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EYE-MOVEMENTS, SURPRISE REACTIONS AND CONSERVATION ACCELERATION IN EMR AND NORMAL CHILDREN

by

© KERI McCREADY WILTON

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

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The undersigned certify that they have read and recommend to the Faculty of Graduate Studies for acceptance a thesis entitled "Eye-Movements, Surprise Reactions and Conservation Acceleration in EMR and Normal Children," submitted by Keri McCready Wilton, in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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Date Sept. 28, 1970.

SHORT ABSTRACT

45 normal and 45 EMR elementary school children, of whom 15 normal and 15 EMR Ss received perceptual/attentional conservation training, were tested on 4 Piagetian conservation tasks (number, length, continuous quantity-solid and liquid) and two conservation violation tasks (number and length). EM and psychophysiological ("surprise reaction") data were collected from the point at which the transformation outcome became apparent, and verbal response data at completion of tasks and after 3 weeks. Comparisons were made between conservers and nonconservers, and between trained and untrained nonconservers. EM and "surprise reaction" data clearly differentiated normal conservers and nonconservers, and to a lesser extent, EMR conservers and nonconservers. Trained and untrained nonconservers in both normal and EMR samples showed similar but not as strong differences, while verbal response differences were still apparent after 3 weeks. Conserver-nonconserver differences were discussed in terms of: Piaget's theroetical position, a "performance-competence" distinction and possible cognitive structural differences between normal and EMR children.

ABSTRACT

The present study examined the possibility of accelerating intellectual development, as defined by Piaget in terms of conservation acquisition, in normal and EMR children. A rationale was developed for incorporating verbal responses, EMs and psychophysiological ("surprise reaction") data as indices of cognitive structural development. An attempt was also made to differentiate between "performance" and "competence" conservation responses using the above indices.

Ninety elementary school children (45 normal and 45 EMR) were classified as conservers and nonconservers on the basis of number and length pretests. Half of the normal and half of the EMR nonconservers were given two perceptual/attentional training sessions. All Ss were presented with four conservation tasks (number, length, continuous quantity solid, and continuous quantity liquid) and two conservation violation items (number and length). The tasks were presented on 16mm. movie and with taped verbal instructions. EMs and "surprise reaction" data were recorded during the period immediately following the point at which the stimulus transformation outcome became apparent, whereas verbal response data were obtained at the completion of each task. Three weeks after the initial movie presentation, trained and untrained nonconservers were retested at their schools on the conservation tasks.

EMs and "surprise reactions" clearly differentiated normal conservers and nonconservers (Study 1) and to a lesser extent EMR

conservers and nonconservers (Study 3). Similar although not as strong differences were obtained between trained and untrained nonconservers in both normal (Study 2) and EMR Ss (Study 4).

It was concluded that EM and "surprise reaction" data had provided useful evidence to supplement verbal response data in the assessment of cognitive structural development, and that training was effective with both normal and EMR Ss. The analyses of EM patterns in terms of general and centrative perceptual activity, and of "surprise reactions", supported Piaget's position with regard to differences between conservers and nonconservers. The conservation acceleration findings were supportive of previous investigations which have shown increases in intelligence test scores following special educational programs. The results were discussed in terms of a "performance-competence" distinction, and in terms of possible cognitive structural differences between normal and EMR children.

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CHAPTER 1

Introduction

The present investigation was concerned with the effects of a specific training procedure on the intellectual development of EMR children. Piaget's (1947) theory of intelligence, specifically the acquisition of conservation, provided the focus. According to Piaget's theory, successful acceleration of the acquisition of conservation is indicative of an acceleration of intellectual development. The majority of studies in this area have used traditional intelligence tests based on interindividual comparisons as indices of intellectual development, and the results are difficult to interpret. Studies of changes in intellectual development in particular individuals appear to call for intraindividual comparisons, and since Piaget's theory is based on such comparisons (Elkind, 1969) and is concerned with the actual nature of the development of intelligence, it seemed a more promising approach.

Piaget (1964a) has suggested several basic criteria which need to be considered in attempting to determine whether or not, training has resulted in cognitive structural changes. Three of these criteria which seemed of central importance, were permanence and generalizability of behavioral changes, and the specification of the nature of cognitive structural changes. While several studies in this area appear to have successfully incorporated the first two of these criteria, attempts to use the third criterion have almost always been restricted to inferences based on verbal data.

The complex relationship between language and cognitive functioning has proven difficult to disentangle (Berlyne, 1965), and moreover, a number of researchers have tended to unjustifiably equate the two. Considerable disagreement has arisen regarding the effectiveness of various training procedures as evidenced by cognitive structural changes (Braine, 1962; Bruner, 1966a; Piaget, 1967), and most of this dissent seems attributable to the ambiguity of verbal data. Thus, what seems to be required are additional nonverbal data on cognitive structural changes.

Although cognitive structural changes presumably have a neurophysiological and chemical basis, biochemical and neurological analyses of cortical tissue are quite impossible with present methods of analysis. Consequently, a study of ongoing psychophysiological functioning appears to be the most practicable approach for investigating the nature of cognitive structural changes. If distinct differences in psychophysiological activity are apparent at various stages of conservation development, these measures should provide useful evidence to supplement verbal data in the assessment of structural changes. Supplementary evidence of this nature should thus permit a more adequate evaluation of attempts to accelerate the acquisition of conservation.

Quite clearly, some aspects of psychophysiological functioning are more useful than others. Within Piaget's theory, the development of cognitive structures are accompanied by a number of changes in perceptual activity and attentional behavior. Consequently, psychophysiological indices of perceptual activity and attentional behavior would seem to be likely sources of potentially useful data. Eye-movements (EMs) are one source of data which is closely related to attentional behavior and perceptual activity. In this connection, O'Bryan & Boersma (1970) have shown a variety of distinct differences between conservers and nonconservers in terms of EM patterns. It was predicted that similar differences would be obtained in the present study between normal or EMR conservers and nonconservers, and if training was effective, between trained and untrained nonconservers.

Charlesworth (1962, 1964b, 1966) has obtained considerable support for his contention that Ss who understand a rule or principle, will show surprise reactions when confronted with its apparent violation, whereas Ss who do not understand the rule or principle will not. He maintains (Charlesworth, 1969) that his findings could have considerable significance for developmental psychology, since they may lead to the formulation of nonverbal estimates of cognitive structural development. Presumably, surprise reactions would most likely occur under the following conditions: when the relevant cues are attended to, when the relevant concept or principle is understood (i.e, the requisite cognitive structures are developed), and when prior expectancies regarding the outcome of the rule or principle in question are violated. Conversely it seems probable, that the occurrence of a surprise reaction following a violation of conservation, is an indication that the cognitive structural changes which Piaget

(1947) claims accompany conservation acquisition, have taken place.

Lewis & Goldberg (1969) have adopted a rationale similar to that of Charlesworth (1969). Moreover they have shown that several components of the orientation reaction (OR) are elicited in young children following the violation of an expectancy. It seems likely that the occurrence of an OR following the violation of an expectancy, reflects the significance of the violated relationship (level of cognitive structural development) for the Ss who show the OR (Lewis & Harwitz, 1969).

A considerable amount of research evidence on the OR has accumulated in the USSR (Sokolov, 1958, 1963; Berlyne, 1960; Razran, 1961; Lynn, 1966; Gray, 1966) and in the West (Graham & Clifton, 1966; Maltzman, 1967; Reese & Lipsitt, 1970). On the basis of this research, GSR, vaso-motor activity and cardiac responses seem promising indices for evaluating the effects of apparent violations of expectancies during conservation tasks. It was surmised that conservers would expect that quantities do not change following spatial transformations, whereas nonconservers would expect that they do. Consequently, it was predicted that surprise reactions would be elicited by conservers, but not by nonconservers, in response to apparent violations of conservation.

The possibility that there is a link between mental retardation and attentional problems has been recognized for many years (Crosby & Blatt, 1968). More recently, the work of Zeaman & House (1963) has underlined this possibility. A similar position has been adopted by

Luria (1963) who argued, on the basis of his research with Russian children, that an OR deficit is a definitive characteristic of "oligophrenia" or mental retardation. The likelihood of attentional problems in mentally retarded persons can also be derived from Piaget's theoretical position (Wohlwill, 1966). A number of studies (e.g., Inhelder, 1963; Woodward, 1963) have indicated that mentally retarded Ss, in comparison with normals, progress through Piagetian developmental stages in the same sequence, but at a much slower rate, and do not reach the level of formal operations. Within Piaget's (1947) theoretical scheme, the decentering of attention is a critical prerequisite for cognitive development. Thus, it seems highly probable that the relatively slow cognitive development of mentally retarded Ss may be a function of difficulties in attentional decentration.

Gelman's (1969) research seems particularly relevant to the present investigation. She contended that nonconservers fail to conserve because they do not attend to relevant cues, and that training can shape appropriate attentional behavior. If her training procedure can shape attentional behavior which is necessary for conservation acquisition, it should be particularly appropriate for mentally retarded Ss, and the major purpose of the present investigation involved an examination of this possibility.

The present study thus involved an investigation of the extent to which cognitive structural changes can be assessed on the basis of verbal, EM and psychophysiological (surprise reaction) data, following natural and accelerated conservation acquisition in EMR and normal children. If the acceleration of conservation acquisition as evidenced by cognitive structural changes can be accomplished in EMR children, it would appear within Piaget's theoretical framework, that the intellectual development of EMR children at this particular stage, can be accelerated.

CHAPTER 2

Review of Literature

Acceleration of Intellectual Development

The possibility of accelerating the intellectual development of mentally retarded persons has been debated for many years. While a number of writers concerned with the education of the mentally retarded, have expressed degrees of optimism regarding this issue (Itard, 1806; Seguin, 1866; Montessori, 1912; and notably Binet, 1909), a long-standing air of pessimism has also been apparent (Kirk, 1964). This is probably attributable to factors such as the widespread belief in the concept of a fixed intelligence (Hunt, 1961, 1969); the work of Goddard (1914), which seemed to imply that mental retardation reflected the influence of unalterable genetic factors; and Doll's (1941) widely accepted definition of mental retardation, which included and emphasized a criterion of essential incurability. While this issue seems to be of basic methodological importance for psychology, it is by no means esoteric.

A recent study (Rosenthal & Jacobsen, 1968), has shown that a teacher's expectations regarding normal children's potential intellectual ability can have a profound effect upon their subsequent intellectual development. Similar expectations on the part of parents, teachers, employers and institutional personnel are also likely to have a powerful influence upon the cognitive development of mentally retarded children. If this is so, it is critical that these expectations should be optimistic, thus tending to facilitate rather than impede their cognitive development. Unless optimistic expectations have solid scientific support however, they are unlikely to gain wider acceptance or to persist. Consequently, it seems important to find out whether or not the intellectual development of mentally retarded children can be accelerated by training or education.

A number of studies have indicated significant gains in IQ test scores on the part of mentally retarded children, following their participation in special educational programs (e.g., Skeels & Dye, 1939; Kirk, 1958; and Spicker, Hodges & McCandless, 1966). A number of complex sampling and methodological problems are involved in research of this nature, however (MacNemar, 1940). Furthermore, even when scores on the best available IQ tests (e.g., Stanford-Binet, WISC, etc.) are used as indices of intellectual development, several measurement difficulties arise; e.g., changes in the factorial structure of tests at different age-levels (Guilford, 1967); the considerable socioeconomic bias of test items (Elley, 1961), which is likely to be a highly ~~potent~~ confounding factor when undifferentiated EMR children are involved (McCandless, 1964); and most significantly, the wide array of definitions of intelligence which underlie current intelligence tests (Robinson & Robinson, 1965).

What is Intelligence?

The concept of intelligence has a long history (Peterson, 1925), but the development of mental-testing by Gàlton, Cattell and others in the late nineteenth century, probably marks the dawn of modern psychological theorizing with respect to intelligence. Most contemporary theoretical approaches to intelligence have emerged from various factor-analytic viewpoints (Goodenough, 1954), which can be classified into two broad groups. Firstly, intelligence has been interpreted as a general factor (process) which enters into all aspects of cognitive behavior. This view has tended to be most popular with British psychologists. The position was derived from the work of Spearman (1904) and has been revised and refined by Burt (1956) and Vernon (1961). A second approach, the multi-factor view, is based on the postulate that intelligence is the sum of a large number of specific abilities. This view was developed by Thorndike (1921) and later Kelley (1928), and has subsequently been expanded and reformulated by Thurstone (1938) and Guilford (1967).

Despite the present statistical sophistication of general and multi-factor approaches in defining intelligence, they have tended to provide descriptions of children's performances on particular tasks which have been chosen at particular age-levels for pragmatic reasons, rather than because they constitute a part of any theoretical sequence of intellectual development. Consequently, although the measurement of intelligence can be undertaken with considerable reliability across a wide age range, the nature of the process of intelligence itself, and the way in which it changes across the developmental span, are still obscure. Clearly, such a state of affairs has tended to restrict examinations of intellectual development parameters, e.g., the inconclusive findings on the much researched heredity - environment question (Anastasi, 1958; Jensen, 1969).

Jean Piaget's View

Since the early 1920's, Jean Piaget, a Swiss psychologist has been studying developmental changes in children's cognitive functioning. A large amount of data on these changes has been collected by Piaget and his collaborators, and in the many books and articles which have been published by them, a theory of intellectual development which has a number of affinities with the seminal notions of Binet & Simon (1908), has emerged. This theory has received considerable empirical support in recent years. While there are similarities between Piaget's view of intelligence and traditional psychometric approaches, there are also major differences. One such difference lies in the fact that psychometric approaches have been concerned with interindividual differences, whereas Piaget's view is most concerned with intraindividual differences (Elkind, 1969). Since attempts to accelerate the intellectual development of mentally-retarded children, are probably most concerned with intraindividual differences, Piaget's view seems a more appropriate theoretical basis for the present study.

