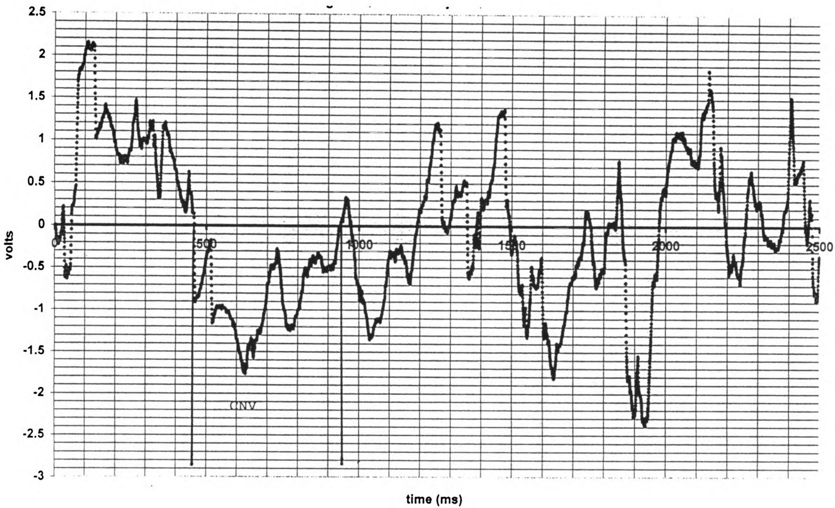

Figure 7. CS061199, Event 15, Experimental Task 6, Picking Up a Heavy Glass, Unguided, Autistic Subject 1, Trial 2.

Comparison of Tasks 4 (Squeezing a Soft Ball – Guided) and Task 5 (Picking Up a Light Glass – Guided)

As pointed out earlier, one main difference between the two guided tasks was novelty. Task 5 (Picking Up a Light Glass) was a novel guided task. The subjects did not know what the task would be about when the investigator guided them, whereas Task 4 (Squeezing a Soft Ball) was familiar to the subjects as they had performed the identical task independently in Task 2. As shown in Table 2, the group's means for all four dependent variables (duration, average amplitude and area of the CNV or largest NPS, and overall area of negativities) were higher for the novel task (Task 5, Picking Up a Light Glass - Guided) as compared to the familiar task (Task 4, Squeezing a Soft Ball – Guided). Although individual data did not show this trend in every trial and for each of the dependent variables, the overall tendency was significant. To test whether the novelty effect was significant, a Wilcoxon matched pairs signed-ranks test was performed.

Effect of Novelty on Duration and Average Amplitude in Task 4 (Squeezing a Soft Ball – Guided) and Task 5 (Picking Up a Light Glass)

When the duration of the CNV/largest NPS in Task Four was compared to the same dependent variable in Task 5, a significant difference was found [T ($N = 5$) = 0, $p < .05$]. The T-value had to be below or equal to 1 to be statistically significant. This means that the duration of the CNV/largest NPS was significantly longer in the novel task than in the familiar task. For the parameter of average amplitude, no significant difference was found ($T = 7$). The magnitudes of brain activity in this dimension were not significantly different between the two.

Effect of Novelty on Area and Overall Area of Negativities of Task 4 (Squeezing a Soft Ball – Guided) and Task 5 (Picking Up a Light Glass – Guided)

When the area of the CNV/largest NPS was compared in the two tasks, a significant difference [T ($N = 5$) $= 0$, $p < .05$] was found. The area of the CNV/largest NPS was significantly larger in the novel task than in the familiar task. However, a comparison between the areas of overall negativities during the entire sampling time did not reveal significant differences ($T = 3$).

Research Question 3: Guided Versus Unguided Condition

Is there a difference between the CNV elicited when the autistic subject is manually guided and unguided to do an event?

In posing this question, the goal was to determine whether there were differences in brain activity between the two conditions. Two sets of tasks were designed to address this question. Tasks 2 (Squeezing a Soft Ball – Unguided) and Task 4 (Squeezing a Soft Ball - Guided), and Task 5 (Picking Up a Light Glass – Guided) and Task 6 (Picking Up a Heavy Glass – Unguided) were compared. The novelty aspect was the major difference between Tasks 2/4 and Tasks 5/6, as described earlier.

The three subjects were tested twice and the test results were pooled across five trials for each of the dependent variables. The results are displayed in Tables 3 (Tasks 2 and 4) and 4 (Tasks 5 and 6). Figure 4 displays a CNV in Task 4 (Squeezing a Soft Ball – Guided), and Figure 5 displays a CNV in Task 6 (Picking Up a Heavy Glass – Unguided).

Comparison of Task 2 (Squeezing a Soft Ball – Unguided) with Task 4 (Squeezing a Soft Ball – Guided)

The subjects performed a task in the unguided condition first, followed by the identical task in the guided condition. The group as a whole did not meet the criteria for duration and average amplitude in the guided and unguided conditions, as shown in Table 3. However, the group met the criterion for average amplitude in both conditions. The group also met 63% of the 400 ms criterion for duration in the guided condition, and 70.3% of the criterion in the unguided condition. Table 3 displays the data for Task 2 (Squeezing a Soft Ball – Unguided) and Task 4 (Squeezing a Soft Ball – Guided). The difference between the two conditions was statistically insignificant, as described later.

Duration and Average Amplitude of the CNV/Largest NPS for Task 2 (Squeezing a Soft Ball – Unguided) and Task 4 (Squeezing a Soft Ball – Guided)

The group's mean for the duration and average amplitude of Task 2 (Squeezing a Soft Ball - Unguided) was 281.300 ms (SD = 52.0), and the group's mean for average amplitude was -0.815 volts (SD = 0.323). For Task 4 (Squeezing a Soft Ball - Guided), the group's mean for duration of the CNV/largest NPS was 252.100 ms (SD = 93.900). The group's mean for average amplitude was -0.755 volts (SD = 0.180). In the guided condition, all individual subjects met the requirement for minimum average amplitude, in both the guided and the unguided conditions. The duration requirement was not met by every subject on either task. Consequently, the CNV criteria of amplitude and duration were not met by any subject in the unguided condition on any trial. But one of the three subjects met both CNV criteria in the guided condition.

Table 3. Dependent Measures of Largest NPS on Experimental Task 2 (Squeezing a Soft Ball – Unguided) Versus Experimental Task 4 (Squeezing a Soft Ball – Guided).

			Largest NPS for Each Subject in Each Trial With an Indication Which NPS Meets CNV-Defined Criteria			
Trial	Subjects	Condition	Duration (ms) (CNV >400 ms)	Avg. Amplitude (volts) CNV >0.500 volts	Area (volts*ms)	Overall Area (volts*ms)
1	1	Guided	-	-	-	-
1	1	Unguided	-	-	-	-
1	2	Guided	209.192	**-0.635**[b]	133.060	517.140
1	2	Unguided	283.667	**-0.7122**[b]	202.261	596.061
1	3	Guided	236.003	**-0.883**[b]	208.798	375.453
1	3	Unguided	271.751	-0.419	296.819	896.762
2	1	Guided	208.199	**-0.989**[b]	206.327	713.960
2	1	Unguided	270.714	**-1.205**[b]	214.248	805.288
2*	2	Guided	**417.476**[a]	**-0.548**[b]	228.856	548.472
2	2	Unguided	217.823	**-1.084**[b]	245.874	521.726
2	3	Guided	189.663	**-0.718**[b]	136.466	636.476
2	3	Unguided	362.445	**-0.654**[b]	237.084	728.137
Mean		Guided	252.100	-0.755	182.700	558.300
SD		Guided	93.900	-0.180	44.600	128.000
Mean		Unguided	281.300	-0.815	239.300	709.600
SD		Unguided	52.000	-0.323	36.600	152.200

* Contingent Negative Variation (CNV).
[a] Shows that CNV criterion for duration was met.
[b] Shows that CNV criterion for average amplitude was met.

In Task 4 only one CNV was established by Subject 2, Trial 2 (see Figure 4). With regard to duration, his value was 1.5 SD above the mean. When the value for average amplitude was considered, he was within 1 SD of the mean. Subjects 1 and 3 produced large NPS that did not meet the criterion for duration. However, the criterion for average amplitude was met on each trial. In Task 2, no CNV was produced by any of the subjects. A large NPS was established by Subject 3, Trial 2, meeting 90% of the criterion for duration. The criterion for average amplitude was met.

To test whether significant differences existed between the two conditions, a Wilcoxon matched pairs signed-ranks test was done by pooling data across subjects and trials. When Task 2 (Squeezing a Soft Ball - Unguided) was compared to Task 4 (Squeezing a Soft Ball - Guided), no significant differences were found with regard to duration ($T = 5$) and average amplitude ($T = 5$) of the CNV/largest NPS.

Area of the CNV/Largest NPS and Overall Area of Negativities for Task 2 (Squeezing a Soft Ball – Unguided) and Task 4 (Squeezing a Soft Ball – Guided)

The group's mean for the area of the CNV/largest NPS in Task 2 (Squeezing a Soft Ball - Unguided) was 239.300 volts*ms ($SD = 36.6$). The group's mean for the area of overall negativities was 709.600 volts*ms ($SD = 152.2$). These values were longer than those obtained for the guided conditon. The group's mean for Task 4 (Squeezing a Soft Ball - Guided) was 182.700 volts*ms ($SD = 44.6$) for the area of the CNV/largest NPS, and 558.300 volts*ms ($SD = 128.0$) for the overall area of negativities.

