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ABSTRACT

Event-related Potentials (ERPs) were recorded to both auditory and visual stimuli from the scalps of nine autistic males and nine normal controls (all Ss between 12 and 22 years of age) to examine the differences in information processing strategies. Ss were tested on three different tasks: an auditory missing stimulus paradigm, a visual color discrimination, and an auditory tone discrimination task. The brain electrical activity was recorded and analyzed (both trial by trial and averaged waveform) for one thousand milliseconds following the target stimuli. Results indicated that the amplitude of the averaged P300 component was significantly reduced in the autistic group compared to the normal group. The N100 component was also smaller in amplitude, but it did not reach statistical significance. The latency of components was not significantly different among groups during the visual tasks; however, the latency of the P300 component was significantly longer in the autistic group during auditory tasks. The accuracy of performance with the operant button press and the appearance of the N100-P200 components in the autistic group suggested that the autistic individuals were attentive to the task. The sporadic occurrence of the P300 (when analyzed trial by trial) indicated that the autistic group was not consistently engaged in active stimulus evaluation at the higher information processing level. The delayed latency of the P300 component during auditory tasks in the autistic group hinted that there was more time required to complete stimulus evaluation in the auditory modality at the higher processing level than was required of the visual system at the same level. Results are consistent with the view that autistic learners show higher order processing deficits as displayed by their profound language defects and problems with complex thoughts. (Author/CL)

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ELECTROPHYSIOLOGICAL (EVENT-RELATED POTENTIALS) INDICES OF COGNITIVE PROCESSING IN AUTISTIC LEARNERS

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ABSTRACT. Event-related Potentials (ERPs) were recorded to both auditory and visual stimuli from the scalps of nine autistic males and nine normal controls to examine the differences in information processing strategies. Subjects were tested on three different tasks (in the following order): 1) an auditory missing stimulus paradigm; 2) a visual color discrimination; and 3) an auditory tone discrimination task. The brain electrical activity was recorded and anlyzed (both trial by trial and averaged waveform) for one thousand msecs following the target stimuli. Results indicate that the amplitude of the averaged P300 component was significantly reduced in the autistic group compared to the normal group. The N100 component was also smaller in amplitude, but it did not reach statistical significance. The latency of components was not significantly different among groups during the visual tasks; however, the latency of the P300 component was significantly longer in the autistic group during auditory tasks. The accuracy of performance with the operant button press and the appearance of the N100-P200 components in the autistic group suggest that the autistic individuals are attentive to the task. The sporadic occurrence of the P300 (when analyzed trial by trial) indicates that the autistic group is not consistently engaged in active stimulus evaluation at the higher information processing level. The delayed latency of the P300 component during auditory tasks in the autistic group hints that there is more time required to complete stimulus evaluation in the auditory modality at the higher processing level than is required of the visual system at the same level. These results are consistent with the view that autistic learners show higher order processing deficits as displayed by their profound language defects and problems with complex thoughts.

INTRODUCTION

Kanner first described the syndrome of Infantile Autism in 1943 as a profound behavioral disorder with, among other things, severe disturbances of cognitive functioning. Perceptual, cognitive, language deficits appear central to the autistic syndrome, but the specific underlying mechanisms are unknown (DeMyer, Hingtgen, Jackson, 1981). Psychodynamic factors were believed to be the cause during the 50's; but more recently, organic brain pathology has been accepted. The specific biological basis for autism is still not known, but the evidence from research indicates that an organic basis is possible. Many researchers have focused on dysfunctional sites within the brain, such as: reticular activating system (Rimland, 1964); vestibular system (Ornitz, 1970); brainstem (Ornitz & Ritvo, 1968; Fein, Skoff & Mirsky, 1981; Taylor, Rosenblatt & Linschoten, 1982; et al.); bilateral neural structures that include mesolimbic cortex of the mesial frontal and temporal lobes, neostriatum, and the anterior and medical nuclear groups of the thalamus (Damasio & Maurer, 1978); and various other neural areas. Neurochemical and genetic research has also been undertaken to determine the possible neuropathologies. From all of the research evidence thus far reported, it is impossible to determine a single hypothesis as to the dyfunctional system or site. Autism is probably a final common expression of multiple determinants having something to do with related anatomical and biochemical systems and its underlying mechanisms may be obscured by the diversity of causations (Denckla, 1983).