According to Piaget (1947), intelligence is an organized adaptive process which an individual manifests in striving to attain equilibrium between his behavior and the demands of his environment. The process is organized, in that intellectual acts are never isolated, but are always related to the totality of the individual's adaptive behavioral repertoire. He distinguishes between two complementary processes which are involved in adaptation, viz., assimilation - which refers to the interpretation or manipulation of new environmental objects or events, on the basis of previously acquired responses or concepts; and accommodation - a process which arises when existing responses or concepts are inadequate, and the individual is motivated to acquire new cognitive or motor responses, to meet the demands of the situation. Because adaptation to environmental demands and organization of intellectual acts are functional characteristics of intellectual development which endure throughout the individual's lifetime, they are referred to as "functional invariants." The raw material of intellectual adaptation consists of the actions which are performed by the child. Initially these are slow and overt; but gradually they become internalized and increasingly abstract. A basic underlying assumption in Piaget's theory, is that the acquisition of new responses, reflects changes in the individual's mode of functioning. Piaget refers to such changes as "structures," and it is specifically with the changes in these structures or "schemata," as a function of cognitive development, that Piaget and his followers are most concerned.

In discussing the parameters of intellectual development, Piaget (1964a) avoids the traditional heredity-environment issue. He argues that four factors operating in combination are important for the development of intelligence, viz., maturation, experience (physical environmental experience), social transmission (linguistic transmission, education, etc.), and "equilibration" (self regulation of the first three factors). Furthermore, Piaget argues that none of these factors are sufficient in themselves.

At birth and during infancy, i.e., until approximately two years of age, the child is said to be functioning at the sensori-motor level of intellectual development. With subsequent development, sensori-motor schemata become gradually co-ordinated and progressively internalized to form cognitive structures, which in turn gradually become organized into increasingly complex and integrated systems of actions known as "operations." This period of development, which is known as the preoperational stage, normally lasts from approximately two to seven years of age. During the preoperational stage, operations have not yet acquired "reversibility," and as a consequence, concepts of conservation or invariance of quantities, are lacking. One of the most significant features of this period, is the fact that during this time, the child begins to use language. The development of operations continues during the period from seven to approximately eleven years of age, i.e., during the period of concrete operations. During this time, the child develops the ability to carry out simple logical operations on actual concrete objects. But it is not until the child has reached the stage of formal operations, roughly from eleven to twelve years of age and upwards, that abstract propositional reasoning becomes possible.

The gradual development of operations during intellectual development, is also reflected in a number of changes in attention behavior (Piaget, 1947, 1959). Initially, attention is centered on one member of a class, or on one dimension of a stimulus at a time. Gradually however, because of operational development, the child becomes able to perceive and simultaneously to attend and accommodate to several characteristics of the stimulus situation. At this stage, the child's operations have acquired reversibility, and he is able to understand, e.g., that spatially transformed objects can be restored to their original forms.

Conservation Acquisition

The acquisition of the principle of invariance or conservation, i.e., the realization that quantities remain invariant despite any spatial transformations they may undergo, has been extensively discussed by Piaget and his collaborators (e.g., Piaget, 1947; Piaget & Szeminska, 1941; Piaget & Inhelder, 1962, 1966). He regards the acquisition of this principle as a significant indicator of intellectual development (Piaget, 1964a, p. 9), and a reflection of the transition from preoperational to concrete operational thinking. Consequently, within this view of intellectual development, if a particular teaching strategy results in "successful" acceleration of conservation, the acceleration of intellectual development may be presumed. However, can conservation acquisition really be accelerated? Although there is much research which seems to indicate that this is possible, there is an enduring controversy regarding the nature of the conservation principle (Gruen, 1966), and this research has received a somewhat mixed reception (e.g., Bruner, 1966a; Piaget, 1967).

Piaget (1962) maintains that nonconservation is the surest evidence of preoperational thinking, and that the nonconserving child is reasoning from configurations, i.e., estimating quantity from the most salient perceptual cues which are very often unrelated to quantity. Furthermore, he argues (Piaget, 1963a, pp. 80-81) that the nonconserver's reasoning lacks reversibility, and hence he is able to reason only about states of stimuli at any given time, and not about their transformations. Piaget maintains that this arises, because the child at this level centrates on these salient perceptual characteristics, and is not able to decenter to other less salient, but more significant and relevant cues.

The transition from nonconservation to conservation according to Piaget (1947, 1959), follows three broad stages. Initially, attention is focussed on, and reasoning is based on, changes in a single dimension, or in the general shape of the array. Later, attention shifts to, and reasoning is based on, changes in the complementary dimension, and finally systematic scanning of both dimensions, together with an understanding of the principles of compensation, reversibility, and identity, becomes apparent.

Some variation is apparent with respect to the average ages at which particular concepts are attained (e.g., conservation of number -- 6½ to 7 years; conservation of length -- 7 to 8 years; conservation of continuous quantity (solids and liquids -- 7 to 8 years; and conservation of volume -- 11 to 12 years). Piaget (1955) has described this variation in the ages at which various task solutions apparently mediated by the same cognitive structures take place. He refers to this variation as "decalages horizontales" (horizontal differentials), but as Wohlwill (1966) observes, this notion is essentially of the ad hoc variety and has not yet been adequately incorporated into Piaget's general theoretical position.

An alternative point of view on the development of conservation has been offered by Bruner (1964, 1966a), who describes the course of cognitive growth in terms of the gradual acquisition of three systems of representation. In early childhood, where objects and events are defined in terms of actions taken towards them, representation is said to be enactive. Later ikonic representation, a system based on perceptual organization, becomes available, and finally symbolic representation, i.e., words and language is attained. The conservation problems involve several abstract concepts, e.g., more, same, less, etc., and thus require rather more than perceptual organization. Consequently, from Bruner's point of view, it is only when the child is able to extend beyond ikonic representation, that he is able to solve these problems. Presumably, whether or not a child will be able to solve the conservation problems, will depend on his particular level of language development.

Several other interpretations of conservation acquisition have been proposed. Wohlwill (1962) has suggested from a developmental position, that the transition from perception to conception is characterized by an increasing tolerance for irrelevant information, which enables a child who has completed this transition, to solve conservation problems. Staats & Staats (1963) from a mediational S-R point of view, have emphasized the conditioning of appropriate object-verbal response pairings and Watson (1967) has presented similar arguments from a Skinnerian non-mediational S-R point of view. Berlyne (1965) has presented a Hullian analysis of conservation acquisition, in which the necessity for the development of transformational habit-family hierarchies is given maximum emphasis. It seems apparent that the emphases in particular strategies designed to accelerate the acquisition of conservation will vary according to the particular theoretical position which is adopted.

Conservation Acceleration Attempts and Their Evaluation

A large body of research has accumulated since Flavell's cautious 1963 review, which seems to support the contention that the acquisition of conservation of number, length, and continuous quantity (solid and liquid) can be accelerated through training. Of these, Winer (1968) and Wallace (1968) e.g., reported successful acceleration of number conservation. Gruen (1965) and Kingsley & Hall (1967) e.g., achieved similar results with length conservation. Sigel, Hooper & Roeper (1966), Lefrancois (1966) and Towler (1967) claimed to have accelerated conservation of continuous quantities. Gelman (1969) reported successful acceleration of number, length and continuous quantity conservation in five year old children as a function of a single training program.

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Notwithstanding these results however, Piaget and his followers have argued that apparently successful training results maybe, and likely are, misleading, in that in many cases what has probably eventuated is a "pseudo-conservation response" (cf., Inhelder, Bovet, Sinclair & Smock, 1966; Piaget, 1967). Piaget has drawn a careful distinction between "pseudo" and "true" conservation. A child may be able to answer conservation questions correctly, and still not be a "true" conserver in Piaget's sense of the term (Piaget, 1964b, p. 25). He argued that it is necessary to establish that a child has the necessary logical structures, e.g., reversibility, compensation, etc., before he is described as a "true" conserver. A similar point of view has been developed by Smedslund (1961).

Bruner (1964, 1966a, 1966b, 1966c), on the other hand, is primarily interested in finding out whether or not the child has the ability "to recognize invariance of magnitude across transformations in the appearance of things" (1966b, p. 13). He suspects that a child may have the necessary symbolic representation (words and language) to handle conservation problems, but may be misled by irrelevant perceptual cues. This point of view is consistent with that of Braine (1959). Braine maintained that the five year old child may have reached the stage of cognitive development which is necessary to handle conservation problems, but may be unable to demonstrate evidence of this development because he cannot determine the precise meaning of the experimenter's question. Braine suspects that the child who shows the usual patterns of language acquisition and usage, will rarely be able to do this before the age of seven years.

It is noticeable that while Braine (1959) and Bruner (1966a), using modified Piagetian assessment techniques, have both estimated that conservation behavior begins at approximately five years of age, it has been consistently located around the seven year age-level by Piaget and his followers. As Gruen (1966) has observed, these differences essentially involve neither age-norms nor assessment procedures, but rather seem to arise out of different definitions of the term "conservation." The position of Piaget and his followers involves a series of qualitative distinctions between examples of cognitive behavior, based on the presence or absence of other behavior, and these distinctions may or may not be useful. Since the concept has arisen out of Piaget's theoretical framework however, and since the present investigation was within this framework, Piaget's definitional criteria seemed most meaningful for the present study.

Piaget (1964a) has enumerated several criteria which may be used to evaluate training procedures and assess cognitive structural change. These are: <u>durability</u> or retention - the relative permanence of any changes which occur; <u>generalizability</u> or transfer - the extent to which training generalizes to new situations; and specification of <u>structural-changes</u> - specification of the nature of cognitive structural changes which have occurred as a result of training.

One of the most successful of the various methods which have been employed to accelerate conservation acquisition, was developed by Gelman (1969). Her method was based on the premise that five-year old children fail to conserve primarily because they are attending and responding, to task-irrelevant cues. The method, which was developed from Trabasso & Bower's (1968) theory of learning of relevant-redundant cues, utilized a series of oddity learning problems in which number and length were relevant cues on alternate problems. On this basis, a set to respond to number cues on number problems, and to length cues on length problems, was developed. Almost all of the five-year old Ss acquired conservation of number and length, and over 60% showed conservation of quantity (solid and liquid) on subsequent transfer tasks. Furthermore, very little "fade" was evident in these results over a three-week retention test interval. A pilot study undertaken by the present investigator, has indicated that the method is effective with EMR Ss.

The use of Gelman's (1969) method in the present context, seemed indicated for several reasons. It seemed to be the most successful of those published to date in terms of results attained, according to Piaget's criteria of permanence and generalizability. Furthermore, the method was based on the assumption that in order for a nonconserving child to become a conserver, some modification in attentional behavior is required. In view of the central place of decentration i.e., the shifting of the concentration of attention, in Piaget's (1947) view of cognitive development, such an assumption appeared sound. Furthermore, this consideration seemed particularly pertinent with respect to mentally retarded Ss.

Most comparative studies of learning indicate that mentally-retarded Ss require more trials to learn a task than do normal Ss of equivalent CA or MA (Lipman, 1963; Denny, 1964; Baumeister, 1967). Among the various theoretical attempts which have been made to explain this difference (Zigler, 1966), the notion that attentional difficulties may play a significant role has received considerable emphasis and much empirical support. Furthermore, such a notion is not new. The idea seems to have been implied in the emphasis given to sense-training by Itard (1806), Seguin (1866), Decroly (Descoeudres, 1928), Montessori (1912), and others, in their educational programs for the mentally-retarded. Kuhlmann (1904), stated the notion explicitly following a series of discrimination learning studies with mentally-retarded children. Subsequently, similar proposals have been made by Strauss & Werner (1941), Lindsley (1957), O'Connor & Hermelin (1963), Luria (1963), and Zeaman & House (1963). Consequently, if Gelman's procedure really does achieve a modification of attention behavior, as was claimed, it seemed very likely that the procedure would be successful (effective) with EMR children. This possibility is by no means inconsistent with Piaget's theoretical position, a point which Wohlwill (1966) has noted.

A number of findings are available which suggest that mentally retarded persons show similar progressions in the acquisition of operations to those of normals (Woodward, 1959, 1963; Hood, 1962; Inhelder, 1963), although the respective developmental stages were reached at later chronological age levels and the mentally retarded do not reach the formal operational stage. To the author's knowledge however, only one examination has been made of conservation acceleration with mentally-retarded children. Here, Brison and Bereiter (1967), attempted to accelerate conservation of volume and substance, but it is difficult to evaluate the results. Although Piaget's criteria were used in defining pretraining nonconservers, they were not used to define conservers following training. Training effects were evaluated using frequency of conservation responses ("same" - following transformation) on conservation posttest tasks. Although no differences between normals, gifted and educable mentally retarded (EMR) children, in terms of frequency of conservation reponses were found, either on posttest or transfer (within same dimension) tasks, it is possible, and indeed likely that substantial intergroup posttraining differences may have existed. Some empirical support for this contention was provided by the authors, in that EMR Ss did show a weak but significant trend in the direction of more rapid extinction of conservation responses following the presentation of evidence which apparently conflicted with the invariance (conservation) principle. Quite clearly, a rather more detailed investigation of this issue was required.

The Structural Change Problem

In order to make assessments of structural changes on the basis of Piaget's third criterion, data on such changes need to be obtained. Verbal responses (i.e., changes in word meanings, language patterns, etc.) have been the traditional source of this data. The relationship between language and cognitive functioning however, has proven extremely difficult to unravel (Vygotsky, 1956; Piaget, 1959; Berlyne, 1965, 1970b; Furth, 1966). At the same time, verbal behavior seems to be highly responsive to experimenter cuing (Rosenthal, 1966, Kingsley & Hall, 1968), and some recent Russian research suggests that language and thinking are differentially related in mentally retarded and normal children (Shif, 1969).