The Wilcoxon matched pairs signed-ranks test was performed to test for significant differences with regard to the area of the CNV/largest NPS in both conditions. It was found that the area of the CNV/largest NPS was significantly greater in the unguided condition than in the guided condition. In addition, the Wilcoxon matched pairs signed-ranks test was used to test for significant differences between the overall areas of negativities, recorded through the entire sampling time, in both conditions. It was found that there was a significantly larger overall area of negativities in the unguided condition than in the guided condition [T ($N = 5$) $= 0$, $p < .05$].

Comparison of Task 5 (Picking Up a Light Glass – Guided) and Task 6 (Picking Up a Heavy Glass – Unguided)

Another guided and unguided task comparison focused on Task 5 (Picking Up a Light Glass – Guided) and Task 6 (Picking Up a Heavy Glass – Unguided). Table 4 displays the data for Task 5 (Picking Up a Light Glass – Guided) and Task 6 (Picking Up a Heavy Glass – Unguided). Figure 6 displays a CNV by Subject 1, Trial 2, in the unguided condition. The weight of the glass was the only difference between the two conditions, and it was not assumed to change the basic nature of the tasks. The glass-weight difference was expected to equalize task conditions. It was expected to maintain a novelty effect in the unguided condition that occurred after the novel guided condition. This aspect was changed in order to sustain the subjects' attention during task performance.

The group as a whole did not meet the preset criteria for duration and average amplitude of a CNV. The group consistently met the criterion for average amplitude in the guided and unguided conditions. The duration requirement was not met by every subject on either task. Consequently, the CNV criteria of amplitude and duration were not met by any subject in the unguided and guided conditions on any trial. The 400 ms criterion for duration was met by 80% of the group in the guided condition and by 96.5% of the group in the unguided condition.

Table 4. Dependent Measures of Largest NPS on Experimental Task 5 (Picking Up a Light Glass – Guided) Versus Experimental Task 6 (Picking Up a Heavy Glass – Unguided).

			Largest NPS for Each Subject in Each Trial With an Indication Which NPS Meets CNV-Defined Criteria			
Trial	Subjects	Condition	Duration (ms) (CNV >400 ms)	Avg. Amplitude (volts) CNV >0.500 volts	Area (volts*ms)	Overall Area (volts*ms)
1	1	Guided	-	-	-	-
1	1	Unguided	-	-	-	-
1	2	Guided	277.709	**-0.684**[b]	190.070	518.570
1*	2	Unguided	**567.334**[a]	**-0.814**[b]	473.580	802.726
1	3	Guided	322.725	**-0.814**[b]	263.067	790.045
1	3	Unguided	236.996	**-1.093**[b]	259.419	786.859
2	1	Guided	367.079	**-0.588**[b]	216.114	483.661
2*	1	Unguided	**479.950**[a]	**-0.848**[b]	407.295	1,027.580
2*	2	Guided	**430.631**[a]	**-0.744**[b]	320.598	688.234
2	2	Unguided	273.075	**-0.605**[b]	161.267	376.954
2	3	Guided	201.910	**-1.084**[b]	219.297	628.602
2	3	Unguided	373.368	**-0.865**[b]	323.365	927.514
	Mean	Guided	320.00	-0.823	241.800	621.800
	SD	Guided	86.900	-0.154	51.200	125.000
	Mean	Unguided	386.100	-0.849	325.000	784.000
	SD	Unguided	138.600	-0.173	122.400	248.000

* Contingent Negative Variation (CNV).
[a] Shows that CNV criterion for duration was met.
[b] Shows that CNV criterion for average amplitude was met.

Table 5. Dependent Measures of Largest NPS on Experimental Task 2 (Squeezing a Soft Ball – Weak Resistance) Versus Experimental Task 3 (Squeezing a Hard Ball – Strong Resistance).

			Largest NPS for Each Subject in Each Trial With an Indication Which NPS Meets CNV-Defined Criteria			
Trial	Subjects	Condition	Duration (ms) (CNV >400 ms)	Avg. Amplitude (volts) CNV >0.500 volts	Area (volts*ms)	Overall Area (volts*ms)
1	1	Weak	-	-	-	-
1	1	Strong	-	-	-	-
1	2	Weak	283.667	**-0.712**[b]	202.261	596.061
1	2	Strong	364.100	**-0.569**[b]	207.407	710.101
1	3	Weak	271.571	-0.419	296.819	896.762
1	3	Strong	258.842	**-0.901**[b]	233.390	643.912
2	1	Weak	270.714	**-1.205**[b]	214.248	805.228
2	1	Strong	378.664	**-0.694**[b]	263.133	943.651
2	2	Weak	217.823	**-1.084**[b]	245.874	521.726
2	2	Strong	**617.44**[a]	-0.466	287.621	652.735
2	3	Weak	362.445	**-0.654**[b]	237.084	728.137
2	3	Strong	315.774	**-0.978**[b]	309.105	656.387
Mean		Weak	281.300	-0.815	239.300	709.600
SD		Weak	52.000	-0.323	36.600	152.200
Mean		Strong	387.000	-0.722	260.100	721.400
SD		Strong	137.100	-0.216	40.800	127.000

* Contingent Negative Variation (CNV).

[a] Shows that CNV criterion for duration was met.

[b] Shows that CNV criterion for average amplitude was met.

Duration and Average Amplitude of the CNV/Largest NPS for Task 5 (Picking Up a Light Glass - Guided) and Task 6 (Picking Up a Heavy Glass – Unguided)

For the guided condition, Task 5, the group's mean for duration of the CNV/largest NPS was 320.0 ms (SD = 86.9). The mean for average amplitude was -0.823 volts (SD = 0.154). The group's mean for average amplitude was above the criterion, which means that every subject met the criterion on Task 5. The group met 80% of the 400 ms criterion for duration.

However, one of the three subjects, Subject 2, Trial 2, met both CNV criteria in the guided condition. The duration of the CNV produced by Subject 2, Trial 2, was 430.631 ms, which means that it was more than 1 SD above the mean. The average amplitude of -0.588 volts was within 1 SD of the mean.

For the unguided condition, Task 6 (Picking Up a Heavy Glass), the group's mean for duration was 386.100 ms (SD = 138.6). The mean for average amplitude was -0.849 (SD = 0.173). The group's mean was above the requirement for a CNV. Every subject met this criterion in each trial of this task.

Two CNVs were established in the unguided condition. Subject 1, Trial 2, for instance, established a CNV in the unguided condition that was more than 1 SD above the mean in comparison with the group's mean for duration of the CNV. The value for average amplitude was within 1 SD of the mean (see Figure 6).

For Tasks 5 and 6, the Wilcoxon matched pairs signed-ranks test was used to test for significant differences between the guided and unguided conditions. Test results revealed no significant differences between the conditions. The value for T had to be less than or equal to 1 to be significant. On the four dependent variables the values for T were as follows: duration (T = 4), average amplitude (T = 6), area (T = 4), and overall area of negativities

(T = 5) suggesting that there were no significant differences is task performance between the guided and unguided conditions.

Area of the CNV/Largest NPS and the Overall Area of Negativities for Task 5 (Picking Up a Light Glass - Guided) and Task 6 (Picking Up a Heavy Glass – Unguided)

For the guided condition, Task 5 (Picking Up a Light Glass -- Guided), the group's mean for the area of the CNV/largest NPS was 241.800 ms (SD = 51.2), and the mean for the overall area of negativities was 621.800 volts*ms (SD = 125.0). These values were lower than the comparable ones obtained in the unguided condition (Task 6 – Picking Up a Heavy Glass -- Unguided). The area of the CNV for Subject 2, Trial 2, was 1.5 SD above the mean, whereas the value for the overall area of negativities was within 1 SD of the mean.

For Task 6 (Picking Up a Heavy Glass - Unguided), the group's mean for the area of the CNV/largest NPS was 325.0 volts*ms (SD = 122.4). The group's mean for the overall area of negativities was 784.0 volts*ms (SD = 248.0). Subject 1, Trial 2, established a CNV; his area was within 1 SD of the mean, and his overall area of negativities was within 1 SD of the mean.

As displayed in Table 4, three CNVs were observed altogether on Tasks 5 and 6. One CNV was produced in the guided condition (Task 5, Picking Up a Light Glass -- Guided) by Subject 2, Trial 2 (see Figure 5). Two CNVs were established in the unguided condition, Task 6 (Picking Up a Heavy Glass – Unguided). The CNV of Subject 1, Trial 2, is displayed in Figure 6.

The Wilcoxon Matched pairs signed-ranks test was performed to test for significant differences with regard to the area of the CNV/largest NPS and the overall area of negativities recorded throughout the entire sampling time. No significant differences were found when the areas of the CNV/largest NPS were compared between the two conditions. However, a comparison of the overall area of negativities in the guided and unguided conditions resulted in a significant difference [T (N = 5) = 0, $p < .05$]. The T-value = 1. There was significantly more negative activity in the unguided condition than in the guided condition. The fact that the overall area of negativities recorded throughout the entire sampling time differed significantly between the unguided condition and the guided condition suggested that more mental activity was exerted in the unguided condition than in the guided condition on these two tasks.