More specifically, disorders of central processing in autism have been examined through electrophysiological methods by examining the relationship between electrical activity in the brain and cognitive behavior. Early evoked potentials have been utilized to examine the integrity of the auditory system (Student & Sohmer, 1978; Skoff, Mirsky, Turner, 1980; et al.). Electrophysiological studies with autistic individuals have also examined the later endogenous components of the waveform. Rutter, Vaughn, and Simpson (1983) related these components to specific stages of information processing. One important component, "P300," can be seen in many tasks that require the individual to update memory and evaluate information in the stimulus. The P300 wave form has a positive polarity and occurs at approximately 300 milli seconds following the stimulus event. Squires and his group suggested that that process manifested by P300 was involved in stimulus evaluation rather than with response selection (1977). Donchin, McCarthy & Donchin (1977) replicated these findings. Since the waveform components have been associated with particular attentional processes and cognitive responses, these measures have been further used to analyze the deficiencies of cognitive functioning in autistic individuals. The reported studies involving P300 component analyses have all agreed upon the abnormally reduced nature of the component. The major difference lies in the interpretation of "causality." There are several hypotheses to explain the differences seen in autistic individual's response patterns. Novick, Kurtzberg, Vaughan (1979) proposed that childhood autism is associated with a deficiency in information storage. Novick, Vaughan, Kurtzberg (1980) viewed autistics to have auditory defects that are more consistently manifested in higher aspects of processing that involve the registration and storage of stimulus information. Niwa, Ohta and Yamazaki (1983) speculated that the autistics have some cognitive difficulties in the 'active stimulus process.' Tanguay & Edwards (1982) presented the notion that a possible distortion in auditory brainstem input present during a critical phase of early postnatal development can cause a later handicap, because cognitive and language skills depend highly on auditory input. It is difficult to say what is currently the reason for the reduced amplitude of the P300 component seen in autistic individuals. The present condition may have been affected by a prior pathology.

Therefore, the study reported here is not intended to differentiate between possible neurophysiological or neuropsychological defects that underly the cognitive dysfunction in autistic learners; instead the purpose is to examine the stages of information processing and report on the observable differences. Electrophysiological techniques have been used in this study to combine a new assessment with the pre-existing behavioral measures to more adequately describe the cognitive characteristics and learning processes of autistic persons.

METHODS

Subjects. Nine autistic males, ranging in age from twelve to twenty-two, were selected to participate in this study. Diagnosis of this group included use of the Diagnostic and Statistical Manual of Mental Disorders, III (DSM-III, 1980) as well as the definition of the National Society for Autistic Citizens (1979). A normal control group of nine males, age-matched within six months plus or minus, were also evaluated.

Procedure. The Event Related Potentials (ERP) were recorded from a parietal scalp sensor (Pz) according to the International 10-20 System (Jasper 1958) referenced to linked mastoids. Grounding was achieved through a central forehead electrode. Electrode impedance was checked and kept below ten Kohms, with actual readings usually below five Kohms. The subject was seated in front of a video monitor, thirty-six inches from the screen to eyes. A pair of stereo headphones were placed on the subject. Three tasks were presented to each subject in the following manner:

1) The first task was a tone deletion -- a pattern of rythmic tones with a twenty percent random omission of auditory tones. There were twenty-five

targets and one hundred non-targets with a two second inter-stimulus interval. Tones were presented at 1000 Hz for 50 msecs duration. Instructions given to the subjects were to sit as quietly as possible and listen for the tones. One minute later, the tone deletion block tasks were presented binaurally via the headphones.

2) A visual color block task was presented next. Color blocks, red being the target and blue the non-target, were 10.16 cm by 13.34 cm centered on a 21.59 cm by 28.58 cm screen. A response panel, containing two buttons, was placed on the subject's lap. Subjects were given the instruction to "press on red." A practice session was given with 90% accuracy criteria. Headphones were placed on the subject for this task also; however, they were only used for white noise. The color block task was divided into two sessions with a five minute break in between. The first block had sixty-four non-targets and sixteen targets with twenty percent randomization. The same procedure was used for the second block, except that the subject was instructed to respond with the oposite index finger.

3) High-low tones was the third task. This tone discrimination task consisted of high tones of 1200 Hz/50 msec duration and low tones of 1000 Hz/50 msec duration. A practice session, with 90% accuracy criterion, was used to make certain that the subjects could discriminate between two tones. This task consisted of one hundred non-targets (low tones) and twenty-five targets (high tones). Again, target presentation was randomized and occured in twenty percent of the trials.

Each autistic subject was tested on two different days to examine consistency of behavior and response. The same time of day was used for both sessions, and the same procedure was implemented both days.

During all sessions, behavioral data and other important conditions were recorded. The brain electrical activity was amplified by a Beckman

Accutrace polygraph and recorded on FM magnetic audio tape for off-line analysis and permanent storage.