Consequently, it would appear that some data in addition to changes in verbal behavior are required, if less equivocal evidence of structural changes is to be obtained. Psychophysiological responses appear to be one possible source of such additional data, and one probably less responsive than verbal data, to experimenter cuing (O'Bryan & Boersma, 1970). Although biochemical and neurological analyses of brain cell structures would undoubtedly provide valuable data in this respect, a point which has been discussed by Piaget (1949, 1969), its use given existing methods, is not possible. Furthermore, since Piaget's usage of the term "structure" implies a continually modifying entity, there seems to be good reason to suppose that an examination of changes in ongoing central nervous system activity is a prudent starting place.

A large array of psychophysiological activity is available, and clearly some selection has to be made. Russian and Western research in this area had indicated several variables which seemed promising indicators of cognitive activity, viz., exploratory eye-movements (EMs), galvanic skin response (GSR), vaso-motor activity and heart rate (Berlyne, 1960, 1963, 1970a; Lynn, 1966; Creelman, 1966;

1966; Gray, 1966; Graham & Clifton, 1966; Reese and Lipsitt, 1970). While Piaget's work is well known in the USSR, particularly his earlier studies of language development (Vygotsky, 1956; Elkonin, 1968; Luria, 1968; Sokolov, 1968), and although the psychophysiological methods used by Soviet researchers seem admirably suited for investigations into some of the questions which arise from Piaget's theoretical position (Wright, 1963; Jeffery, 1968), to the author's knowledge no such research has yet been reported.

According to Piaget's theoretical scheme a decrease in perceptual and cognitive centration is a critical prerequisite for the transition from preoperational to operational thinking. Consequently, since there should be substantial differences in the cognitive functioning of conserving and nonconserving children, differential perceptual activity should be evident. This possibility was confirmed in a recent study in which corneally-reflected EMs were used as indices of perceptual activities (O'Bryan & Boersma, 1970). A further possible source of relevant physiological data, arises from a suggestion made by Charlesworth (1964a, 1969), viz., that when confronted with an apparent violation of a concept, law or principle, a child who has really acquired the relationship in question, would show more evidence of surprise, than a child who has not. Some empirical support for the use of surprise-reactions as indices of cognitive structural development, has been obtained (Charlesworth, 1962, 1964b, 1966), and their use as supplementary nonverbal indices of cognitive structural development in relation to conservation acquisition, seems promising.

In recent years, a large amount of Russian and Western psychophysiological research has been directed at a complex of physiological reactions, known collectively as the "orientation reaction," or OR (Sokolov, 1958; Berlyne, 1960, 1963; Razran, 1961; Lynn, 1966; Gray, 1966; Graham & Clifton, 1966; Reese & Lipsitt, 1970). A priori there would seem to be much in common between the concept of surprise reactions and that of the OR. Both involve centrally determined reactions to stimulus change, and both should occur, as Charlesworth (1969) argues, following a discrepancy between predicted (expected) and actual sensory input (Berlyne, 1960, 1967; Sokolov, 1958). Lewis & Harwitz (1969) maintain that the differential occurrence of orientation reactions closely reflects the cognitive salience (level of cognitive structural development) which environmental dimensions (concepts) or events involving dimensions have for particular organisms. Some evidence (Lewis & Goldberg, 1969) has been presented which strongly indicates that components of the orientation reaction are elicited in young children, following the violation of an expectancy. Consequently, there would seem to be considerable justification in using a combination of well established components of the orientation reaction as a psychophysiological index of surprise.

In order for a discrepancy between predicted and (expected) and actual sensory input to arise, some expectation will need to have developed on the basis of past experience. Presumably, with conservers, the expectancy which has developed is that quantities do not change following spatial transformations. On the other hand, by definition no such expectancy should occur in nonconservers. Thus if cognitive activity in conserving and nonconserving children is qualitatively different, there should be significant differences between the surprise reactions of each group following apparent violations of the conservation principle.

In summary, the following considerations seem pertinent to the present investigation. Firstly, within Piaget's theory, intellectual development is mirrored by a number of substantial changes in attentional behavior with a resulting trend towards decentration of thinking. Secondly, a number of studies have documented the slower rate of cognitive development of mentally retarded persons with respect to Piagetian stages (e.g., Inhelder, 1962; Woodward, 1962). The association of attentional difficulties with mentally retarded persons has had a long history outside of the Piagetian theoretical framework (Crosby & Blatt, 1968), and since attentional behavioral change is a critical component of cognitive development within Piaget's scheme, it seems highly likely that attentional difficulties are strongly related to the slower rate of cognitive development in the mentally retarded.

Gelman's (1969) training program is based on the contention that for nonconservers to become conservers, modifications in attentional behavior in the direction of maximum attention to task relevant cues needs to be produced. If modifications of this nature are possible, and from a Piagetian theoretical position this is by no means unlikely (Wohlwill, 1966), a training program of this nature should be highly effective with mentally retarded as well as normal children. Furthermore, if such modifications in attentional behavior can be produced, they would seem to be strongly supportive evidence of cognitive structural changes, in view of the critical relationship between attentional changes and cognitive development. Perceptual activity and surprise reactions appear to offer a promising source of data on this question and should provide a valuable supplement to verbal data for assessing cognitive structural changes. The use of these measures should thus permit a more adequate examination of the possibility of accelerating conservation acquisition in EMR and normal children. If conservation acquisition can be accelerated in EMR children, within Piaget's (1947) theoretical framework it would appear that the intellectual development of such children can be accelerated.

CHAPTER 3

Rationale, Postulates and Hypotheses

Rationale

The emergence of Piaget's theory of intellectual development has permitted a new approach to the study of an old problem, viz., whether or not the intellectual development of mentally retarded persons can be accelerated by training or education. Moreover, a number of attempts to accelerate the acquisition of the principle of conservation (an event which Piaget claims closely reflects intellectual development) with normal children, and one study with EMR children, appear to have had some success.

However, because of the differential criteria which have been used, both in defining conservation and in evaluating the effectiveness of training, a large amount of controversy still clouds the issue. Since Piaget's theory provides the rationale for the principle of conservation classification in relation to intellectual development, it seemed most meaningful to use his criteria for defining conservation and for evaluating training within the present context.

While two of Piaget's criteria for examining the effectiveness of training in inducing cognitive structural changes (permanence and generalizability of behavioral changes) do not seem to present major methodological problems, a third (specification of cognitive structural changes) has proved to be extremely difficult to investigate. Most previous studies in this area have used verbal response changes as data on the third criterion. Language and thought are complexly related however (Berlyne, 1965) and there seemed to be a need for supplementary data to reduce the apparent ambiguity of verbal evidence. Centrally determined psychophysiological responses appear to be a promising source of such supplementary data. A wide array of psychophysiological responses have been identified as components of the orientation reaction and of these, exploratory EMs, GSR, vasomotor activity and heart rate changes seem to be important. The exploratory EMs of conserving and nonconserving Ss have already been shown to differ significantly (O'Bryan & Boersma, 1970). Moreover, it seems reasonable to expect that Ss who have acquired conservation would show more evidence of surprise reactions (changes in psychophysiological activity), following presentation of apparent violations of the conservation principle.

Consequently, it seems feasible that a study which incorporates changes in the above aspects of psychophysiological functioning as supplementary evidence of cognitive structural changes, should permit a more adequate evaluation of any attempts to accelerate the intellectual development of EMR children, especially within Piaget's theroetical framework.

Specific Objectives

An attempt was made, using Piaget's definitional and training criteria, to examine the possibility of accelerating conservation acquisition in EMR children. Before this could be undertaken however, an adequate examination of this possibility as it related to normal children, as well as clear evidence of cognitive structural differences between natural (untrained) conservers and nonconservers, in both normal and EMR populations, seemed to be required. Data on normal children seemed to be necessary because certain specific problems are likely to be associated with the OR in mentally retarded children. Luria (1963) speaks of an OR deficit as a characteristic of the mentally retarded child, and although USSR classifications are based primarily on physiological rather than psychometric data, there is sufficient similarity between Luria's claim and several Western points of view, to indicate the need for a cautious approach in this area (cf., House & Zeaman, 1963; O'Connor & Hermelin, 1963).

Therefore, before examining the question of whether or not the acquisition of conservation in mentally retarded children could be accelerated by training, several areas required investigation. An examination needed to be made of the conserver/nonconserver dichotomy in normal and EMR children and of the effectiveness of a conservation acceleration procedure, in terms of cognitive structural differences in normal children. These investigations were undertaken using estimates of general and centrative perceptual activity and surprise reactions, during the solution of conservation and "apparent conservation violation" tasks.

The term "general perceptual activity" was used to describe the level of activity of perceptual behavior. Piaget (1947) maintains that this activity tends to increase with age and it seems likely that conservers and nonconservers would show differential activity levels. General perceptual activity was examined through between group analyses of frequency and duration of eye-movement shifts.

"Centrative perceptual activity" refers to a trend described by Piaget (1947), whereby perceptual and cognitive activity become "decentered" and with the onset of operational thinking (indicated by the acquisition of conservation) are no longer "centered" on particular states or dimensions of stimuli. It was thus expected that conservers and nonconservers would show marked differences with respect to this trend. Centrative perceptual activity was described in terms of within group analyses of the ratios of transformed element-directed and nontransformed element-directed EM activity.

"Surprise reactions" were defined in terms of OR components (Charlesworth, 1969) as the simultaneous occurrence of a GSR conductance increase, a cephalic blood volume increase and a decrease in heart-rate. It was expected that following apparent violations of conservation, conservers would show surprise reactions, whereas nonconservers would not. Between group comparisons of surprise reactions and verbal responses, and within group analyses of EM activity were made following apparent violations of conservation.

The present study was thus designed to investigate:

1. the usefulness of general and centrative perceptual activity and surprise reactions in conjunction with verbal response data for assessing the nature of cognitive structural differences between normal conservers and normal nonconservers (STUDY 1);

2. the effectiveness of a conservation acceleration training procedure adopting Piaget's training criteria and using general and centrative perceptual activity and surprise reactions in conjunction with verbal data for assessing the nature of cognitive structural differences between trained normal nonconservers and normal nonconservers (STUDY 2);

3. the usefulness of general and centrative perceptual activity and surprise reactions in conjunction with verbal data for assessing the nature of cognitive structural differences between EMR conservers and EMR nonconservers (STUDY 3); and

4. the effectiveness of a conservation acceleration training procedure adopting Piaget's training criteria and using general and perceptual activity and surprise reactions in conjunction with verbal data, for assessing the nature of cognitive structural differences between trained EMR nonconservers and EMR nonconservers.

The fourth study was however the prime concern of the present investigation, and should result in a more adequate examination of the feasibility of accelerating intellectual development in EMR children, than has heretofore been attempted.

Definitions

Conservation

Element. - one of the two components (row of counters, stick, beaker of water, etc.) of a conservation task.

<u>Centration.</u> - the centering of attention on a particular stimulus element.

<u>Decentration.</u> - the equal displacement of attention about the stimulus elements.

<u>Transformed element (TE)</u>. - the particular element of the stimulus which is changed by the experimenter during a conservation task, in contrast to the nontransformed stimulus element (NTE).

<u>Greater element (GE)</u>. - the particular element of a stimulus array in a conservation task, which following stimulus transformation, is reported by a <u>S</u> (nonconserver) to be greater in quantity, length or amount, than the lesser element (LE).

<u>Logical conservation response (LR)</u>. - a verbal response to any specified conservation problem in which a logical justification of the type described by Piaget (1947) is included.

<u>Intuitive conservation response (IR)</u>. - a verbal response to any specified conservation problem in which an intuitive justification of the type described by Piaget (1947) is included.

<u>Nonconservation response (NCR)</u>. - a verbal response to any specified conservation problem which fails to meet the criteria for logical or intuitive conservation responses.

<u>Task I</u>. - the filmed or actual presentation of number

and length conservation problems. These problems were used for pretests, and laboratory and retention tests.

Task II. - the filmed or actual presentation of solid and liquid continuous quantity conservation problems.

Task III. - the filmed number and length conservation violation problems.

Periods

Pre-Film Period (PFP). - the 5 second period immediately preceding the presentation of the movie.

Stimulus Transformation Period. - the period of time varying from 7.0 seconds to 13.5 seconds during which the filmed stimulus transformation was presented.

Transformation Outcome Period (TOP). - the period of time varying from 6.5 seconds to 9.0 seconds from the point at which the outcome of the stimulus transformation becomes visible, until 5 seconds after the completion of the transformation. This period varied with tasks, but was constant across subjects.

Decision Period. - the period of time from the onset of TOP to the S's decision response to a particular conservation or conservation violation problem. The stimulus transformation outcome was visible during this period.

Eye Movement Data

Fixation. - one or more successive corneal reflections, recorded at a rate of 10 frames per second, within the same circular area subtended by 15 minutes of arc in the stimulus field. Specifically, the point on which the S concentrates his gaze for a minimum period of one-tenth of a second while EMs are being recorded.

Run. - two or more consecutive fixations of at least one-tenth second duration, exclusively on one or the other stimulus elements.

Shift. - a movement in fixation from one point to another which is greater than the diameter of a circle subtended by 15 minutes of arc.

Coupling. - a shift in fixation from one stimulus element to the other, i.e., where a comparison is going on between the elements.

First 30 Frames (3 seconds). - the first 30 frames of EM data recorded at the rate of 10 frames per second, on any task.

Psychophysiological Measures

Log Conductance Units. - a natural logarithmic transformation of the reciprocal of the skin resistance value at the point of electrode attachment.