Although the group data did not indicate significant differences between the two conditions, the individual subject data showed different patterns. Subject 1 consistently achieved higher values in the unguided condition, whereas Subjects 2 and 3 showed more variable outcomes. At times they achieved higher values in the guided condition and at other times in the unguided condition. In general, the effect of task presentation (novelty effect) resulted in higher values for Experimental Task 5, where the subjects were guided without having previous experience with the actual task itself as compared to Experimental Task 4.

<u>Examining a Possible Novelty Effect Between Task 2 (Squeezing a Soft Ball – Unguided) and Task 6 (Picking Up a Heavy Glass -- (Unguided)</u>

Task 2 (Squeezing a Soft Ball – Unguided) was compared to Task 6 (Picking Up a Heavy Glass -- Unguided), to test the novelty effect in the unguided condition. The Wilcoxon matched pairs signed-ranks test did not reveal significant differences between tasks for the four dependent variables. The T-value for duration of CNV/largest NPS = 2, for average amplitude T = 5, for area of the CNV/largest NPS T = 3, and for the overall area of

negativities T = 3. In the unguided condition, the effect of novelty versus familiarity was not statistically significant.

Research Question Four: Change of Resistance

Is there a difference between the CNV elicited from autistic subjects when the event stimuli vary in the amount of resistance?

The goal was to determine whether there were differences in brain activity when the subject independently touched two balls varying in the amount of resistance. Two tasks, one representing weak resistance (squeezing a soft ball) and one representing strong resistance (squeezing a hard ball), were designed to address this question. The subjects were tested twice. The results for the three subjects pooled across five trials for each of the dependent variables are displayed in Table 5.

<u>Comparison of Task 2 (Squeezing a Soft Ball – Unguided) and Task 3 (Squeezing a Hard Ball – Unguided)</u>

Task 2 (Squeezing a Soft Ball – Unguided) offered weak resistance, whereas Task 3 (Squeezing a Hard Ball – Unguided) offered strong resistance. According to Affolter's theory of guided interaction, the nervous system codes tactual input in terms of resistance. Hence, changes in brain activity should be observable when the form of resistance experienced by the subject changes from weak to strong.

Duration and Average Amplitude of the Largest NPS for Task 2 (Squeezing a Soft Ball – Unguided) Versus Task 3 (Squeezing a Hard Ball – Unguided)

For Task 2 (Squeezing a Soft Ball - Unguided, Weak Resistance), the group's mean for the duration of the largest NPS was 281.300 ms (SD = 52.0), and the average amplitude was -0.815 volts (SD = 0.323). The group as a whole did not meet the criteria for a CNV. The group met 70.3% of the criterion for duration, as well as the criterion for average amplitude. For Task 3 (Squeezing a Hard Ball - Unguided, Strong Resistance), the group's mean for duration was 387.000 ms (SD = 137.1). The group as a whole did not meet the criteria for a CNV. However, the group met 96.75% of the criterion for duration. The group's mean for average amplitude also was met.

The Wilcoxon matched pairs signed-ranks test was used to test whether any significant differences occurred between the two conditions (weak versus strong resistance). The test results revealed no significant differences between the two conditions on the dependent variables of duration and average amplitude of the CNV/largest NPS.

Judging from Table 5, none of the three subjects met the required CNV criteria for duration and average amplitude for either the weak or the strong resistance. Although the group results showed no significant differences between task conditions, data analyses for each subject revealed some subject biases. Subjects 1 and 2 showed a greater amplitude shift relative to the hard ball when the soft ball was squeezed (weak resistance). Conversely, Subject 3 showed more amplitude when the hard ball was squeezed (strong resistance). Subjects 1 and 2 showed increased duration of the largest NPS when the hard ball was squeezed, whereas Subject 3 showed the same tendency in her second trial, but not in her first trial.

Area of the Largest NPS and Overall Area of Negativities for Task 2 (Squeezing a Soft Ball – Unguided) and Task 3 (Squeezing a Hard Ball – Unguided)

For Task 2 (Squeezing a Soft Ball – Unguided, Weak Resistance), the group's mean for the area of the largest NPS was 239.3 volts*ms (SD 36.6). For Task 3 (Squeezing a Hard Ball – Unguided, Strong Resistance), the group's mean for the area of the largest NPS was 260.1 volts*ms (SD = 40.8). For Task 2 (Squeezing a Soft Ball – Unguided), the group's mean for the overall area of negativities was 709.600 volts*ms (SD = 152.2). For Task 3 (Squeezing a Hard Ball – Unguided), the group's mean for the overall area of negativities was 721.400 volts*ms (SD = 127.0).

Subjects 1 and 2 showed increased areas of the largest NPS when the hard ball was squeezed. Subject 3 showed the same tendency in her second trial, but not in her first trial.

With respect to the overall negativities recorded for the entire sampling time, Subjects 1 and 2 showed increased negativities when the hard ball was squeezed, whereas Subject 3 showed increased negativities when the soft ball was squeezed. Consequently, Subjects 1 and 2 showed the same biases, whereas Subject 3 almost consistently showed the opposite bias with regard to the duration of the largest NPS, its average amplitude, its area, and the overall area of negativities of the entire sampling time

A comparison between the areas of the largest NPS and the overall area of negativities revealed a significant difference [T ($N = 5$) = 0, $p < .05$] in both conditions on the Wilcoxon matched pairs signed-ranks test. This means that there was significantly more negative activity indicative of cognitive functioning outside the area of the largest NPS extending over the entire sampling time.

CHAPTER FOUR

DISCUSSION AND INTERPRETATION OF RESULTS

The present study was motivated by the difficulties arising from treating children with severe impairments along the autistic/PDD spectrum because this population does not respond to conventional treatment paradigms with the success one would expect. According to Affolter and colleagues (1980, 1993, 1996b), one might assume that conventional treatment paradigms require children to use their visual and auditory inputs at a supramodal level. The prerequisite for this level is that the children have gained a multitude of experiences following nonverbal explorations.

Within the framework, the representation of events at the nonverbal level is also assumed to be a prerequisite for meaningful language to occur. To be functioning at this relatively high level, a child must have experienced a fairly normal development in infancy and early childhood. In other words, the child must have been able to explore his or her environment by using tactile-kinesthetic input as a primary source of information to pave the way for intermodal integration and serial organization of perceptual input.

Children with severe impairments might have problems with extracting adequate T-K information from their environments, integrating perceptual input from various modalities (vision and audition might not get aligned adequately with other senses), or organizing perceptual information serially (events might not get sequenced appropriately).

Assuming that the hypotheses proposed by Affolter and colleagues (1980, 1993, 1996b) are correct, it makes sense to intervene at exactly the level where the deficits occurred. For most severely impaired children, this would mean intervention at a nonverbal level to allow the child to solve functional problems, explore his or her environment, and represent events of daily life mapped onto his or her experiences. Affolter and colleagues' observations of normal infants led them to believe that guiding would help impaired children make the connections they missed out on when they tried to make the explorations on their own.

As Affolter and colleagues' hypotheses address normal and impaired development of children, the present investigation was designed to examine some of their basic assumptions by testing exactly the clinical population that causes so many problems for clinicians -- the children along the autistic/PDD spectrum. If tactile-kinesthetic input is primary to visual and auditory input in development and is needed to anchor the other senses, then children with perceptual disturbances should benefit from the guided interaction paradigm and one should be able to measure its impact.

Applying the CNV as a Measurement Tool

Over the past decades, electrophysiological studies have been designed to learn more about human cognitive functions by measuring the electrical activity of the brain. In particular, activities in response to one or two identifiable stimuli such as event-related potentials or CNV have been subjected to many investigations. Surface negativity that depends on the association of two successive stimuli is called CNV (Donchin et al., 1972; Tecce & Cattanach, 1993). Its magnitude is increased when a motor response is made to the second stimulus (Peters et al., 1970); this is due partly to enhanced attentiveness resulting from greater task involvement and partly to the addition of a readiness potential (Bereitschaftspotential). Peters et al. (1977) reported that as a paired-associates learning task became easier, the CNV decreased. The researchers interpreted this finding as the result of decreased interest and alertness. Nakamura et al. (1979) observed that when careful S2 discrimination required greater attentiveness. The CNV was enhanced. Fenelon (1984) used attention to explain the increased CNV with greater equivocation between the match of S1 and S2.

If the CNV is a correlate of attention, as indicated in the literature cited above, it might be a useful tool to measure some theoretical assumptions about cognitive processes as claimed by the guided-interaction paradigm. The CNV has been used to test normal adults on a S1 and S2 standard-reaction-time paradigm (Donchin et al., 1972; Imashioya et al., 1987; Lai, 1997; Tecce et al., 1978d; Washer et al., 1996). It has also been used to compare normal adult performance of neurotics and psychotics (Timsit-Berthier et al., 1973) and traumatic brain-injured individuals (Nativ, 1991; Rugg et al., 1987). However, the number of studies conducted with normal and/or impaired children is relatively small. McPherson (1998) conducted a study to investigate phonological processing in reading-disabled adolescents, and Kemner (1994) carried out an investigation to compare visual and somatosensory event-related brain potentials in autistic, ADD, dyslectic, and normal children. To the investigator's knowledge, no CNV study, has been conducted with autistic children using the kinds of stimuli used in the present study with the possible exception of the Push Button Task. Consequently, this researcher attempted to discover (a) whether the CNV paradigm was feasible with an impaired population -- in particular, autistic children; (b) whether brain functioning indicative of attention was detectable in the guided condition; (c) whether there were differences in brain functioning between the guided and unguided conditions; and

(d) whether there were observable differences in brain functioning when the event stimuli varied in the amount of resistance.