Instrumentation. The task stimuli were presented to the subjects on an Amdek color monitor or via stereo headphones. An Apple II Plus microcomputer with two disk drives and an Isaac interface were used to administer the task. The EEG data were amplified using a Beckman Accutrace polygraph and low pass filtered at 400 cps and high pass filtered at .5 cps and converted to FM signals on a Vetter model 2D FM converter. Each time a target appeared, a signal marker was placed into an FM recording adapter and was then placed on the tape along with the electrical response from the brain for 1000 msecs. A Pioneer stereo cassette tape deck was used to record the information after it went through the FM adapter. The data, after manual analysis of the waveforms, was processed into a graph of averaged waveforms and printed for future reference.

Procedure for Analysis of Waveforms. The brain electrical activity, which was stored on cassette tape, was inputted into a microcomputer system for analysis and display. One thousand msecs of brain electrical activity from each target trial was examined for artifact or saturation. Artifactfree trails were summed and averaged to each previously accepted waveform. This method, developed by Michael Torello, has also been used with head trauma patients and dyslexics. Electrical voltage produced by eye blinks in normal and autistic subjects was evaluated and found to exceed 40 microvolts (uv). Therefore, the importance of controlling for eye blink and other muscle artifact was included in this design by editing out all high amplitude spikes over 40 microvolts.

RESULTS

This study was designed to examine the differences in waveform components between autistic individuals and normals on three tasks. Two modalities were compared, both for between group differences and for within group with the autistic individuals. The Mann-Whitney U Test was employed to analyze statistically significant differences.

Results from the analysis of data indicate that there was no significant difference between groups for the P200 amplitude or latency; however, autistic individuals had a significantly smaller amplitude of the P300 component on all tasks when compared to the normal group. The latency of the P300 component was significantly longer during the auditory tasks, but did not reach statistical significance in the visual modality. See Table 1.

TABLE I

Comparison of Autistic with Normal Individuals
for
Amplitude and Latency of P200 and P300 on
Visual and Auditory Tasks

	P200 AMP	P300 AMP	P200 LAT	P300 LAT
VISUAL	.53	2.98*	-1.35	- .96
AUDITORY	.65	3.10*	1.03	-2.13*

*P = .05

The data for the autistic population was examined for consistency of performance during repeated assessment on two different days. There was no significant difference of P200 and P300 AMP in either the visual or auditory modality. See Table II.

TABLE II

Comparison of Day One Amplitudes of P200 and P300 Components with those recorded on Day Two

	P300 AMP x DAY	P200 AMP x DAY
VISUAL	.313	1.67
AUDITORY	.655	-.22

Analyzing the data for the autistic population and the normal controls to examine modality differences within the groups, there appears to be no significant difference between modalities shown on the latency of P200 and P300 waveform components. See Table III.

TABLE III

Comparison of Modalities within the Autistic Group and within the Normal Controls

AUTISTIC X MODALITY	
P200 AUDITORY LAT x P200 VISUAL LAT	Z = -1.63
P300 AUDITORY LAT x P300 VISUAL LAT	Z = - .53
NORMAL X MODALITY	
P200 AUDITORY LAT X P200 VISUAL LAT	Z = - .85
P300 AUDITORY LAT X P300 VISUAL LAT	Z = - .53

It is necessary to describe the appearance of the waveform components to more adequately discuss the results. The N100 component was seen during all tasks in all autistic subjects, but the deflection was only below the baseline (negative) in five cases. This pattern is seen in the averaged waveform. Strong N100s were seen in individual trials when using the trial by trial method of analysis.

The P200 amplitude was higher than the P300 amplitude in 90% of all recordings from the autistic group. The pattern for the controls was just the opposite, with the P300 being the most robust positive deflection before 500 msecs. in the waveform. One explanation for this finding might be the amount of variability seen in the latency of components trial by trial within the autistic group. The latency of the P200 component was not significantly different from the normal controls.

The P300 amplitude (in the average waveform) was significantly reduced in the autistic group when compared to the normal controls. The frequency of trial by trial occurrence of the P300 component was reduced in the autistic group, which tended to flatten out the averaged waveform component. The fact that the P300 component occurs in the waveform in some trials, and as large as normals in amplitude, with each autistic subject, has many important implications for teaching autistic individuals. Another important finding regarding the P300 was that the latency of the component was not significantly different between groups on the visual tasks, but it did reach significance on the auditory tasks. This lends support to remedial work in a visual modality, rather than verbal, for autistic learners.