Conductance Level (CL). - any point on the GSR record (See Figure 1).

Conductance Change (CC). - a continuous rise in CL expressed as the difference between onset CL and peak CL.

GSR Onset. - that point during the TOP on the GSR record at which the greatest CC commences (See Figure 1).

GSR Peak. - that point on the GSR record at which the peak of the greatest CC is reached (See Figure 1).

Plethysmograph Baseline. - an arbitrary baseline on the plethysmograph record which yielded positive BV readings only.

Blood Volume (BV). - an approximate relative index of the amount of blood at the systolic peak in the surface blood vessels at the mounting point of the photo-plethysmograph transducer defined as mean BV reading in mm. from the baseline to the systolic peak (See Figure 1), during a specified time interval (Brown, 1967, p. 64).

Blood Volume Pulse (BVP). - an approximate relative index of amount of continuous change in blood flow in the surface blood vessels at the point of transducer mounting (Lader, 1967, p. 165) defined as the mean BVP reading in mm. from the diastolic trough to the systolic peak (See Figure 1) during a specified time interval (Brown, 1967, p. 64).

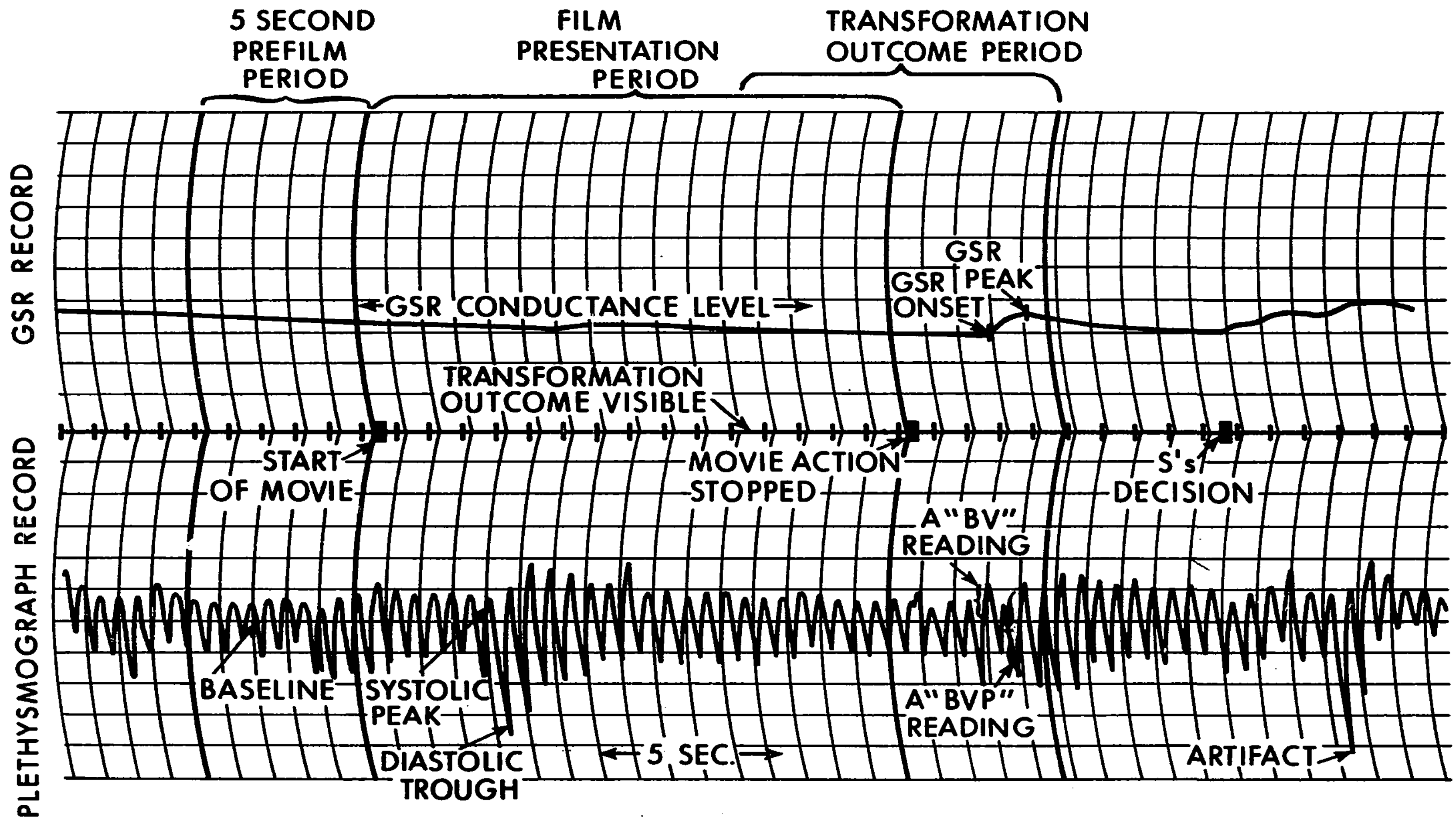


Fig. 1. A sample psychophysiological response record showing dependent variable measures

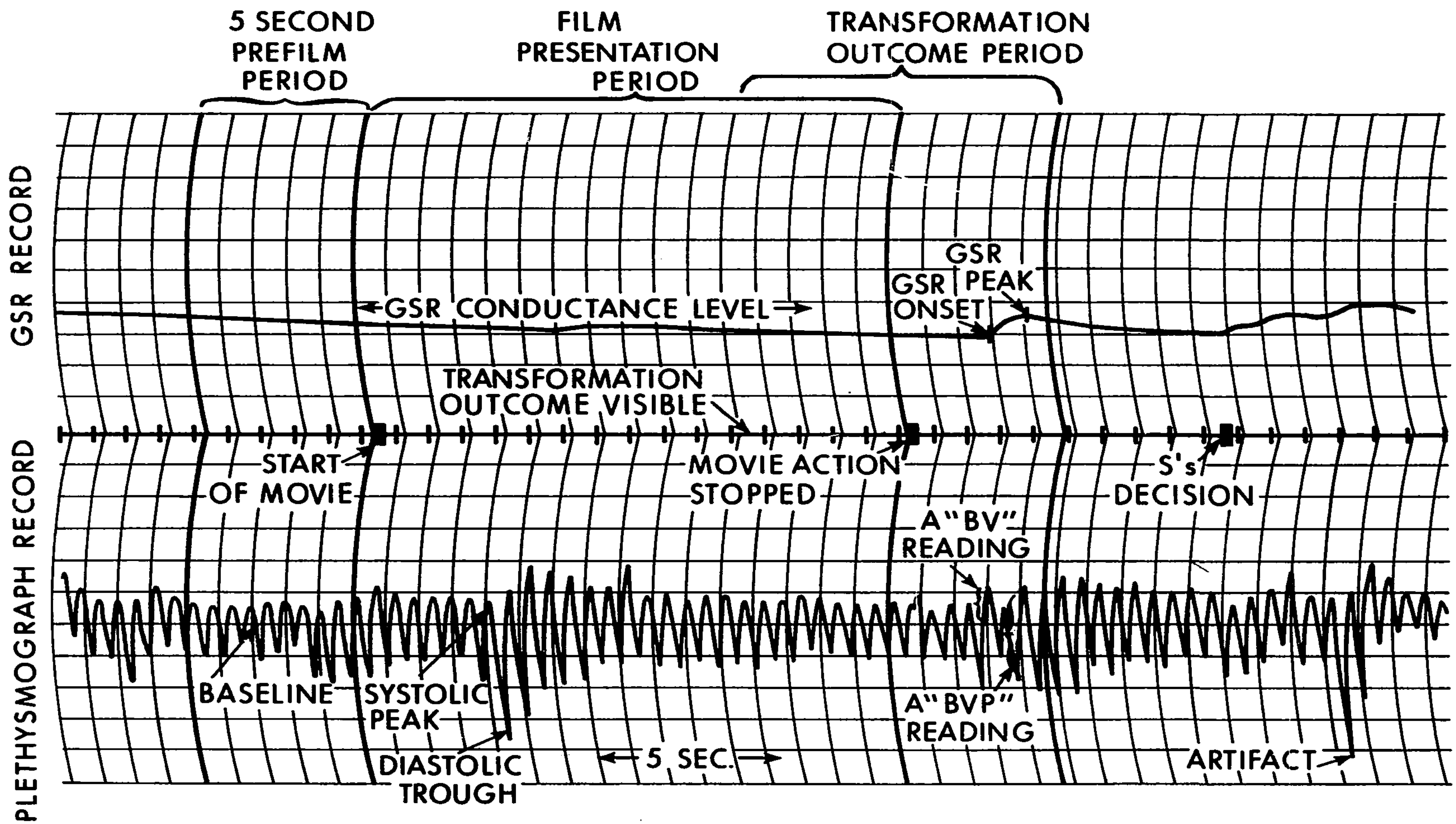


Fig. 1. A sample psychophysiological response record showing dependent variable measures

Heart Rate (HR). - the frequency of heart beats during any specified time interval. This estimate was obtained from the photo-electric plethysmograph output by counting the number of systolic peaks during the specified time interval.

Surprise reaction. - There appeared to be considerable justification for using OR components as indices of surprise reactions (Charlesworth, 1969). At the same time, the OR is usually defined (e.g., Reese & Lipsett, 1970) as a complex of motor and psychophysiological responses which occur together during a specified time interval. Consequently, any single motor or psychophysiological response measure would probably not be an adequate OR index, and some combination of measures seemed necessary. The GSR, vasodilation, and heart-rate components appeared to be well documented (e.g., Sokolov, 1958; Berlyne, 1960; Lynn, 1966; Gray, 1966; Graham & Clifton, 1966) and seemed appropriate for the present investigation. On this basis, the following definition of a surprise reaction was formulated in terms of OR components:

> A surprise reaction shall be defined as the simultaneous occurrence during TOP, of a GSR conductance change, a positive mean BV change and a negative mean heart rate difference.

Dependent Variables

Performance data

Latency to decision. - the time in seconds, between the onset of TOP and the S's decision relative to the particular task.

Frequency of unscorable frames. - the summated total of one tenth second frames of EM data, which because of eye-blinks, head-movements or fixations on nonstimulus material, were not scorable.

Percentage of logical conservation responses. - the percentage of logical conservation responses obtained on Tasks I and II.

Eye Movements

Frequency of couplings. - the total number of couplings observed during Tasks I, II or III, during the specified time interval.

Frequency of runs. - the total number of runs made on the TE, NTE, or over both (total) elements, during the specified time interval.

Frequency of fixations. - the total number of shifts in fixation plus one fixation on TE, NTE or over both (total) elements, during the specified time interval.

Mean length of run. - the ratio of the summated number of one-tenth second fixation points, in all runs, to the summated number of runs made on the TE, NTE or over both (total) elements during the specified time interval.

Mean length of fixation. - the ratio of the summated number of one-tenth second fixation points, to the summated total number of fixations, on the TE, NTE or over both (total) during the specified time interval.

Examination time. - the summated total number of one-tenth second fixation points, on either the TE or the NTE, during the specified time interval.

Psychophysiological Measures

Pre-film conductance level. - the average minimum conductance level during the PFP expressed in log conductance units.

Maximum conductance change. - the greatest change in CL during TOP, expressed as the difference in log conductance units between CL at GSR onset, and CL at GSR peak.

Conductance difference. - the difference between the pre-film CL and the maximum CL during TOP, expressed in log conductance units.

Latency to GSR onset. - the time in seconds from the beginning of TOP and the GSR onset.

Latency to GSR peak. - the time in seconds from the beginning of TOP and the GSR peak.

Mean blood volume (BV) change. - the difference between the mean of the single BV readings during PFP and TOP, expressed as a percentage of the mean PFP reading.

Mean blood volume pulse (BVP) change. - the difference between the means of the single BVP readings during PFP and and TOP, expressed as a percentage of the mean PFP reading.

Mean heart rate (HR) difference. - the mean difference in beats per minute, between HR during the PFP and that observed during the TOP.

Percentage of surprise reactions. - the percentage of surprise reactions obtained during TOP on number and length violation items.

Theoretical Postulates and Experimental Hypotheses

Piaget (1947) has argued that whereas operational thought is decentered and able to accommodate the various spatial transformations which an object may undergo, the distinguishing characteristic of preoperational thought is that it is centered on a particular state of the object. The centrated nature of preoperational cognition is reflected in several distinct characteristics of perceptual activity which should be apparent during conservation problem solving. According to Piaget (1947) the preoperational child tends to concentrate his perceptual activity on a particular dimension of the elements of a conservation problem, and to a greater extent (Piaget, 1947, 1961) on the element judged to be greater along that dimension. His perception tends to be global (Piaget, 1961) and perceptual activity tends to be at a minimum.

One previous study using a similar procedure to that employed in the present investigation (O'Bryan & Boersma, 1970) has indicated that meaningful distinctions may be made between the EM patterns of normal conservers and nonconservers. Movie tasks involving conservation of length, area and continuous quantity (solid and liquid) were used and it was found that fixation positions, number of couplings and runs, and mean length of run both shortly after stimulus transformation and during the total solution period differentiated the performance of the two groups. On the basis of the above theoretical notions and research findings, Postulate 1 was thus proposed:

<u>Postulate 1</u>: Normal and EMR children who show nonconservation responses on tasks involving number, length or continuous quantity (solid or liquid) will, during the solution of these tasks:

a. show a minimum of general perceptual activity in terms of couplings, runs, and fixations between the elements of the stimulus field;

b. show maximum centrative perceptual activity in terms of frequency and duration of runs and fixations, and percentage of examination time on the particular stimulus array or element, reported to be more in number, longer or more in substance.