Addressing the Methodological Aspect of the CNV

Experimental Task 1 (Push Button) was carried out to investigate whether the CNV was a possible measurement for the autistically impaired population. As the CNV had not been commonly used with children, the suitability of this paradigm for autistic subjects had to be established first. In particular, one researcher found that learning disabled children failed to establish a CNV, as described earlier.

With the technology and equipment available in the Neurophysiology Laboratory at MSU, CNVs were observed in unimpaired individuals. Consequently, the investigator assumed that it was possible to observe a CNV with the available technology. For the stated reasons, the first research question concerned the methodological issue of whether a CNV could be elicited in autistic subjects.

Altogether, five CNVs were observed in two of the autistic subjects in the present study. On four of six tasks, including the prototypic Push Button Task, a CNV was established. A CNV was also observed in the normal pilot subject.

With regard to Task 1 (Bush Button), Subjects 1, 2, and 3 were tested on two trials. One CNV was observed in Subject 1 (see Figure 1), Subject 2 established a large NPS (see Figure 2), and Subject 3 exhibited a large NPS that was similar in shape to a CNV (see Figure 3). Although a CNV was observed on the Push Button Task (Subject 1, Trial 1), it needs to be emphasized that a CNV was not observed every time an autistic subject was tested. Nevertheless, all of the subjects were able to sustain attention for a certain period of time, and the group's mean for average amplitude was above the criterion (as defined by the investigator as a minimum requirement for a CNV) on every task. This outcome suggests that the autistic subjects were able to exhibit brain activity of the required magnitude on every task. However, it was harder to sustain the negativity over the necessary period of time on each task.

The fact that one subject was able to establish a CNV on the Push Button Task demonstrates that on this task this particular subject was able to attend in a way expected of an unimpaired learner, and he was able to do so on a task that had also elicited CNVs in normal subjects.

Although Subject 2 did not establish a CNV on the Push Button Task, he established CNVs on other tasks and conditions. The Push Button Task might not have captured his attention as much as other tasks. Subject 3 developed a large NPS very similar in shape to a CNV. As the configuration of her largest negative potential shift on two tasks was similar to the CNVs observed in Subjects 2 and 3, one might speculate that some autistic subjects failed to establish a CNV at the criteria set for this study because of an inability to sustain their attention long enough to allow the classic CNV pattern to form. Indirect support for this speculation comes from an investigation on phonological processing in reading-disabled adolescents and normals by McPherson et al. (1998). The researchers found a reduced CNV in the reading-disabled group. In addition, they found ERP evidence suggesting that the reading-disabled population had two distinct abnormal brain processes (phonological processing and speed of processing).

Subject 3 also failed to establish a CNV on the Push Button Task and she also failed to produce a CNV on any other task. Because this subject produced a large NPS with the same kind of configuration on another task, one might assume that her pattern of brain activity was slightly deviant as compared to that of Subjects 1 and 2. However, whether differences in attention are observable outside the laboratory is a different question altogether. The differences between a large NPS and a CNV are expressed in ms, an amount of time that is hardly noticeable behaviorally. Hence, the question of whether the difference in the ability to pay attention between Subjects 1 and 3 extends beyond the laboratory setting needs to be investigated in future research.

The dependent variable of overall negativities of the entire sampling time was not mentioned in the literature as a measure to evaluate brain activity in CNV studies because it does not give additional information about the actual CNV. However, it does provide a measure of how much time and amplitude the subject invested in actual cognitive processing during the entire task. Subtracting the CNV parameters from the entire sampling time would also show how much cognitive functioning was taking place outside the actual area of the CNV. The Wilcoxon matched pairs signed-ranks test revealed a significant difference between the area of the CNV and the overall area of negativities. This demonstrated that the subjects engaged in more cognitive activity outside the area of the CNV than inside the CNV area. Consequently, one might assume that cognitive processing extended over the entire sampling time regardless of whether a CNV was elicited.

When looking at the tasks altogether, five CNVs were established by two of the three autistic subjects. So it does appear that, in response to the first research question, CNVs can be elicited in children with autism. However, the interpretation of the findings as evidence of attention needs to be tempered. On the basis of the investigator's behavioral observations, Subject 3 appeared to be very attentive on all tasks throughout both trials. However, she failed to establish a CNV that met the defined criteria on any of the tasks.

Another mitigating factor is the severity of the symptoms displayed by the subjects. Although the autistic subjects clearly were moderately severe to severely impaired, they did not appear to have the kinds of perceptual dysfunctions that are exhibited by children who are often referred to Affolter and colleagues' clinic as autistic by other professionals. Affolter and coworkers have characterized the classic autistic child as one who cannot integrate the different modalities. A child meeting Affolter and coworkers' definition would not be able to perform the Push Button Task, for instance, because of inability to relate the nonverbal tactual instructions to the visual input. In other words, the child or subject would not have known what to do. It stands to reason that a child with that degree of impairment would have been untestable on any of the tasks attempted by this investigator. It is, however, important to consider the severity of an impairment when considering the feasibility of an ERP study with children diagnosed as autistic.

Thus, one should not get the impression from the present study that this population is easy to test. The investigator had worked with the subjects on a regular basis for almost a year before attempting any testing. This approach was time consuming and required the cooperation of many parties, but it was essential for successful testing of unmedicated autistic subjects. To make the subjects as comfortable as possible, their aide accompanied them to the laboratory. The aide sat in the same room with the subject and also watched the subject closely when the investigator had to leave the child for a moment to attend to the computer. During school hours, the investigator picked up the autistic subjects and their aides from school to take them to the Neuro-Audiologic laboratory and drove them back to school. The support of the school administrators, the AI classroom teacher, the aides, and the speech-language pathologist for the AI children in the district was absolutely essential for this procedure. All these parties gave their support to this study.

The positive finding that a CNV can be elicited in autistic subjects is encouraging. It has future potential for investigating attention while certain tasks are performed online. The

CNV paradigm might be used not only in the study of autistic behaviors but also in the study of other clinical populations such as children with specific-language impairment (SLI). With regard to the present investigation, inclusion of more autistic children is needed for purposes of ensuring reliability of the data.

Addressing the Clinical Conceptual Questions

Three research questions were posed to investigate clinical conceptual issues. One question concerned whether it was possible to elicit a CNV in the guided condition. Guiding as a means of intervention is a hotly disputed issue in the field. Opponents of Affolter and colleagues' theoretical framework claim that the brain does not process input given to the child during guiding. The reasoning is that guiding is a passive act for the individual who is being manually led to perform a functional task. The person guiding might be actively involved in performing the task, but not the person that is being guided.

Affolter and colleagues, on the other hand, argued that the child can be actively involved in performing the task while being guided. When a child is active and attentive, prerequisites for learning are fulfilled. The present study was designed to shed some light on this controversy. The findings are interpreted in view of what was learned about guiding and the role of resistance as follows:

Eliciting a CNV in the Guided Condition

Subjects 1, 2, and 3 were guided on two experimental tasks. The difference between the tasks was the novelty effect, which will be elaborated on later. Only Subject 2 established CNVs in both guided experimental tasks on his second trial. Subject 3, Trial 1, achieved a very large NPS, and Subject 1, Trial 2, produced a very large NPS as well. Hence, a CNV can be elicited in the guided condition, although it was observed in the same subject in both the novel and the familiar tasks. It should be noted that Subject 2 was the most severe of the three autistic subjects, and he was very attentive throughout his second trial, more so than throughout his first trial. The largest NPS, for Subject 1, Trial 2, fell short of the requirement for minimum duration of the CNV by only 32.9 ms, but the criterion for average amplitude was met. It needs to be pointed out that Subject 1's overt behavior suggested that he was very attentive throughout his first trial but much less so during the second one. Nevertheless, he still established a large NPS on the task in question. Most of Subject 1's data on the first trial were not stored, and all attempts to retrieve the saved data failed. Subject 3 failed to establish a CNV in the guided condition and did not meet the preset criteria of this study. However, the configuration of her NPS was similar to the CNVs established by Subjects 1 and 2.

It appears reasonable to assume that CNVs can be elicited in the guided condition in more than one subject. One reason why Subject 2 established a CNV on every guided task might be that he benefited the most from the guided input, even when the task was familiar, as he was the most severe of the three subjects. Although Subjects 1 and 3 established large NPS on the novel task, they might not have shown a CNV because they realized what the investigator wanted them to do more quickly than did Subject 2. One must keep in mind that guiding is only a means to enable the severely impaired child to learn how to perform a certain task independently. Consequently, the frequency of guiding that children need will vary, depending on the degree of their impairment, and so might the emergence of the CNV.

Both CNV and largest NPS, which failed to meet CNV criteria, are assumed to result from cortical activity and indicate attention, as described earlier. Thus, it is reasonable to assume that all of the subjects were attentive while being guided. If they were attentive, then they had to be actively involved in the task, even though they were not performing the task independently.