DISCUSSION

Current ERP research with autistic individuals has addressed cognitive dysfunction and the underlying hopotheses. Novick, et al., 1979, 1980; Niwa, et al., 1983; Tanguay, et al., 1982 all agree that there are marked dificits in information processing on the level of stimulus evaluation when compared to normals. There seems to be more severe impairment in auditory processing at the higher level than the visual modality (Novick, et al., 1979). The autistic individuals in this study were able to actively participate in visual

and auditory tasks and respond with correct choices, but the higher processing strategies seemed to be impaired. The autistic group remained [redacted] in performance over days. The major finding was autistic individuals did engage in a task, but they were unable to maintain organized patterns of mental processing.

Clinically, ERP research is another assessment tool that can enable one to measure internal operating modes without behavioral responses. ERP research can aid instructors in developing programs that adapt instructional techniques to individual differences, by describing modalities of strength.

The results from this study lend support to the theory that autistic individuals do process information differently than normal individuals. This processing difference needs to be studied further. Many experimental variables need to be manipulated to better understand the training requirements and instructional techniques that best aid the autistic learners.

ERP studies lend support to the developmental theories and to the relationship between development and cognitive activities through repeated analysis of components in the same individuals over time or through estabishing normative samples at various ages (Thatcher and Johns, 1977). This can be important for educators to understand normal development of cognitive functioning. In addition the study of ERP in populations with identified learning characteristics and problems, such as autistic youth, can help define differences in cognitive development for these populations and thus assess the contribution of developmental variables to the patterns these individuals display in educational settings. Parents and teachers will then be able to make well informed decisions in providing appropriate educational experiences for these individuals.

ERP studies help define materials which demand that the individual engage specific information processing strategies that are reflected in brain electrical activity. By noting when the P300 component occurs, instructors can use materials and instructions that elicit this waveform component.

The major objective of this study was to more adequately describe the specific areas of strength and weakness within the information processing system that were reflected in brain electrical activity. More understanding of the neural substrates that are engaged during cognitive processing will add a new dimension to the research. Neurobiological studies and timing of intervention with autistic learners is extremely valuable. By combining ERP research with the existing tools of assessment and the many fields of research on autism, it becomes possible to obtain a wider picture of the educational needs and possible interventions of each autistic learner.

It is well established that autistic individuals have marked interpersonal communication difficulties. The delayed latency and reduced amplitude of ERP waveform components of autistic subjects compared with normals during the auditory task in this study may suggest cognitive information processing problems for these individuals. The auditory modality probably is not the strength of the autistic learning style. Perhaps the parent and teacher of an autistic learner would be well advised reducing the amount and the pacing of auditory information presented to the learner. On the positive side, it may be advantageous to focus instruction in the visual modality where the autistic learner's cognitive processes seem to be somewhat more like normal learners. For example many persons who have experience with autistic learners have found it advantageous to speak the individuals name, --- make eye contact --- and then give instructions slowly repeating the information as needed.

A further implication of using the potential visual-spatial strength is the autistic learning style may be to employ the graphics capability of the computer for curriculum and instruction. Computer graphics can present information visually with immediate, consistent, and repeated repetitions and feedback to the autistic learner with little or no auditory processing required for success. The utility of the computer with autistic youth was employed with success during 1982 and 1983 in the Vance Cotter Summer Day Camp for Autistic Youth held at The Nisonger Center at The Ohio State University. In addition in March 1984 the Apple Education Foundation funded a project in Breezeport Texas Independent School District and the University of Houston the focus of the project is to use the Apple microcomputer graphics, music, and manipulative CRT displays to assist autistic learners in developing more affective communicative processes. Along the same lines, Naour, Martin, and Languis (1984) have reported a visuo-spatial information processing strength in learning disability youth. Languis and Heigle (1984) have initiated a project (also funded by the Apple Education Foundation) to utilize microcomputers to facilitate the writing effectiveness of learning disability and gifted learners.

A final implication for educational personnel may lie in the fact that autistic learners displayed the P300 waveform during some, but by no means all, target stimuli whereas normals displayed the waveform very consistently. The autistic learner seems to display an erractic attentional focus. Training in attention to single stimulus events seems to be warranted with the initial goal being the consistent elicitation of the P300 component first in the laboratory setting and then various learning environments. Through the establishment of the component in the stimulus evaluation processes of these learners, paradigms employing other modalities of stimulus presentation, as well as multi component stimuli, i.e., color and shape, can be presented and investigated for eliciting specific information processing strategies. Investigation of a variety of inventions and instructional strategies to improve focused and sustained attention may yield substantive benefits for the autistic learner that will transfer effectively to many educational tasks.

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