On the basis of Postulate 1a, the following between group hypotheses were formulated:

Hypothesis 1A.1: Nonconserving children, whether normal or EMR, will show during the first 3 seconds of the decision period, fewer couplings than conservers or trained nonconservers.

Hypothesis 1A.2: Nonconserving children, whether normal or EMR, will show during the first 3 seconds of the decision period, fewer total runs over both elements, than conservers or trained nonconservers.

Hypothesis 1A.3: Nonconserving children whether normal or EMR, will show during the first 3 seconds of the decision period, greater total mean length of run over both elements, than conservers or trained nonconservers.

Hypothesis 1A.4: Nonconserving children whether normal or EMR, will show during the first 3 seconds of the decision period, fewer total fixations over both elements, than conservers or trained nonconservers.

Hypothesis 1A.5: Nonconservers, whether normal or EMR, will show during the first 3 seconds of the decision period, a greater total mean length of fixation over both elements, than conservers or trained nonconservers.

On the basis of Postulate 1b the following within group hypotheses were formulated:

Hypothesis 1B.1: Nonconserving children whether normal or EMR, will show during the first 3 seconds of the decision period more runs on the stimulus element they nominate as being greater (GE).

Hypothesis 1B.2: Nonconserving children, whether normal or EMR, will show during the first 3 seconds of the decision period, a greater mean length of run on the stimulus element they nominate as being greater (GE).

Hypothesis 1B.3: Nonconserving children, whether normal or EMR, will show during the first 3 seconds of the decision period, more fixations on the stimulus element they nominate as being greater (GE).

Hypothesis 1B.4: Nonconserving children, whether normal or EMR, will show during the first 3 seconds of the decision period, a greater mean length of fixation on the stimulus element they nominate as being greater (GE).

Hypothesis 1B.5: Nonconserving children, whether normal or EMR, will spend, during the first 3 seconds of the decision period, a greater amount (percentage) of time looking at the stimulus element they nominate as being greater (GE).

With the acquisition of conservation however, operational thought characterised by decentration becomes possible. Formerly, perceptual and cognitive activity were concentrated on particular states and dimensions of stimuli, whereas they now tend to be more evenly distributed between the transformed and the nontransformed elements. Furthermore, perceptual behavior has become more active than it was previously. According to Piaget, (1960) it is partly as a function of these attentional changes that the child comes eventually to understand the relationship between dimensions and quantities. At this stage cognitive activity 'no longer issues from a particular viewpoint of the subject, but coordinates all the different viewpoints in a system of objective reciprocities (Piaget, 1947, p. 142).' Consequently, with the acquisition of conservation, marked changes should be evident with respect to general and centrative perceptual activity. Postulate 2 was thus proposed:

Postulate 2: Normal or EMR children who acquire conservation naturally or as a function of training, as determined by the presence of logical justifications of conservation (Piaget, 1947) on tasks involving number, length or continuous quantity (solid or liquid) will, during the solution of these tasks:

a. show a maximum of general perceptual activity in terms of couplings, runs and fixations between the elements of the stimulus field;

b. show minimum centrative perceptual activity in terms of the frequency and duration of runs and fixations, and percentage of examination time on the transformed element.

The following between group hypotheses were formulated on the basis of Postulate 2a:

Hypothesis 2A.1: Normal or EMR conservers and trained nonconservers will show during the first 3 seconds of the decision period, more couplings than nonconservers.

Hypothesis 2A.2: Normal or EMR conservers and trained nonconservers will show during the first 3 seconds of the decision period, more total runs over both elements than nonconservers.

Hypothesis 2A.3: Normal or EMR conservers and trained nonconservers will show during the first 3 seconds of the decision period, a shorter total mean length of run over both elements, than nonconservers.

Hypothesis 2A.4: Normal or EMR conservers and trained nonconservers will show during the first 3 seconds of the decision period, more total fixations over both elements, than nonconservers.

Hypothesis 2A.5: Normal or EMR conservers and trained nonconservers will show during the first 3 seconds of the decision period, a shorter total mean length of fixation over both elements, than nonconservers.

The following within group hypotheses were derived from Postulate 2b:

Hypothesis 2B.1: Normal or EMR conservers and trained nonconservers will demonstrate, during the first 3 seconds of the decision period, a similar frequency of runs on both stimulus elements.

Hypothesis 2B.2: Normal or EMR conservers and trained non-conservers will demonstrate, during the first 3 seconds of the decision period, a similar mean length of run on both stimulus elements.

Hypothesis 2B.3: Normal or EMR conservers and trained non-conservers will demonstrate, during the first 3 seconds of the decision period, a similar frequency of fixations on both stimulus elements.

Hypothesis 2B.4: Normal or EMR conservers and trained non-conservers will demonstrate, during the first 3 seconds of the decision period, a similar mean length of fixation on both stimulus elements.

Hypothesis 2B.5: Normal or EMR conservers and trained non-conservers will demonstrate, during the first 3 seconds of the decision period, a similar percentage of time spent looking at both stimulus elements.

Charlesworth (1962, 1964a, 1964b) has provided some evidence to support his contention that Ss who have acquired a concept or principle will tend to show surprise reactions when confronted with an apparent violation of that concept or principle, whereas children who have not acquired the relationship, will not. Lewis & Harwitz (1969) have argued that the cognitive salience which environmental dimensions (concepts) or events involving dimensions have for particular organisms, will be reflected in the differential occurrence of orientation reactions (ORs). Furthermore, some evidence (Lewis &

Goldberg, 1969) has been presented which strongly indicates that an apparent violation of an expectancy tends to elicit components of the OR in young children. Presumably with conservers, the expectancy is that quantities do not change despite any spatial transformations they have have undergone. On the other hand, no such expectancies should arise with nonconservers. Thus when an apparent violation of conservation occurs, surprise (Charlesworth, 1969) or orientation reactions (Lewis & Harwitz, 1969) should arise in conservers but not in nonconservers. The following postulate was therefore proposed:

Postulate 3: Normal and EMR children who acquire conservation naturally, or as a function of conservation training, as determined by the presence of logical justifications of conservation (Piaget, 1947) on conservation tasks will, when confronted with an apparent violation of the principles of conservation, show more evidence of surprise or orientation reactions in terms of changes in psychophysiological and perceptual activity, than will nonconservers.

On the basis of Postulate 3 the following between group hypotheses were formulated:

Hypothesis 3A.1: Normal or EMR conservers and trained nonconservers will show, following the presentation of Task III more verbal responses attributing the apparent violations of conservation to some legerdemain.

Hypothesis 3A.2: Normal or EMR conservers and trained nonconservers will show, during the transformation outcome period (TOP), more surprise reactions than nonconservers.

The following within group hypotheses were derived from Postulate 3:

Hypothesis 3B.1: Nonconservers, whether normal or EMR, will show during the first 3 seconds of the decision period on Task III, a ratio of frequency of runs on the elements they nominate as greater (GE) and lesser (LE) similar to that shown during the equivalent time intervals on Tasks I and II, whereas conservers and trained nonconservers will show an increase in this ratio.

Hypothesis 3B.2: Nonconservers, whether normal or EMR, will show during the first 3 seconds of the decision period on Task III, a ratio of mean lengths of run on the elements they nominate as greater (GE) and lesser (LE) similar to that shown during the equivalent time intervals on Tasks I and II, whereas conservers and trained nonconservers will show an increase in this ratio.

Hypothesis 3B.3: Nonconservers whether normal or EMR, will show during the first 3 seconds of the decision period on Task III, a ratio of frequency of fixations on the elements they nominate as greater (GE) and lesser (LE) similar to that shown during the equivalent time intervals on Tasks I and II, whereas conservers and trained nonconservers will show an increase in this ratio.

Hypothesis 3B.4: Nonconservers , whether normal or EMR, will show during the first 3 seconds of the decision period on Task III, a ratio of mean lengths of fixation on the elements they nominate as greater (GE) and lesser (LE) similar to that shown during the equivalent time intervals on Tasks I and II, whereas conservers and trained nonconservers will show an increase in this ratio.

Hypothesis 3B.5: Nonconservers, whether normal or EMR, will show during the first 3 seconds of the decision period on Task III, a ratio of percentage of time spent looking at the elements they nominate as greater (GE) and lesser (LE) similar to that shown during the equivalent time intervals on Tasks I and II, whereas conservers and trained non-conservers will show an increase in this ratio.

CHAPTER 4

Method

Subjects

Two populations were involved in the proposed investigation, viz., EMR and normal children. EMR Ss were defined here as those children enrolled in opportunity classrooms within the Edmonton Public School System, who scored within the 50-85 range on the Wechsler Intelligence Scale for Children (Wechsler, 1949); who were without known organic (neurological) defects, and who showed no evidence of either sensory or emotional difficulties. Normal Ss were defined from a random sample of children attending regular first or second grade classes within the Edmonton Public School System, who showed no evidence of sensory, emotional or organic difficulties. These Ss were also administered the WISC. IQ and CA data are presented in Table 1.

In addition, all children were given standard Piagetian pretests of conservation of number and length at school. On the basis of this pretesting, three groups were selected from the above populations: natural conservers (C); trained nonconservers (T), i.e., nonconservers who were trained; and nonconservers (NC). Ss were required to give logical conservation responses on both tasks to be classified as conservers, and conversely nonconservation responses on both tasks to be classified as nonconservers. A total of 225 Ss were administered the conservation pretest and 90 Ss (45 normals and 45

Table 1

IQ and CA Data for Experimental Groups

	Normal Ss			EMR Ss		
	C	T	NC	C	T	NC
WISC Verbal Scale IQ Data						
Mean	114.67	99.27	106.27	73.60	74.40	70.27
S.D.	11.12	9.25	9.24	5.71	6.79	6.49
Range	95-135	90-115	90-120	62-81	60-83	60-80
WISC Performance Scale IQ Data						
Mean	115.40	105.00	111.60	79.13	77.60	74.33
S.D.	12.18	5.69	13.99	7.13	6.96	7.54
Range	90-136	94-115	91-133	67-85	64-84	58-84
WISC Full Scale IQ Data						
Mean	116.60	102.40	109.80	73.87	73.53	69.07
S.D.	10.23	7.06	11.13	4.73	5.84	6.58
Range	98-133	91-116	91-129	62-82	63-81	55-79
Chronological Age (CA) Data						
Mean	86.20	79.93	82.33	123.33	119.47	116.80
S.D.	8.58	6.33	7.53	13.08	15.55	17.80
Range	75-100	72-95	72-96	98-144	96-141	87-145

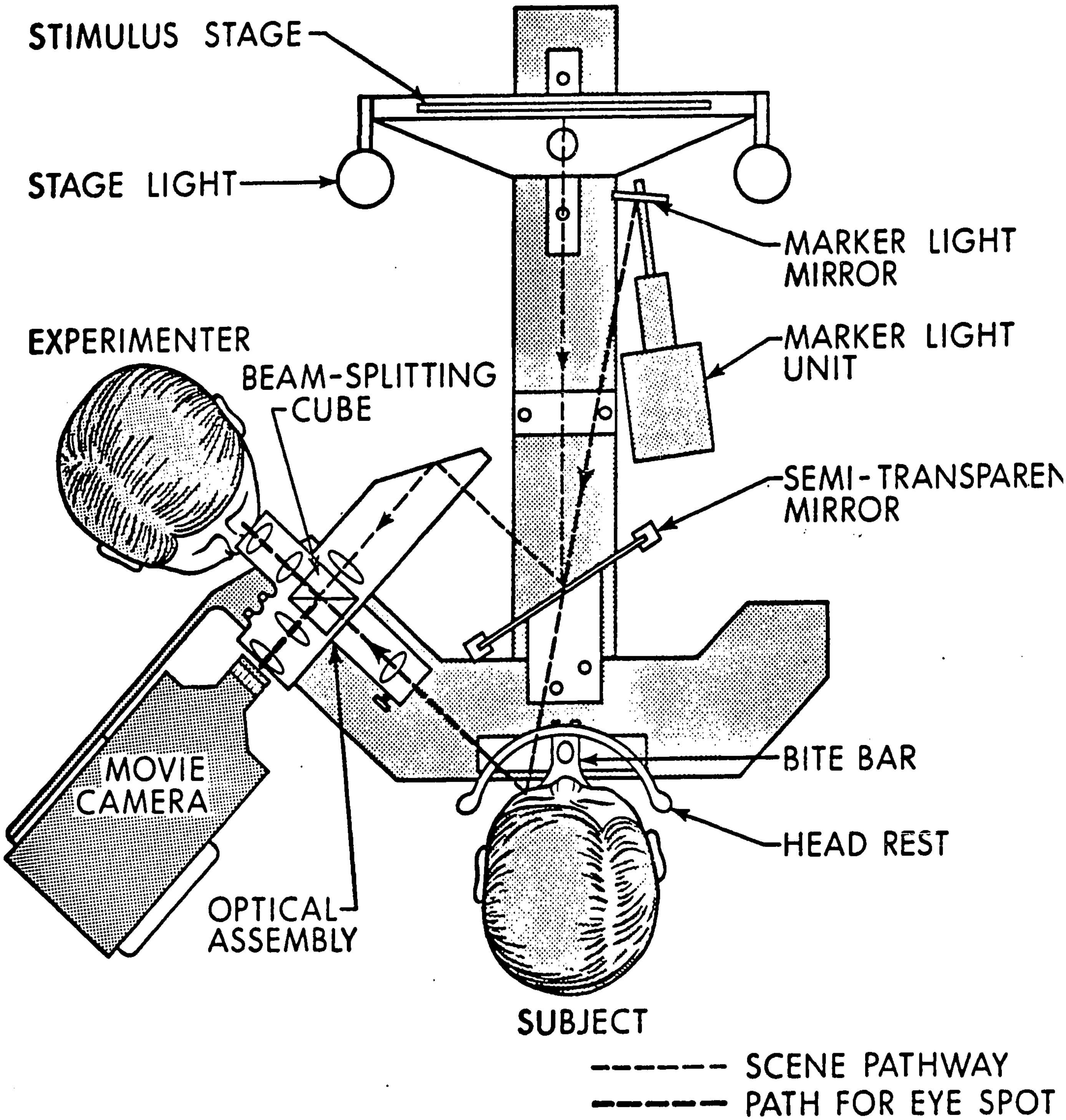
retardates — 15 in each of the three sub-groups) were selected at random within each treatment group. An attempt was made to match the groups (normal and EMR) as closely as possible on sex-ratios.