The Wilcoxon matched pairs signed-ranks test revealed a significant difference between the area of the CNV/largest NPS and the overall area of negativities, suggesting that the area of overall negativities was significantly different from the area of the CNV/largest NPS. Consequently, considerably more brain activity was observed outside the area of the CNV/largest NPS than inside it. Taking this fact into account, it seems reasonable to use the measure of overall area of negativities as another indicator of cognitive activity during the entire sampling time.

Novelty Effect as a Factor in the Guided Condition

To test for significant differences between the two guided conditions, the Wilcoxon matched pairs signed-rank test was used. Comparison of the duration of the CNV/largest NPS in the two tasks (novel versus familiar) showed a significant difference. The subjects' responses to guiding were tempered by the novelty of the task. The duration of the CNV/largest NPS was significantly longer during the novel task than the familiar task for all subjects in all trials. The average amplitudes were not significantly different in the two tasks.

A significant difference also was found when the area of the CNV/largest NPS was compared in the two tasks. The area of the CNV/largest NPS in the novel task was significantly larger than the area in the familiar task. The overall area of negativities, on the other hand, did not reveal a significant difference between the two tasks.

Hence, larger CNVs/NPSs were found in the novel task as compared to the familiar task. This trend held for all three autistic subjects. Bloom (1996) pointed out that the level of effort is closely connected to the arousal level and determines the interest or level of engagement that the child brings to the task. In her research, Bloom found evidence that effort and attention were increased in novel situations in contrast to familiar ones. This finding provides support for the finding in the present study. All subjects exhibited larger NPS with regard to the dependent variables of duration and area in the novel task than in the familiar task, regardless of whether CNV criteria were met.

One needs to consider, though, that autistic subjects as a group might exhibit a different behavior toward novel stimuli than do normal controls or children with other kinds of impairments. The findings of the Kemner et al. (1994) study are relevant here. These researchers investigated whether autistic children differed from normal children, those with attention-deficit disorder, and dyslectic children. The researchers used tasks involving processing of visual and/or somatosensory stimuli. The autistic group showed larger N1 and P3 (indicators of cognitive functioning and attention used in ERP studies) to novel stimuli in the visual and somtosensory modality. Although Kemner et al. used different measures, the results were clearly consistent with the outcomes of the present investigation. The clinical observation that autistic children react more strongly than normal children to changes in their environment might also have contributed to the findings regarding the novel task in the present study.

In sum, then, the present investigator found that at least one autistic subject established a CNV on two different guided tasks, and two other subjects came close to the parameters defined for a CNV. Hence, it is possible to get a child's attention under guidance. The effect, however, might not always reach the dimensions needed to be defined as a CNV. Given that it is possible to establish a CNV under guided task conditions (Squeezing a Soft Ball and Picking Up a Light Glass), and when the subject performs a task independently (e.g., Push Button Task), the next question is whether there are differences in brain activity between the two conditions.

CNV Differences between Guided and Unguided Conditions

To investigate this question, it was necessary to compare responses under identical or similar task conditions. In this study, squeezing a ball was compared in the guided and unguided conditions. Picking up a light glass was compared to picking up a heavy glass in both the guided and unguided conditions. Two CNVs were observed in the guided condition and two in the unguided condition. Subject 1 established CNVs only in the unguided conditions. Subject 2 established CNVs in the guided and unguided conditions. Subject 3 established three very large NPS (Trials 1 and 2) in the unguided condition. Her largest NPS fell short of the minimum requirement for duration by 26.6 ms. The criterion for average amplitude was exceeded by 0.365 volts.

The Wilcoxon matched pairs signed-ranks test was used to compare the results in the guided and unguided conditions. No significant differences were found when the areas of the CNV/largest NPS and the average amplitude of the CNV/largest NPS were compared for squeezing a soft ball in the two conditions. One has to keep in mind that Task 4 (Squeezing a Soft Ball) was familiar to the subjects by the time they completed it in the guided condition.

However, a significant difference was found when the area of the CNV/largest NPS in the guided condition was compared to the area of the CNV/largest NPS in the unguided condition. The latter was significantly larger in the unguided condition than in the guided condition. When the overall area of negativities in the guided condition was compared to the overall area of negativities in the unguided condition, a significant difference was also found. The overall area of negativities was significantly larger in the unguided condition than in the guided condition. This outcome is consistent with the findings of Carr et al. (1996), as described earlier. The researchers found that more brain areas were active when the subject lifted a finger independently than when he or she was guided to perform the same task. One might speculate that the independent planning and execution of a motor task, for instance, is more complex and requires the allocation of more cognitive resources than a task condition designed to facilitate performance by guiding. In contrast, no significant differences were found between guided and unguided conditions with regard to duration and average amplitude in Task 2 (Squeezing a Soft Ball -- Unguided) and Task 4 (Squeezing a Soft Ball -- Guided).

For Tasks 5 (Picking Up a Light Glass -- Guided) and Task 6 (Picking Up a Heavy Glass -- Unguided), the Wilcoxon matched pairs signed-ranks test was used to test for significant differences between the guided and unguided conditions. On the four dependent variables -- duration of the CNV/largest NPS, average amplitude of the CNV/largest NPS, area of the CNV/largest NPS, and overall area of negativities -- no significant differences were found between the guided and unguided conditions.

When the area of the CNV/largest NPS was compared to the overall area of negativities in the guided condition as well as in the unguided condition, significant differences were found. This suggests that there was more brain activity outside the CNV/largest NPS than inside it.

It is interesting that the area of the CNV/largest NPS and the overall area of negativities were significantly larger in the unguided condition when the task was familiar, whereas this difference disappeared when the task became novel.

The finding for Subject 1, who established CNVs only in the unguided condition, is in agreement with the finding of Carr et al. (1996). The researchers compared an active performance condition in which the subject moved his hand independently with a "passive" sensory baseline condition in which the same movement was produced by the experimenter manipulating the subject's hand. Activity in the somatosensory cortex, proximate parietal association areas, and the motor cortex was measured using fMRI. The active performance condition produced more activated pixels than did the passive condition.

In contrast, Subject 2's data were not consistent with the Carr et al. (1996) findings. This subject established CNVs in both conditions. However, as Thelen (1995) stated, the perceptual system extracts only the information it needs. Subject 2 might have needed to focus almost as much in the guided condition as in the unguided condition, whereas Subject 1 might have found the task requirement in the guided condition less taxing.

Subject 3, on the other hand, did not establish a CNV in either condition. Like Subject 1, she produced larger NPS in the unguided condition than in the guided condition with the exception of the novel task, Task 5 (Picking Up a Light Glass), where she had a much larger NPS in the guided condition than in the unguided condition during her first trial. In her second trial, she showed the opposite pattern. One might assume that she learned in the first trial and was able to use her knowledge fully in her second trial in the unguided condition.

With regard to Affolter and colleagues' (1980) claim that the input to the brain is the same in both conditions, the following was observed in the present investigation: The measurement outcomes did not differ statistically when the subject was faced with a novel situation. When faced with a familiar situation, the subject appeared to exert more mental energy in the unguided condition, at least in terms of the area of the CNV and overall area of negativities.

The developmental stage of the child also appears to be a decisive factor. The most severely impaired subject (Subject 2) was the only one who established a CNV in the guided condition on two different tasks. Guiding appeared to be most beneficial to him. It needs to be emphasized, though, that Subject 1 established large NPS approaching the criteria defined for a CNV in the guided condition. As mentioned earlier, Subject 1 might have been able to make some hypotheses about the goal of the tasks more rapidly than did Subject 2. Subject 1 might benefit more from guiding when a task becomes more cognitively challenging.

Subject 1 showed more negativity in the unguided condition. Subject 2 showed increased activity in the unguided condition on his first trial and increased negativity in the guided condition on his second trial. He appeared to be more variable. Subject 3 showed the same variable pattern, although she had difficulty sustaining the duration and average amplitude of her NPS long enough to establish a CNV.

The assumption that the input given to the brain is the same in the two conditions was not sustained by the present data. The information appears to get to the brain. But how much a child benefits from guiding appears to depend on the child's developmental stage and the difficulty of the task. When performance of a certain task is beyond a certain child's zone of ability, guiding may become necessary to help the child move ahead. If a certain task is well within a child's zone of competence, the unguided condition will elicit greater negativities as the child is in charge of planning and executing the task.

However, the question of interest to the clinician is whether the children can learn under the guided condition; the answer to that query has to be in the affirmative. To compare performances in the guided and unguided conditions in more detail, a more refined method of analysis might be necessary. A method that allows EEG segments to be analyzed in the alpha bands that have been shown to reflect attentional processes while using more than one channel might be a possible way to proceed, provided that undesired artifacts can be controlled.

Change of Resistance

The fourth research question dealt with the role of resistance in human perception. Affolter and colleagues (1980, 1993, 1996b) proposed that tactual input is coded in varying degrees of resistance. If this assumption is correct, one should be able to observe differences in brain activity when the amount of resistance varies. Differences in the CNV elicited from autistic subjects were investigated when the event stimuli varied in the amount of resistance. The Wilcoxon matched pairs signed-ranks test was used to determine whether any differences occurred between the condition offering weak resistance and the condition offering strong resistance. No significant differences were observed on any of the four dependent variables -- duration of the CNV/largest NPS, average amplitude of the CNV/largest NPS, area of the CNV/largest NPS, and overall area of negativities -- during the entire sampling time. However, for both conditions, significantly more negativity for the entire area was recorded, suggesting (as mentioned before) that there was more activity outside the CNV/largest NPS area than inside it. The statistical outcomes were surprising to the investigator, but a failure to observe a difference does not mean that the subjects were not able to perceive a difference.