Each child's school records were examined for medical data and children who deviated significantly from the standard 20/20 vision, or who showed auditory difficulties (2.72% of the normal Ss and 26.71% of EMR Ss), were discarded from respective sample populations. Since corneal reflection EM recording techniques will not tolerate the reflective characteristics of glass, children requiring eye-glasses or contact-lenses, were not included in the samples.

Apparatus

Eye-movements were recorded by a Polymetric Model V-1164 eye-movement recorder. The recorder incorporates the use of corneal-reflections superimposed upon a photograph of the stimulus material (cf. Mackworth, 1967). The resultant corneally-reflected EMs were filmed by a Pathé "Professional" 16mm reflex camera (See Figure 2) at a constant exposure rate of 10 frames per second.

A Grass Model 5 Polygraph, integrating a Model 5E DC driver-amplifier and Models 5P1 and 5P3 low-level DC preamplifiers, was used to obtain both GSR and plethysmographic recordings. For GSR measurement, zinc electrodes of 0.34" in diameter were attached, using a zinc-sulphate paste, one to the central whorl on the distal-phalanx of the S's thumb on the non-dominant hand, and the other to a lightly sanded area of skin on the volar surface of the S's forearm



SCHEMATIC VIEW OF EYE MOVEMENT CAMERA

(nondominant side), approximately 2" from the wrist (cf. Lykken, 1959). Plethysmographic recordings were obtained by means of a Grass Model RPT-1 (light reflected) photoelectric transducer, of the type described by Weinman (1967), which was attached to the center of the S's forehead approximately 2" above the nose.

A 16mm L-W Photo-Optical Data Analyser Model 224-A was used for presentation of the laboratory stimulus material. This projector permits considerable adjustment in presentation speed, and allows presentation of "stop-action" stimulus material, together with appropriate control frames, without interruption of the testing sequence.

Task instructions were tape-recorded and presented at a constant volume through head phones attached to a Sony 4 track tape recorder.

Stimulus Materials

Two rows of six 1½" diameter (i.e., 6 red and 6 blue) plastic poker chips were used for the number conservation pretest while two 9" x ¾" strips of black cardboard were used for the length conservation pretest. Spatial transformations of these materials and those used in Tasks I and II were undertaken in the manner described by Piaget (1947).

Laboratory testing involved the movie presentation of conservation tasks. A previous study (O'Bryan & Boersma, 1971) has indicated that essentially equivalent results can be expected from movie and traditional presentations of conservation tasks. The stimulus movie had three parts. First, the standard number and length conservation problems on which training has been given were shown (Task I); then followed two transfer items continuous-quantity solid and liquid (Task II). Finally, a series of number and length conservation problems which appeared to "magically" violate the principle of conservation, together with appropriate control tasks, were presented (Task III).

Task items Ia (number conservation) and Ib (length conservation) were identical to the pretest items, except for their presentation via movie. The solid continuous quantity item, involved the presentation of two balls of plasticine of 2" diameter, one of which was rolled to form a sausage. In the liquid continuous-quantity item, two 8 oz. clear glass beakers each half filled with water were presented and the water in one of the beakers was poured into a higher and narrower 6 oz clear glass beaker.

The final section of the film (Task III) presented a series of situations in which the principle of conservation, as it relates to number (chips) and length (black cardboard strips) problems, appeared to be violated. In number conservation problems the number of chips increased in one of the rows when it was spread out, and in the length problems one of the cardboard strips lengthened as it was moved.

The assumption was made that conserving Ss would have strong expectations of conservation prior to a transformational sequence. However the possibility existed that because of these strong expectations, a number of Ss might have failed to perceive the conservation violations on their initial occurrence. Consequently, repeated presentation of these items seemed to be required. In an attempt to avoid the occurrence of a set on the part of Ss towards an expectation of change in the quantity of the transformed stimulus, several control items in which the quantity did not change (i.e., no deception was attempted) were included.

It seemed necessary to control for several factors in the task presentation order; viz., it needed to begin with violation instances of both number and length conservation; a violation instance needed to occur at the end of the series since a control item would have been unable to serve any purpose in this position; and the sequential occurrence of a long series of length or number items was to be avoided. The following presentation order was designed with these factors in mind: 1. Number conservation violation (2 rows of 6, changed to a row of 6 and a row of 8); 2. Length conservation violation (2 nine-inch strips of card were presented, and one of these became 12" long when it was moved); 3. Control item (length); 4. Number conservation violation; 5. Control item (number); 6. Control item (length); 7. Length conservation violation; 8. Control item (number); 9. Length conservation violation; 10. Number conservation violation. Data analyses were carried out on the first scorable number and length violation items in which inequality of the TE and NTE was reported. Table 2 presents an outline of violation tasks used in the analyses. Inspection of this table reveals that more than 85% of the analyses involved the first presented item.

Table 2

Frequency of Ss in each Group, According to Particular Violation Tasks Used in Analyses of EM and Psychophysiological (Psy.) Data

		Normal Ss						EMR Ss					
		N-C		N-T		N-NC		R-C		R-T		R-NC	
Items Used		N	L	N	L	N	L	N	L	N	L	N	L
First presented	EM	13	14	12	14	13	14	7	15	11	12	13	13
	Psy.	13	15	13	15	15	15	10	15	11	14	15	15
Second presented, because equality perceived on 1st	EM	2	--	2	--	--	--	5	--	4	1	--	--
	Psy.	2	--	2	--	--	--	5	--	4	1	--	--
Second presented because first unscorable	EM	--	1	--	1	2	1	2	--	--	1	2	2
	Psy.	--	--	--	--	--	--	--	--	--	--	--	--
Third presented because first and second unscorable	EM	--	--	1	--	--	--	1	--	--	1	--	--
	Psy.	--	--	--	--	--	--	--	--	--	--	--	--

The *three-week retention tests* involved the nonmovie presentation of Tasks I and II.

Testing Procedure

After initial individual pretesting, the children were transported (4 per day) to the University. In the laboratory, the *Ss* were tested individually. They were seated comfortably, fitted with a bite-bar to minimize head-movements during EM photography, and the GSR electrodes and photoelectric transducer were attached. The eye-movement recorder was then positioned and calibrated and Tasks I, II and III were administered. In Studies 2 and 4, *Ss* were individually readministered Tasks I and II at school, approximately 3 weeks after their laboratory session.

Tasks I, II and III were presented on 16 mm black and white movie film, which was rear-projected on to a 7.8" x 7.8" stimulus viewing screen. The screen was positioned on a horizontal plane approximately 24" in front of the *S's* eyes.

In an attempt to standardize presentation techniques, control for experimenter interaction, and facilitate filming EMs and collection of GSR and plethysmographic data, the movie presentations were synchronized with taped verbal instructions. In addition, before any data was collected, a series of 35 mm slides of Stanford-Binet Picture Absurdity Tasks (Terman & Merrill, 1960) was presented and *Ss* were trained to close their eyes, when they had solved each problem.

Because pilot investigations had indicated consistently strong surprise reactions to taped verbal instructions in both normal and EMR Ss, and because the present study was additionally concerned with the presence or absence of surprise reactions as a function of the various stimulus transformations, a minor modification in the questioning procedure of O'Bryan and Boersma (1970) was necessary. Whereas in their study the conservation question was asked immediately following the stimulus transformation, in the present study Ss were questioned prior to stimulus transformation. Thirty Ss were selected at random from the experimental population, and a check was made for retention across the question - decision interval. No fade was apparent in any of the treatment groups.

Within Task I, the number conservation problem (Item Ia) was followed by the length problem (Item Ib). The Ss were asked each conservation question prior to the stimulus transformation period and were instructed to close their eyes when they had reached a post transformation decision. During the decision-period, the S's EMs in relation to the stimulus display, were filmed. After the Ss had made a decision, photography of EMs ceased and the S's verbal responses were tape-recorded. The same procedure was followed during the presentation of Task II, with the solid and liquid continuous quantity tasks presented in that order. EM, psychophysiological and verbal data were recorded as outlined above during the presentation of Task III. Control psychophysiological data, were collected during the presentation of Task I.

Scoring Procedure

EM data was scored according to the position of each fixation point in relation to the TE and the NTE. However a number of frames were present in which the corneal reflection was indefinable, blurred, or not apparent (e.g., as a result of a blink, or a very rapid EM). The scoring of these frames was estimated as follows:

> All fixation points in the first half of a sequence of frames (X) which was to be interpolated, were estimated as being in the same area as the fixation point immediately preceding X. All fixation points in the latter half of X were estimated as being in the same area as the fixation point immediately following X. Where X was an odd number of frames, the extra frame was added to the second half of X.

It was decided that any S who showed more than 10% interpolated data on any task would be eliminated from the study. No Ss were eliminated on this basis. A random sample of 20 EM records were analysed by two independent observers, and over 95% agreement was obtained.

Psychophysiological data was scored in terms of the definitions listed in Chapter 3.

General Design

The present investigation consisted of a series of four comparative studies of perceptual activity and surprise reactions, viz., 1. comparison between normal conservers and normal nonconservers;

2. comparison between trained normal nonconservers and normal nonconservers; 3. comparison between EMR conservers and EMR nonconservers; 4. comparison between trained EMR nonconservers and EMR nonconservers (see Figure 3). Studies 1 and 3 were comparative investigations, while Studies 2 and 4 were experiments which incorporated the Pretest-Posttest Control Group Design (Campbell & Stanley, 1963).

As previously mentioned, Ss were pretested in the schools and three normal and three EMR groups were selected. The T groups received two training sessions on two consecutive mornings at school. In the afternoon, following the second training session, they were transported to the University where the experimental tasks were presented, and verbal and psychophysiological response data collected. Data from the C and the NC groups were also collected during this time, but none of these groups received any training beforehand except the eye-closing conditioning sessions.

An attempt was made to control for variations in intrasession history (Campbell & Stanley, 1963). Each of the six experimental groups was divided into two subgroups which contained approximately half of the Ss in each group. The resulting twelve subgroups were run in a counterbalanced order as follows: 1. Normal Conservers-Subgroup 1; 2. Normal Nonconservers-Subgroup 1; 3. EMR Conservers-Subgroup 1; 4. EMR Nonconservers-Subgroup 1; 5. Normal Trained Nonconservers-Subgroup 1; 6. EMR Trained Nonconservers-Subgroup 1; 7. EMR Trained Nonconservers-Subgroup 2; 8. Normal Trained Nonconservers-Subgroup 2;

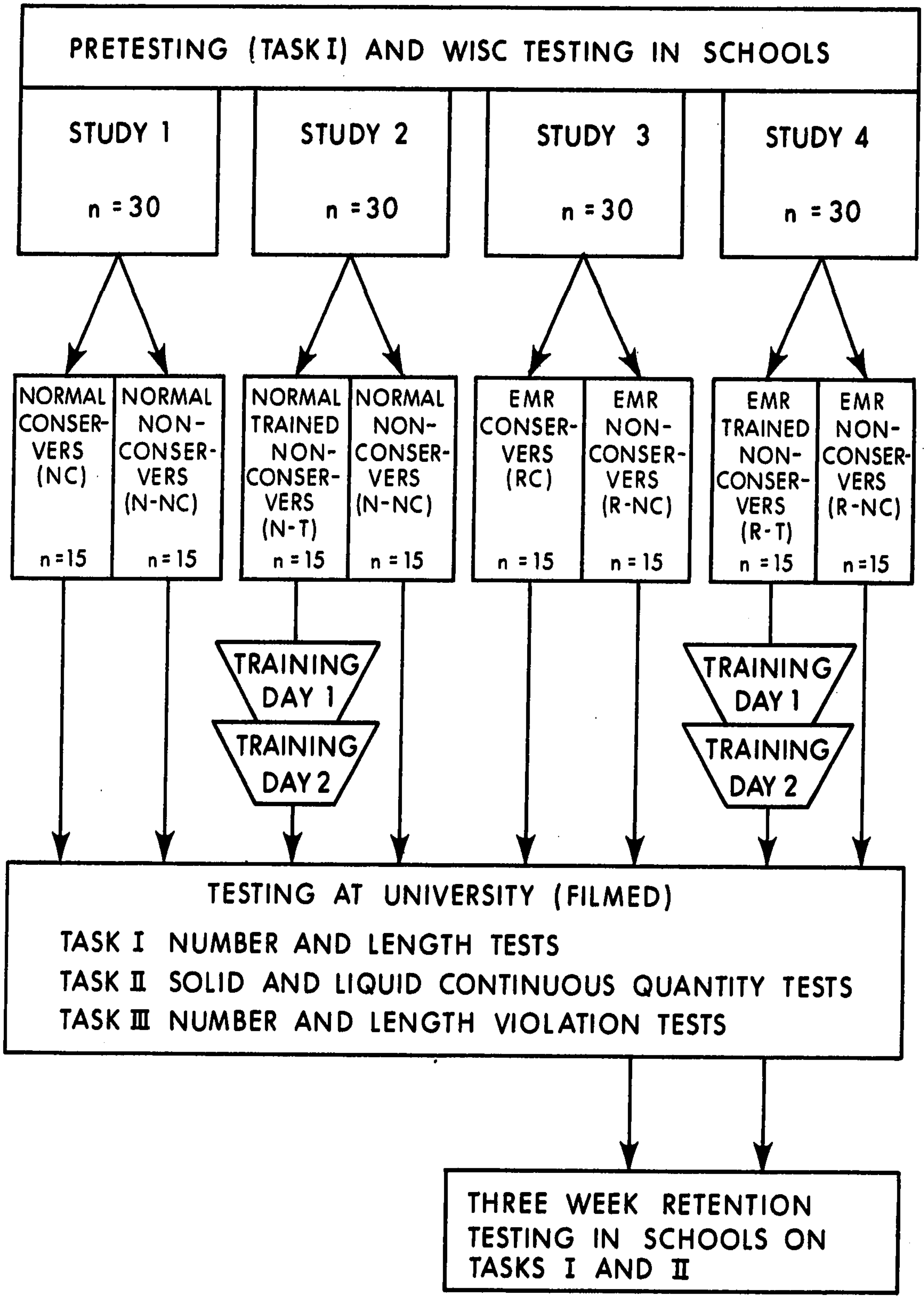


Fig. 3. OUTLINE OF EXPERIMENTAL PROCEDURE

9. EMR Nonconservers-Subgroup 2; 10. EMR Conservers-Subgroup 2; 11. Normal Nonconservers-Subgroup 2; 12. Normal Conservers-Subgroup 2. Two weeks after their laboratory visit, the T and the NC groups were readministered the posttests (number and length) and the transfer tests (solid and liquid - continuous quantity) at school. Figure 3 presents an outline of the experimental procedure.

Statistical Analyses

Preliminary between-group comparisons were made for each study on several types of performance data. Latency to decision data was analysed using t tests for independent samples (Winer, 1962, pp. 30-33). Homogeneity of variance was tested using the F test for variances from independent samples (Ferguson; 1966, pp. 181-182). Where the assumption of homogeneity of variance appeared untenable, Welch's t' (Welch, 1947) was calculated. Analyses of frequency of unscorable frames of EM data were undertaken using a 2 X 3 analysis of variance design with repeated measures on the second factor. Groups (conserver, trained nonconserver or nonconserver - depending on the study) was the non-repeated factor and Tasks (I, II and III) were the repeated measures. Since homogeneity of covariance is a critical assumption in repeated measures designs, and since this requirement is seldom met, the Greenhouse and Geisser procedure for degrees of freedom adjustment was following in testing all main and interaction effects involving repeated measures (Winer, 1962, pp. 305-6). In Studies 2 and 4, frequency of logical conservation responses on Tasks I and II, in both the laboratory tests and 3 week retention tests, were compared using the z test for independent proportions (Ferguson, 1966, p. 177).

Between group hypotheses were tested using a 2 X 2 analysis of variance design with repeated measures on the second factor. As above, Groups (conserver, trained nonconserver or nonconserver - depending on the study) was the nonrepeated factor, and Tasks (I and II for Hypotheses 1A.1 - 2A.5) were the repeated measures. The z test for independent proportions (Ferguson, 1966, p. 177) was used for testing Hypotheses 3A.1 and 3A.2.[1]

A number of additional exploratory between-group analyses were also undertaken, in an attempt to examine the performance of the groups in more detail with respect to the TE and the NTE. These analyses also involved a 2 (Groups) X 2 (Tasks) analysis of variance design with repeated measures on the second factor as specified above. The following variables were analysed in this way: frequency of runs on the TE, frequency of runs on the NTE, mean length of run on the TE, mean length of run on the NTE, frequency of fixations on the TE, frequency of fixations on the NTE, mean length of fixation on the TE, mean length of fixation on the NTE, examination time on the TE, and examination time on the NTE. These variables were also analysed for Tasks I and III, and in addition exploratory analyses were undertaken on frequency of couplings, total runs over both elements, total mean length of run over both elements, total fixations over both elements, total mean length of fixation over both elements, prefilm conductance

[1]All t and z tests of experimental hypotheses involved one-tailed values, whereas two-tailed tests were used for exploratory analyses.

level, maximum conductance change, conductance difference, latency to GSR onset, latency to GSR peak, mean blood volume change, mean blood volume pulse change and mean heart rate change.

Within group Hypotheses 1B.1 - 3B.5 were tested using the t test for correlated samples (Winer, 1962, pp. 39-42).

CHAPTER 5

Results and Discussion

Appendices

Appendix A

In an attempt to achieve maximum clarity and parsimony in the presentation of the experimental results, the means for each dependent variable measure of EM, psychophysiological and performance data are presented in Tables A (normal Ss) and B (EMR Ss). Means are listed for each task item (i.e., Ia, Ib, IIa, IIb, IIIa, and IIIb) and for each task, i.e., I/2, II/2 and III/2. Task means were obtained by summing over each pair of items for each task and dividing by two. The analyses reported in Chapter 5 and in Appendix B are based on task means, and row and column means associated with 2 X 2 analysis of variance designs may be obtained from Table A and B values, by summing over the two tasks involved and dividing by two.

Appendix B

In addition to the analyses reported in Chapter 5, a number of exploratory analyses (no hypotheses were formulated) were undertaken. It was suspected that these analyses would yield similar results to those for which hypotheses were formulated. This appeared to be the case. Consequently to avoid redundancy the results of these analyses are reported in dialogue form in Appendix B, and findings which appear to have relevance for a particular study are incorporated into the results section of each study.

Performance and Training Data

Latency to task solution data in seconds is presented in Tables A and B (Appendix A). Normal conservers (N-C) took significantly longer to reach task decisions than normal nonconservers (N-NC) on Task I ($M_{nc} = 19.30$, $M_{nnc} = 11.18$; $t' = 3.34$, $df = 28$, $p < .01$) and Task III ($M_{nc} = 15.97$, $M_{nnc} = 7.82$; $t' = 3.18$, $df = 28$, $p < .01$)[1]. Similar but nonsignificant intergroup differences were obtained on Task II. Normal trained nonconservers (N-T) showed a significantly longer latency to decision on Task I than normal nonconservers ($M_{nt} = 18.03$, $M_{nnc} = 11.18$; $t' = 2.22$, $df = 28$, $p < .05$), but intergroup differences on Tasks II and III, although in the same direction, were nonsignificant.

EMR conservers (R-C) tended to take longer in reaching task decisions than EMR nonconservers (R-NC) on all three tasks, but none of these differences between the groups on Tasks were significant. EMR trained nonconservers (R-T) showed longer decision latencies than EMR nonconservers on Task II ($M_{rt} = 14.61$, $M_{rnc} = 8.74$; $t' = 2.51$, $df = 28$, $p < .05$), but differences between the groups on Tasks I and III, while in the same direction, were nonsignificant. In general, it is evident that conservers and trained nonconservers in both normal and EMR groups, tended to spend longer reaching a decision on the tasks, than nonconservers.

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[1]For ease of presentation of means, lower case letters without hyphens are used to denote groups.

Since there were considerable differences between the groups in terms of task decision latencies, any intergroup differences there may be in EM dependent variables taken over total solution time, would have been confounded with decision latency. Consequently, analyses on the data in terms of a constant time interval rather than the total solution period, seemed indicated. The first three seconds of the decision period seemed the best available time interval for this purpose on the basis of previous research (Boersma, Muir, Wilton & Barham, 1969; O'Bryan & Boersma, 1970).

Analyses of data on frequency of unscorable frames as a function of studies during the first three seconds of the decision period revealed no significant differences between experimental groups (see Tables A and B). Furthermore, in no case did the percentage of missing data arising from short decision latencies, exceed four percent per group. Thus, the first three seconds of the decision period yielded a high proportion of scorable data for each group, and consequently it was decided to adopt this unit as the constant time interval for the analyses of the EM data.

An evaluation of the conservation acceleration training procedure in terms of verbal data was also made. Percentages of logical conservation responses on Tasks I and II for studies 2 and 4 were accordingly analysed. On the laboratory tests, trained normal nonconservers showed a significantly higher proportion of logical conservation responses than normal nonconservers (Task I: N-T = 80%, N-NC = 0.00%, $z = 7.81$, $p < .0001$; Task II: N-T = 47%, N=NC = 0.00%, $z = 4.87$, $p < .0001$) and trained EMR nonconservers showed more logical conservation responses than EMR nonconservers (Task I: R-T = 100%, R-NC = 0.00%, z = 7.81, $p < .0001$) Task II: R-T = 57%, R-NC = 0.00%, z = 4.89, $p < .0001$).

A similar pattern was evident on the three week retention tests. Here trained normal nonconservers showed more logical conservation responses than normal nonconservers (Task I: N-T = 77%, N-NC = 3%, z = 5.79, $p < .0001$; Task II: N-T = 53%, N-NC = 0.00%, z = 4.61, $p < .0001$), and trained EMR nonconservers showed significantly more logical conservation responses than EMR nonconservers (Task I: R-T = 97%, R-NC = 10%, z = 6.71, $p < .0001$; Task II: R-T = 80%, R-NC = 7%, z = 5.78, $p < .0001$). It was thus concluded that the training procedure had been effective with respect to Piaget's three training criteria (permanence and generalizability of behavioral changes, and apparent cognitive structural changes) in terms of verbal response data in both normal and EMR nonconservers, and analyses of EM and psychophysiological data for Studies 2 and 4 seemed meaningful and were undertaken.

Table 3 presents a summary of the percentages of <u>Ss</u> in each group who recognized the conservation violations. It is apparent in both normal and EMR <u>Ss</u> that a relatively high percentage of conservers and trained nonconservers, and a relatively low percentage of non-conservers, recognized the violations of conservation. Moreover, as expected, the first presented number and length violation items seemed to differentiate the groups most clearly. In the light of these observations, more detailed analyses of verbal responses and

Table 3

Percentage of Ss Recognizing Conservation Violations

	Normal Ss			EMR Ss		
	C	T	NC	C	T	NC
Violations of Number Conservation						
Task III.1	1.00	0.60	0.20	0.60	0.60	0.06
Task III.4	1.00	0.66	0.43	0.80	0.79	0.28
Task III.10	1.00	0.70	0.46	0.86	0.79	0.28
Violations of Length Conservation						
Task III.2	1.00	0.80	0.13	0.86	0.72	0.33
Task III.7	1.00	0.80	0.21	0.92	0.86	0.43
Task III.9	1.00	0.80	0.23	1.00	0.92	0.50

"surprise-reactions" following the first recognized number and length conservation violations seemed indicated and were made.

Study 1: Perceptual Activity and Surprise Reactions in Normal Conservers and Normal Nonconservers

Results

Conservation Tasks. A Tasks (I and II) by Groups (N-C and N-NC) analysis of variance with repeated measures on Tasks, was used for between group analyses of general perceptual activity. The following results were obtained. Conservers, in comparison with nonconservers, showed more couplings ($M_{nc} = 3.42$, $M_{nnc} = 1.79$; $F = 15.373$, $df = 1/28$, $p < .001$), more runs over both elements ($M_{nc} = 2.14$, $M_{nnc} = 1.69$; $F = 4.516$, $df = 1/28$, $p < .05$), and a longer mean length of run in one tenth second units, over both elements ($M_{nc} = 12.83$, $M_{nnc} = 18.33$; $F = 10.491$, $df = 1/28$, $p < .01$), more fixations over both elements ($M_{nc} = 10.87$, $M_{nnc} = 8.15$; $F = 12.329$, $df = 1/28$, $p < .01$) and a shorter mean length of fixation in one tenth second units, over both elements ($M_{nc} = 3.11$, $M_{nnc} = 4.19$; $F = 10.491$, $df = 1/28$, $p < .01$). No significant Task or interaction effects were obtained. Thus Hypotheses IA.1 - 1A.5 (which refer to NNC), and Hypotheses 2A.1 - 2A.5 (which refer to NC) are supported, and a clear differentiation between normal conservers and normal nonconservers in terms of general perceptual activity seems indicated.

Within group differences in task performance in relation to the TE and NTE on Tasks I and II were analysed using correlated t tests. For each S, data was summed over task items (i.e., over items Ia, Ib, IIa and IIb) and divided by four. These scores were then used as "raw scores" from which group means for the correlated t tests were calculated. Table 4 summarizes these results.[2] More specifically these analyses revealed that nonconservers made significantly more runs on the GE ($t = 2.34$, $df = 14$, $p < .05$), had a shorter mean length of run in one tenth second units on the GE ($t = 1.97$, $df = 14$, $p < .05$), made significantly more fixations on the GE ($t = 2.59$, $df = 14$, $p < .05$), had a longer mean length of fixation in one tenth second units on the GE ($t = 1.85$, $df = 14$, $p < .05$) and spent a significantly larger amount of examination time (tenths of seconds) on the GE ($t = 2.28$, $df = 14$, $p < .05$). Similar analyses for conservers failed to yield significant differences. These results provide support for Hypotheses 1B.1 - 1B.5 and 2B.1 - 2B.5, thus suggesting that conserving and nonconserving Ss showed clearly different patterns of centrative perceptual activity.

Exploratory analyses of perceptual activity were undertaken using the Tasks by Groups analysis of variance design. Appendix B - Study 1 presents the results in detail. Specifically, it appears that conservers showed more active perceptual behavior and did not "center"

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[2]In Tables 4 and 6, the terms GE and LE are used to denote the elements erroneously perceived by the nonconservers as greater and lesser in quantity (2 normal and 2 EMR nonconservers perceived the NTE as greater).