A look at the individual data for each autistic subject revealed an interesting pattern. When they squeezed the hard ball, the two autistic boys showed increased duration of the CNV/largest NPS on all measures. The only dependent variable that was lower when the hard ball was squeezed was the average amplitude of the CNV/largest NPS. When the soft ball was squeezed, Subjects 1 and 2 showed the opposite pattern. With the exception of average amplitude of the CNV/largest NPS, all values were lower for the latter condition, which represented weaker resistance. The autistic girl, on the other hand, showed mixed results on her two trials, so no clear pattern was established.

According to the guided-interaction paradigm, changes in brain activity were to be expected when a child squeezed a soft ball versus a hard ball. The assumption is that perceptual impairment exists because the brain cannot easily identify the input in terms of changes in resistance. Hence, one would expect the impaired child to exert more of an effort when squeezing a soft ball as compared to a hard ball. Visual inspection of the waveforms revealed differences in the two conditions (Figures 5 and 6). However, no statistically significant differences were found. The only significant differences found were when the overall area of activities was compared to the area of the CNV/largest NPS in the two conditions.

The fact that no significant differences in the two conditions were found for the four dependent variables for the autistic subjects was surprising. It was assumed that the nervous system would have to search harder for information when weak resistance was encountered. However, a Wilcoxon matched pairs signed-ranks test comparing the condition offering weak resistance with the condition offering strong resistance revealed significant differences for the normal pilot subject ($\underline{T} = 0$). The $\underline{T}$-value had to be less than or equal to 1 to be statistically significant. The normal pilot exerted significantly more mental energy when squeezing the soft ball as compared to the hard ball.

The results for the autistic subjects can be partially explained by the fact that they wanted to achieve the same effect when they squeezed the hard ball as they had experienced when they squeezed the soft ball. They were keenly aware of the change of resistance offered by the hard ball. The investigator noticed that all three subjects (Subjects 1 an 2 on both trials, Subject 3 on Trial 1) spontaneously enlisted the other hand when they felt the hard ball to help them search for more information, whereas the normal pilot was aware of the differences in touch when he felt a hard surface versus a soft surface. As a result, more effort exerted with two hands instead of the one hand used to squeeze the hard ball resulted in greater negative readings on three of the four dependent variables. The normal pilot subject, however, kept to the instructions and used just one hand.

Probing Differences Between Autistic and Normal Subjects

This study included only subjects with a diagnosis of autism. Hence, an important question, whether the kinds of data observed in this study would differ from what would be observable in normal children, still needs to be addressed. In the present study, this issue could not be explored as a research question. However, some preliminary normal pilot observations were made that might provide directions for future research.

A typically developing 10-year-old pilot subject was tested. The investigator evaluated him on the test Clinical Evaluation of Language Fundamentals (CELF 3). Performance in the normal range was observed. The researcher also read his progress reports from school, which showed grade-level academic achievement.

There were two differences between the testing procedures used for the normal pilot and the autistic subjects. The number of trials (the number of times one action of a particular task was repeated and averaged with the EEG apparatus) was 16 for the pilot subject instead of 6 as it was for the autistic subjects. The response box for experimental Task 1 (Push Button Task) was still being constructed when the pilot subject was tested. Consequently, that task was not performed. Results for the normal pilot subject are presented in Table 5 for Task 2 (Squeezing a Soft Ball – Unguided), Task 3 (Squeezing a Hard Ball – Unguided), Task 4 (Squeezing a Soft Ball – Guided), Task 5 (Picking Up a Light Glass – Guided), and Task 6 (Picking Up a Heavy Glass – Unguided). The normal pilot investigation was aimed at answering several questions that paralleled the main research questions concerning the autistic subjects. These questions are identified in each of the following discussion sections.

<u>Research Question 1 – Is it possible to elicite a CNV in the Normal Pilot Subject under the task conditions of the autistic subjects of this study?</u>

This question was aimed at the impaired population. Normal children have been known to establish a CNV, as described earlier. The normal pilot subject was not tested on the Push Button Task, which was designed to test whether the autistic subjects were able to establish a CNV for reasons already stated. However, it seems reasonable to emphasize that the normal pilot subject established a CNV. His CNV had a duration of 601.676 ms and an average amplitude of -0.8605 volts. The normal pilot subject's CNV exceeded the 400 ms criterion for duration by 201.676 ms and the -0.500 volts criterion for average amplitude by -0.3605 volts. He established the CNV on Task 2 (Squeezing a Soft Ball – Unguided), see Table 6. It is also interesting that a subject was able to establish a CNV on this task.

<u>Research Question 2 – Is it possible to eliciting a CNV in the guided condition: Performance of normal pilot subject in the guided condition as compared to the autistic group.</u>

The normal pilot subject did not establish a CNV in the guided condition. He met the criterion for average amplitude on both guided tasks. However, he only reached only 67.9% of the 400 ms criterion for duration on experimental Task 4 (Squeezing a Soft Ball –

Table 6. Pilot Data for Normal Subject.

Event	Task	Largest NPS for Each Subject in Each Trial With an Indication Which NPS Meets CNV-Defined Criteria				
		Condition (CNV >400 ms)	Duration (ms) CNV >0.500 volts	Avg. Amplitude (volts) (volts*ms)	Area (volts*ms)	Overall Area
Squeezing a Soft Ball	2	Unguided	**601.676**[a]	**-0.8605**[b]	518.085	687.063
Squeezing a Hard Ball	3	Unguided	349.535	**-0.5768**	201.836	469.787
Squeezing a Soft Ball	4	Guided	271.751	**-0.5364**	145.946	501.240
Picking Up a Light Glass	5	Guided	227.066	**-0.5145**	116.998	459.857
Picking Up a Heavy Glass	6	Unguided	235.010	**-0.6775**	159.433	495.251

* Contingent Negative Variation (CNV).
[a] Shows that CNV criterion for duration was met.
[b] Shows that CNV criterion for average amplitude was met.

Guided), and only 56.8% of the 400 ms criterion on experimental Task 5 (Picking Up a Light Glass – Guided).

One of the autistic subjects (Subject 2, Trial 2) established a CNV on both guided tasks. In addition, on experimental Task 5 (Picking Up a Light Glass – Guided), the values for the autistic subjects were higher. Subject 3, Trial 1, met 80.7% of the 400 ms criterion for duration, and Subject 1, Trial 2, met 91.8% of the criterion for duration. The normal pilot subject met only 56.8% of the criterion. The difference between the two guided tasks was the novelty effect. The autistic subjects appeared to achieve higher values on the novel task than on the familiar task. The values for the familiar task (Squeezing a Soft Ball – Guided) were comparable for the autistic subjects and the normal pilot subject.

The higher values for the novel task might be interpreted as an indication of increased cognitive processing in the impaired group under the guided condition as compared to the normal pilot subject. This might mean that the autistic group as a whole benefited more from guiding (getting more information in that condition) than did the normal pilot subject.

The fact that the impaired subject showed more brain activity in the guided condition than did the normal pilot subject is in agreement with Affolter and colleagues' ( ) claim that guiding helps perceptually impaired children perceive the information they need. However, their claim that the input to the brain is the same in the guided and unguided conditions appears not to be supported by the present data. The more severe the child's perceptual impairment, the more the child will profit from guiding. The less severe the impairment, the less beneficial guiding becomes. Guiding clearly appears to be a tool to help children perceive the input. However, once they can extract the information from the environment on their own, they will show greater negativities in the unguided condition, reflecting the complexity involved in mental processing and motor execution of a simple task.

Research Question 3: Differences between the Guided and Unguided Condition in the Normal Pilot Subject

Data for Task 2 (Squeezing a Soft Ball – Unguided) and Task 6 (Picking Up a Heavy Glass – Unguided) were compared, as shown in Table 6. The normal pilot subject established one CNV on experimental Task 2 (Squeezing a Soft Ball – Unguided). On experimental Task 6 (Picking Up a Heavy Glass – Unguided), he met the criterion for average amplitude, but he met only 58.8% of the 400 ms criterion for duration.

Two of the autistic subjects (Subject 2, Trial 1, and Subject 1, Trial 2) established CNVs on experimental Task 6 (Picking Up a Heavy Glass) in the unguided condition; see Table 4. The individual data for the autistic subjects show that in more than one instance the unguided condition yielded higher values for duration and average amplitude of the NPS. However, there were also instances in which the reverse was the case. More autistic and typically developing subjects are needed to reveal whether there is a trend or whether the same range of variability will be exhibited in a larger sample.

Research Question 4: Change of Resistance

The normal pilot subject appeared to be sensitive to varying degrees of resistance. Data for Task 2 (Squeezing a Soft Ball – Unguided) and Task 3 (Squeezing a Hard Ball - Unguided) were compared, as shown in Table 6. The normal pilot subject established a CNV on Task 2 (Squeezing a Soft Ball -- Unguided) in the condition where weak resistance was encountered. On Task 3 (Squeezing a Hard Ball -- Unguided), the normal pilot subject met the criterion for average amplitude, but he met only 87.3% of the 400 ms criterion for duration.

The autistic subjects did not establish a CNV on either task. However, the values for Task 3 (Squeezing a Hard Ball -- Unguided) appeared to be slightly higher for the autistic subjects as compared to the normal pilot subject. The criterion for average amplitude was met by all autistic subjects on Task 3. Subject 2, Trial 2, exceeded the criterion for duration by 217.44 ms. Subject 1, Trial 2, met 94.7% of the 400 ms criterion for duration, and subject 3, Trial 2, met 79% of the 400 ms criterion for duration.

The normal pilot subject appeared to exert less mental energy than the autistic subjects. This finding is not surprising because the autistic subjects used two hands on almost every trial to achieve the same effect as they had experienced on the previous task. As a result, more brain activity was observable. This finding may imply that the tactile-kinesthetic system was insufficiently developed in the autistic group.

Implications for Future Research

In this study, altogether six CNVs were elicited in the autistic subjects and the normal pilot subject. Judging from this value alone, it is reasonable to assume that the CNV-paradigm is a possible tool to investigate cognitive processes as indicative of attention in normal and impaired subjects. The fact that autistically impaired children were able to establish a CNV, meeting the criteria set in this study, is promising. It shows that some of the autistically impaired subjects were capable of exhibiting attention patterns similar to his or her unimpaired peer. It also shows that the CNV paradigm might be a usable tool for the impaired population in general. As described earlier, there are studies showing that impaired children are not able to establish a CNV. Of course, more impaired and unimpaired subjects need to be tested on a CNV paradigm to confirm or disconfirm the present findings.

As the findings for the normal pilot subject were derived from only one normal control subject in one trial, more normal control subjects need to be tested under the same conditions and with the same number of trials as the autistically impaired group. The inclusion of a normal control group is essential to investigate whether the findings of the normal pilot subject would be corroborated by the findings of a normal control group.

The number of the autistic subjects was small. As the data of the autistic group demonstrated, autistic subjects did not show the same patterns of performance throughout the trials. If more autistic subjects were added to this investigation, one might be able to observe if there are certain tendencies in the autistic population depending on the level of impairment and the developmental stage of the subjects.

Although CNVs were elicited with the laboratory equipment available to the present investigation, some changes in the equipment would be beneficial with regard to future outcomes. For instance, if one could vary the interstimulus interval, tasks could be designed that would add a little bit more complexity and give the subjects more time to process the stimuli.

The dependent variable of overall negativities recorded during the entire sampling time to evaluate brain activity might be a useful measure for between and in-group comparisons, in particular, at some point in the future when more subjects can be added to the investigation and reliable comparisons with normal control subjects can be drawn.

Conclusions

The present study addressed the methodological question whether a CNV could be elicited in autistic subjects. It also addressed three clinical conceptual questions based on the feasibility of the first methodological issue.

Research Question 1: Is it possible to elicit CNVs in autistic children?

As a CNV was established in one autistic subject on the Push Button Task, which was designed to address this question, it was concluded that autistic subjects can establish a CNV. Since an autistic subject was able to establish a CNV in the present study, one might assume that the paradigm can be used to test other populations such as language-impaired children. In this study, the CNV proved to be an adequate tool to investigate cognitive processing in terms of attention in the autistic population. Thus, the CNV paradigm might render itself to investigate research questions addressing cognitive processing.

Research Question 2: Is it possible to elicit a CNV when the autistic subject is manually guided to do an event?

The study found that a CNV indicative of attention was established under the guided condition by Subject 2, while Subjects 1 and 3 established large NPS approaching the dimensions as defined for a CNV. This finding will contradict the assumption that the information in the guided condition does not reach the brain.

As described earlier, the normal pilot subject achieved lower values on the tasks in the guided condition than did the autistic subjects. The autistic subjects responded to the novelty effect by exhibiting higher values on the novel task in the guided condition. This effect was not found in the normal pilot subject. The normal pilot subject achieved higher values when performing the familiar task, presumably because it was the first task in the guided condition. The novelty effect in the second guided task might have been too weak.

Research Question 3: Is there a difference between the CNV elicited when the autistic subject is manually guided and unguided to do an event?

Possible CNV differences between the guided and unguided conditions were investigated. An equal number of CNVs was observed in both conditions. Affolter and colleagues' claim that the information gets to the brain in both conditions was partly supported by the fact that no significant differences were found between the guided and unguided conditions in the autistic subjects.

However, there appears to be one difference. For the guided input to be beneficial, some aspects of the task may have to be challenging for the guided individual. Once the nervous system has learned the task, more energy may be invested in independent planning, executing and monitoring of the task. This assumption appears to be supported by the fact that the most severe of the autistic subjects in the present study established CNVs under both guided conditions, whereas the somewhat higher functioning subjects were either more inclined to establish a CNV in the unguided condition or established a large NPS that was similar to a CNV in configuration but lacked the defined dimensions.

The fact that the most severe autistic subject established a CNV when he was guided to perform the tasks yields some support for the claim made by Affolter and colleagues that the tactile-kinesthetic input is an important additional modality for gaining the child's attention for learning. One might assume that this subject's nervous system responded to the guided input best because his tactual-kinesthetic system was not yet sufficiently developed, and he, therefore, needed the input. Consequently, the T-K input was most beneficial at this point in his cognitive development.

It appears that the effect of guiding on attention will depend on the severity of the impairment of a subject and on the complexity of the task. It is reasonable to assume that even a mature unimpaired nervous system might respond well to partial guiding, provided the individual is not able to perform a certain aspect of the task independently, for instance, drawing some facial features.

Research Question 4: Is there a difference between the CNV elicited from autistic subjects when the event stimuli vary in the amount of resistance?

Nervous system changes in response to stimuli varying in the amount of resistance were examined to test the assumption made by Affolter and colleagues that the brain codes degrees of resistance. However, no significant differences in measures of brain activity were found when the two experimental conditions (Squeezing a Soft Ball – Unguided versus Squeezing a Hard Ball – Unguided) were compared on the four dependent variables.

Nevertheless, a comparison of the data of the normal pilot subject on Task 2 (Squeezing a Soft Ball -- Unguided) and Task 3 (Squeezing a Hard Ball -- Unguided) revealed higher values for the task offering weak resistance. The normal pilot subject exerted more energy when the soft ball was squeezed as compared to the hard ball.

The results of the autistic subjects can be partially explained by the fact that they wanted to achieve the same effect when they squeezed the hard ball as they had experienced when they squeezed the soft ball in the previous task. On five of the six trials, the autistic subjects enlisted the other hand when they felt the hard ball to help them squeeze harder to achieve the same effect as before. The confrontation with this new situation increased the subjects' attention. It also increased the autistic subjects' muscular effort which led to greater negativities when the hard ball was squeezed. One might conclude that the nervous system of the autistic subjects was still in the process of coding the various degrees of resistance, whereas the normal pilot subject's nervous system had already coded for the varying degrees of resistance.

Summary

The present study was motivated by the difficulties arising from treating children with severe impairments along the PDD/autistic spectrum since this population does not respond to conventional treatment paradigms with the success one would expect. According to the theory stated by Affolter and coworkers, one might assume that conventional treatment paradigms require children to use their visual and auditory input at a supramodal level. The prerequisite for this level is that the children have gained a multitude of experiences following nonverbal explorations.

The representation of events at the nonverbal level is also a prerequisite for meaningful language to occur. To be functioning at this relatively high level, a child must have experienced a fairly normal development in infancy and early childhood. In other words, the child must have been able to explore his environment by using his tactile-kinesthetic input as a primary source of information to pave the way for intermodal integration and serial organization of perceptual input.

On the contrary, children with severe impairments might have problems either with the extraction of adequate T-K information from their environment, or with the integration of perceptual input from various modalities (vision and audition might not get aligned adequately with other senses), or with organizing perceptual information serially (events might not get sequenced appropriately). Assuming the hypotheses made by Affolter and colleagues are correct, it stands to reason to intervene at exactly the level where the deficits occurred. For most severely impaired children, this would mean intervention at a nonverbal level to allow the child to solve functional problems, explore his environment, and represent events mapped onto his experiences.

If Affolter and colleagues' hypotheses are correct, one should be able to observe attention while severely impaired children are performing a problem-solving task at the nonverbal level. To measure brain activity electrophysiologically, the CNV paradigm was adopted for the present investigation. One methodological research question and three clinical conceptual research questions were addressed. The subjects performed 6 experimental tasks. The recorded data was pooled across two trials for two subjects and across one of the six tasks for a third subject. This amounted to a maximum of five to six data points to analyze each experimental variable. The Wilcoxon matched pairs signed-ranks test was used to test for significant differences. The results were as follows with regard to the individual research questions.

The first research question was designed to determine whether the CNV paradigm could be used to evaluate cognitive processing in autistically impaired children. The present study showed that autistically impaired children were able to establish a CNV or NPS that were below the designated criteria set for this study. Three subsequent research questions investigated clinical conceptual issues.

The second research question investigated whether a CNV could be observed in the guided condition. The present study demonstrated that a CNV was established in the guided condition. Hence, it was shown that the subjects received the perceptual input in this condition. The benefit of guiding appeared to depend on the subject's developmental stage and on the novelty and complexity of the task.

The fact that the most severe of the autistic subjects established 2 CNVs in the guided condition demonstrated that this subject benefited the most from the guided input. This provided indirect evidence for the assumption made by Affolter and coworkers that the T-K input provided evidence that tactual input from guiding adds critical information capable of getting the subject's attention and anchors the other senses.

The third research question investigated possible CNV differences between the guided and unguided conditions. When task performances were compared in the guided and unguided conditions, no significant differences were found for the novel task. However, two significant differences were found for the duration and area of the CNV in the familiar task suggesting that more mental energy was exerted in the unguided condition as compared to the guided condition.

The autistic subjects demonstrated significantly more cognitive activity in the novel task as compared to the familiar task suggesting that the novelty effect was very pronounced in the autistic subjects as a group.

The fourth research question investigated the role of resistance. When the event stimuli varied in the amount of resistance, the subsequent changes in brain activity were not significantly different in the two conditions (weak resistance as compared to strong resistance). Some subject biases were observed. In most trials, the autistic subjects enlisted the other hand to achieve the same effect as they had experienced in the prior task. The normal pilot subject, on the other hand, developed a CNV when he squeezed the soft ball but not when he squeezed the hard ball suggesting that he had to search harder for information in the condition offering weak resistance.

APPENDIX A

Copy of Diagnostic and Statistical Manual of Mental Disorders: DSM-IV (Fourth Edition). American Psychiatric Association, Washington, D.C.

■ Diagnostic criteria for 299.00 Autistic Disorder

A. A total of six (or more) items from (1), (2), and (3), with at least two from (1), and one each from (2) and (3):

(1) qualitative impairment in social interaction, as manifested by at least two of the following:

(a) marked impairment in the use of multiple nonverbal behaviors such as eye-to-eye gaze, facial expression, body postures, and gestures to regulate social interaction

(b) failure to develop peer relationships appropriate to developmental level

(c) a lack of spontaneous seeking to share enjoyment, interests, or achievements with other people (e.g., by a lack of showing, bringing, or pointing out objects of interest)

(d) lack of social or emotional reciprocity

(2) qualitative impairments in communication as manifested by at least one of the following:

(a) delay in, or total lack of, the development of spoken language (not accompanied by an attempt to compensate through alternative modes of communication such as gesture or mime)

(b) in individuals with adequate speech, marked impairment in the ability to initiate or sustain a conversation with others

(c) stereotyped and repetitive use of language or idiosyncratic language

(d) lack of varied, spontaneous make-believe play or social imitative play appropriate to developmental level

(continued)

□ Diagnostic criteria for 299.00 Autistic Disorder

(3) restricted repetitive and stereotyped patterns of behavior, interests, and activities, as manifested by at least one of the following:

(a) encompassing preoccupation with one or more stereotyped and restricted patterns of interest that is abnormal either in intensity or focus

(b) apparently inflexible adherence to specific, nonfunctional routines or rituals

(c) stereotyped and repetitive motor mannerisms (e.g., hand or finger flapping or twisting, or complex whole-body movements)

(d) persistent preoccupation with parts of objects

B. Delays or abnormal functioning in at least one of the following areas, with onset prior to age 3 years: (1) social interaction, (2) language as used in social communication, or (3) symbolic or imaginative play.

C. The disturbance is not better accounted for by Rett's Disorder or Childhood Disintegrative Disorder.

Diagnostic and Statistical Manual of Mental Disorders: DSM-IV (Fourth Edition). American Psychiatric Association, Washington, D.C.

APPENDIX B

Copy of
Human Subjects' (UCRIHS) Approval
and Consent Form

MICHIGAN STATE
UNIVERSITY

June 28, 1999

TO: Dr. Ida Stockman
326 Northlawn
East Lansing, MI 48823

RE: **IRB #98395** CATEGORY:2-C
RENEWAL APPROVAL DATE: June 28, 1999

TITLE: ELECTROENCEPHALOGRAPHIC (EEG) ANALYSIS DURING A GUIDED INTERACTION TASK VERSUS UNGUIDED CONDITION IN NORMAL AND AUTISTIC CHILDREN

The University Committee on Research Involving Human Subjects' (UCRIHS) review of this project is complete and I am pleased to advise that the rights and welfare of the human subjects appear to be adequately protected and methods to obtain informed consent are appropriate. Therefore, the **UCRIHS APPROVED THIS PROJECT'S RENEWAL.**
This letter approves the change in location for the testing & the addition of three adult subjects.

RENEWALS: UCRIHS approval is valid for one calendar year, beginning with the approval date shown above. Projects continuing beyond one year must be renewed with the green renewal form. A maximum of four such expedited renewal are possible. Investigators wishing to continue a project beyond that time need to submit it again for complete review.

REVISIONS: UCRIHS must review any changes in procedures involving human subjects, prior to initiation of the change. If this is done at the time of renewal, please use the green renewal form. To revise an approved protocol at any other time during the year, send your written request to the UCRIHS Chair, requesting revised approval and referencing the project's IRB# and title. Include in your request a description of the change and any revised instruments, consent forms or advertisements that are applicable.

PROBLEMS/CHANGES: Should either of the following arise during the course of the work, notify UCRIHS promptly: 1) problems (unexpected side effects, complaints, etc.) involving human subjects or 2) changes in the research environment or new information indicating greater risk to the human subjects than existed when the protocol was previously reviewed and approved.

If we can be of further assistance, please contact us at 517 355-2180 or via email: UCRIHS@pilot.msu.edu.

Sincerely,

David E. Wright, Ph. D.
UCRIHS Chair

OFFICE OF
RESEARCH AND GRADUATE STUDIES

University Committee on Research Involving Human Subjects (UCRIHS)

Michigan State University
246 Administration Building
East Lansing, Michigan
48824-1046

517/355-2180
FAX 517/353-2976

DEW: ab

cc: Christel Berretta

All UCRIHS forms are located on the web: http://www.msu.edu/unit/vprgs/UCRIHS/

Consent Form

You are being asked to participate in a research study that is based on Felicie Affolter's theory that input via the sense of touch is essential for exploring one's environment and hence at the root of learning. Vision and audition are secondary to the perception of touch and need to be integrated intermodally. Children with severe impairments along the pervasive developmental disorder (PDD)/autistic spectrum fail to explore their environment successfully on their own. Consequently, these children start at a task, but fail at its completion. Affolter believes that this group of children benefits from a therapy where the children are guided manually through functional problem-solving tasks with the structured help of a therapist. The more the children understand the goal of a certain task, the more they will take over and eventually will perform the task independently. The question is whether the brain registers the sensory input under the guided condition and whether the recorded brain activity can be identified as characteristic of attention. Positive findings in this research study might change the way we work with this group of children. We might come to a more functional, problem-solving approach that is very much "hands on".

The goal of this research is to explore the question whether there is comparable sensory input registered by the brain in guided and unguided conditions. Furthermore, it will be examined whether there is brain activity indicative of attention under the guided condition. The role of resistance to human perception will also be examined. The first set of two experiments involves squeezing a hard ball (offering a lot of resistance) and a soft ball (offering little resistance) to investigate the importance of resistance to human perception. To offer an environment, where the impaired child finds a lot of resistance, is a prerequisite for Affolter's treatment paradigm. While hard and soft balls are being squeezed, brain activity is being registered. A comparison between the two kinds of resistance will allow us to draw some conclusions about this basic assumption in Affolter's theory.

The second set of experiments deals with topological changes. The subject will "move apart" (move apart = one topological change) 10 pairs of wooden blocks. The subject will also "move together" (move together = one topological change) 10 pairs of blocks. These tasks will be carried out in guided and unguided conditions.

Your son will be tested three times. Language testing at the beginning of the study will take about 30 minutes and take place in your home. There will be one visit to the neurophysiology/audiology lab at MSU where the experiments will be carried out. Each visit will last for 30 minutes.

For the duration of these 30 minutes, three electrodes will be pasted on the subject's scalp. This is not painful and does not cause any discomfort. The subject's participation is voluntary. If the subject refuses to comply with the experimental procedures, he may discontinue his participation in the experiments without any penalty and at any time. The subject will still be entitled to the honorarium of 25.00 dollars although he discontinued experimental procedures.

All results will be treated with strict confidence and the subjects will remain anonymous in any report of research findings. On request and within these restrictions results may be made available to the subjects and their parents or legal guardians.

An honorarium of $ 25.00 will be given to each subject on each visit to the neurophysiological/audiological lab in the Communication Arts and Sciences building on campus of MSU.

At the beginning of the study, three undergraduate students will be tested to ensure that the computer and EEG apparatus are working flawlessly. These students will not receive a honorarium for their services.

If parents, legal guardians, or subjects have any questions or concerns, they are welcome to contact the investigator, Christel Beretta, (telephone number 349-4722) at any time.

You understand that your participation in this research project will not involve any additional costs to you or your health care insurer.

You give permission for your son ____________________ to participate in the above-stated research study.

Name of parent or guardian: ____________________________

Name of undergraduate student: __________________________

UCRIHS APPROVAL FOR
THIS project EXPIRES:

JUN 2 8 2000

SUBMIT RENEWAL APPLICATION
ONE MONTH PRIOR TO
ABOVE DATE TO CONTINUE

LIST OF REFERENCES

LIST OF REFERENCES

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