Table 4

Summary of Correlated t Tests on Task I & II EM Data for Normal *Ss*

	Nonconservers (N-NC)				Trained Nonconservers (N-T)				Conservers (N-C)			
	$\overline{GEX}$[a]	$\overline{LEX}$[b]	t	p	$\overline{TEX}$[c]	$\overline{NTEX}$[d]	t	p	$\overline{TEX}$	$\overline{NTEX}$	t	p
Number of runs	1.50	1.07	2.34	**	1.68	1.55	0.52	NS	1.67	1.47	0.60	NS
Mean length of run	20.64	12.77	1.97	*	14.17	14.13	0.01	NS	11.44	13.00	0.52	NS
Number of fixations	7.60	4.82	2.59	*	8.55	7.72	0.77	NS	8.00	8.28	0.25	NS
Mean length of fixation	5.76	4.37	1.85	*	4.29	3.91	1.03	NS	4.34	3.93	0.89	NS
Amount of Examination time	23.73	14.40	2.28	*	19.28	17.60	0.49	NS	17.05	16.48	0.15	NS

[a] $\overline{GEX}$ Mean value on element chosen as greater
[b] $\overline{LEX}$ Mean value on element chosen as lesser
[c] $\overline{TEX}$ Mean value on transformed element
[d] $\overline{NTEX}$ Mean value on non-transformed element

* $p < .05$
** $p < .01$
NS Not significant at .05 level

on a particular element. These results are similar to those discussed above and probably reflect similar aspects of perceptual behavior.

Violation Tasks. Analyses of these data are presented in three sections: a) in terms of the variables which seem most crucial to this aspect of the study, namely, verbal reports and "surprise reactions"; b) in terms of within group analyses of EM data, i.e., inter-element comparisons; and c) in terms of exploratory between group (N-C vs N-NC) comparisons of specific psychophysiological and EM measures (Appendix B - Study 1).

A comparison between the N-C and N-NC groups on verbal responses to violation items, revealed that 100% of the conservers attributed the apparent conservation violations to some legerdemain, whereas only 16% of the nonconservers responded in this way ($z = 6.56$, $p < .0001$), thus providing strong support for Hypothesis 3A.1.

A substantially higher percentage of "surprise reactions" (the simultaneous occurrence during the TOP of a GSR conductance change, a cephalic blood volume increase and a heart rate decrease) was obtained from conservers (N-C = 53%, N-NC = 17%; $z = 2.98$, $p < .005$) than from nonconservers. Strong support was thus gained for Hypothesis 3A.2, and in view of the intergroup differences on verbal responses, it would appear that the occurrence of "surprise reactions" closely reflects the recognition of conservation violations.

Table 5 presents within group analyses of EM data on Task III. The results indicate with respect to the TE and NTE, that conservers made more runs on the TE ($t = 3.68$, $df = 14$, $p < .01$), had a significantly longer mean length of run in one tenth second units, on the TE ($t = 2.93$, $df = 14$, $p < .01$), made more fixations on the TE ($t = 5.13$,

Table 5

Summary of Correlated t Tests on Task III EM Data for Normal Ss

	Nonconservers				Trained Nonconservers				Conservers			
	$TE\bar{X}$[a]	$NTE\bar{X}$[b]	t	p	$TE\bar{X}$	$NTE\bar{X}$	t	p	$TE\bar{X}$	$NTE\bar{X}$	t	p
Number of runs	1.43	1.10	1.11	NS	1.53	1.23	1.26	NS	1.97	1.17	3.68	**
Mean length of run	22.90	11.26	1.95	*	21.12	12.65	1.63	NS	24.91	9.01	2.93	**
Number of fixations	8.60	5.23	1.94	*	9.07	6.07	1.81	*	12.77	5.67	5.13	***
Mean length of fixation	4.22	2.83	1.70	NS	4.53	3.53	1.52	NS	3.85	2.40	1.96	*
Amount of Examination time	26.00	14.80	1.73	NS	23.73	14.67	1.65	NS	30.37	11.23	3.70	**

[a] $TE\bar{X}$ Mean value on transformed element

[b] $NTE\bar{X}$ Mean value on non-transformed element

* $p < .05$

** $p < .01$

*** $p < .001$

NS Not significant at .05 level

df = 14, $p < .001$), had a longer mean length of fixation in one tenth second units on the TE ($t = 1.96$, df = 14, $p < .05$), and spent a greater amount of examination time (tenths of seconds) on the TE ($t = 3.70$, df = 14, $p < .01$). Nonconservers showed a significantly shorter mean length of run in one tenth second units on the TE ($t = 1.95$, df = 14, $p < .05$), and more fixations on the TE ($t = 1.94$, df = 14, $p < .05$), but none of the other differences were significant. Inspection of Table 4 in conjunction with Table 5 reveals that non-conservers tend to centrate on the TE in both cases with the strongest effect being associated with Table 4. More interesting however is the marked contrast evident in the case of conservers. Here for Task III, all dependent variables showed significant effects, whereas none were significant on Table 4. Thus support was obtained for Hypotheses 3B.1 - 3B.5, indicating that in comparison with nonconservers, conservers showed greater changes in centrative perceptual activity on the violation tasks.

Exploratory analyses of violation task EM and psychphysiological data are presented in Appendix B - Study 1. The analyses of individual psychophysiological dependent variables for all practical purposes revealed no consistent intergroup differences. The only significant finding was associated with mean BVP change and this was probably a chance occurrence.

One finding which emerged from exploratory analyses of general perceptual activity during violation tasks, was that conservers showed more couplings on Tasks I and III than nonconservers. A more interesting and probably more important finding however, was that conservers showed a significant decrease in couplings during the conservation violation tasks. Specifically, they tended to spend more time examining the legerdermain element, thus suggesting that both groups were now focussing on the TE, although probably for different reasons. Conservers over both tasks, also showed more fixations, which seems to indicate that their perceptual activity, at least in terms of fixations, was greater than that of nonconservers. Conservers compared with nonconservers, also showed greater increases in frequency of fixations, mean length of run and amount of examination time, on the TE, during Task III. In addition a task effect, with violation tasks eliciting more perceptual activity in terms of fixations for both groups was evident. In short, conservers showed fewer couplings on violation tasks; it would appear that exploration of the TE had increased for Ss who noticed the violation. Actual statistical data is presented in Appendix B - Study 1. These results are consistent with the results of within group analyses reported above.

In short, the following results emerged from Study 1. Conservers in comparison with nonconservers, showed predicted differences in general and centrative perceptual activity on conservation tasks. Predicted intergroup differences in verbal and "surprise reactions" to conservation violations were also obtained, and in conservers these reactions were accompanied by predicted changes in centrative perceptual activity.

Discussion

The results of between and within group analyses of Task I and II EM data provided strong support for Hypotheses 1A.1 - 1A.5 and 2A.1 - 2A.5, and for Hypotheses 1B.1 - 1B.5 and 2B.1 - 2B.5. These findings appear to indicate that in terms of corneally reflected EMs, the general perceptual behavior of conservers is considerably more active than that of nonconservers, and that the lesser perceptual activity of nonconserving Ss is accompanied by a tendency on their part to "center" or fixate significantly longer and more often on the element judged to be greater following transformation. It is thus concluded that Postulates Ia, Ib, IIa, and IIb are tenable. These results seem consistent with Piaget's (1947, 1970) distinctions between the perceptual/attentional concomitants of preoperational and operational thinking, and replicate the findings of O'Bryan and Boersma (1970).

The conservation violation tasks also differentiated the groups in the predicted direction. The marked differences between the groups in terms of their verbal responses to the apparent violations of conservation, suggest that the expectancies of the conservers and non-conservers with respect to the possible transformation outcome, were very different prior to the completion of the transformation. All of the conservers reported that something "wrong" had occurred, and they attributed the violation to legerdemain. On the other hand, almost all of the nonconservers gave the usual nonconservation response and rationale (c.f., Table A).

The differences between the groups in terms of "surprise reactions", indicate that during the TOP on conservation violation tasks, psychophysiological activity differentiated conserving and non-conserving Ss. With respect to EMs, the within group analyses of Task III data revealed a number of marked changes in the conservers' centrative perceptual activity, whereas little or no change was apparent in nonconservers. As predicted, the changes in conservers' centrative perceptual activity involved substantial increases in the duration and frequency of fixations and runs on the TE (i.e., the element which was manipulated to appear greater), and in the percentage of time spent looking at the TE. Although the centrative perceptual activity of conservers on Task III appeared to be similar to that shown by nonconservers, there were probably very different reasons for each group's performance. Nonconservers probably showed more perceptual activity on the TE because as in conservation tasks, this element appeared to be greater (Piaget, 1961) following transformation. In the case of conservers however, the increase in perceptual activity on the TE was probably a function of their recognition of conservation violation. Alternatively, since the violation tasks required "accommodation" on the part of conservers, and since any conservation task requires "accommodation" on the part of nonconservers, the obtained result may be reflective of accommodative perceptual activity. The results of exploratory analyses in terms of general perceptual activity and of additional EM data on Tasks I and III also reflect these changes noted in centrative perceptual activity. It is thus concluded that Postulate III is tenable. The obtained result provides considerable support for Charlesworth's (1964a, 1969) and Lewis and Harwitz's (1969) contentions regarding the utility of surprise and orientation reactions as nonverbal indices of cognitive structural change.

Piaget's (1947, 1962, 1970) position is also strongly supported in that there appear to be marked differences in the cognitive functioning of conserving and nonconserving Ss following apparent conservation violations. Presumably, surprise reactions are mediated by cortical activity and it seems highly likely that the occurrence of such reactions closely reflects the cognitive structural changes which, according to Piaget (1947), accompany the acquisition of conservation.

It would appear that the individual psychophysiological dependent variables did not differentiate the groups, except in the case of mean BVP change. If mean BVP change was an index of surprise, a greater mean BVP would be predicted from conservers and from both groups on Task III. The obtained results were however in the reverse direction. In view of the minimal differences which were obtained on all other individual psychophysiological dependent variables, it is suggested that these results are probably a chance finding, and hence of little theoretical significance. The occurrence of intergroup differences in "surprise reactions" in the absence of similar differences in individual psychophysiological dependent variables, is not inconsistent with the general direction of Western and Russian research on the OR, which has tended to underline the importance of multiple related psychophysiological, indices, rather than single isolated psychophysiological reactions.

General and centrative perceptual activity and "surprise reactions" thus seem to be useful supplementary indicators of cognitive structural development and, when accompanied by verbal data, they should lead to more adequate evaluations of conservation acceleration attempts.

Study 2: Perceptual Activity and Surprise Reactions in Trained Normal Nonconservers and Normal Nonconservers

Results

Conservation Tasks. A two way (Groups by Tasks) analysis of variance with repeated measures on Tasks (I & II), was used for between group analyses of EM data, and the following results were obtained. In comparison with normal nonconservers (N-NC), the trained normal nonconservers (N-T) showed more couplings (M_{nt} = 2.90, M_{nnc} = 1.79; $F = 9.493$, $df = 1/28$, $p < .01$), more runs over both elements (M_{nt} = 2.17, M_{nnc} = 1.69; $F = 6.316$, $df = 1/28$, $p < .05$), a shorter mean length of run in one tenth second units, (M_{nt} = 13.10, M_{nnc} = 18.33; $F = 10.555$, $df = 1/28$, $p < .01$), more fixations over both elements (M_{nt} = 10,55, M_{nnc} = 8.15; $F = 7.404$, $df = 1/28$, $p < .05$), and a shorter mean length of fixation in one tenth second units over both elements (M_{nt} = 3.27, M_{nnc} = 4.19; $F = 6.462$, $df = 1/28$, $p < .05$). Both groups showed more fixations on Task I (M_I = 9.98, M_{II} = 8.72; $F = 4.301$, $df = 1/28$, $p < .05$). No other

Task or interaction effects were significant. For all practical purposes, N-T Ss showed the same type of general perceptual activity as that of N-C Ss in Study 1. Consequently, Hypotheses 1A.1 - 1A.5 (which refer to N-NC Ss) and Hypotheses 2A.1 - 2A.5 (which refer to N-T Ss) are supported, and marked differences between N-T and N-NC Ss with respect to general perceptual activity, are apparent.

Correlated t-tests were used for within (TE vs. NTE) group analyses of EM data in relation to the TE and NTE, on Tasks I and II. For each S data was summed over tasks (i.e., items Ia, Ib, IIa and IIb) and divided by four as in Study 1. These results are summarized in Table 4 (page 73). As in Study 1, N-NC Ss showed more runs on the GE ($t = 2.34$, $df = 14$, $p < .05$), had a shorter mean length of run in one tenth second units on the GE ($t = 1.97$, $df = 14$, $p < .05$), made significantly more fixations on the GE ($t = 2.59$, $df = 14$, $p < .05$), had a shorter mean length of fixation in one tenth second units on the GE ($t = 1.85$, $df = 14$, $p < .05$) and spent a significantly larger amount of examination time (tenths of seconds) on the GE ($t = 2.28$, $df = 14$, $p < .05$).[3] In the case of N-T Ss however, none of the TE-NTE differences were significant. Thus Hypotheses 1B.1 - 1B.5 and 2B.1 - 2B.5 are supported, and distinct N-T and N-NC intergroup differences in centrative perceptual activity are evident. The more interesting finding however, is that centrative perceptual activity of N-T and N-C Ss is very similar, thus indicating that EM patterns of trained nonconservers closely resemble those of natural conservers.

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[3]The results reported for N-NC Ss are identical to those reported in Study 1 since they involve the same Ss.

The above mentioned Groups by Tasks analysis of variance design was used for exploratory analyses of perceptual activity. These analyses which are reported in Appendix B - Study 2, indicated differential perceptual activity on the part of N-T and N-NC Ss. Specifically, it appears that N-T Ss showed more active perceptual behavior and were not centering on a particular element. These results seem consistent with those obtained from the above analyses, and are probably reflective of similar aspects of perceptual behavior. At the same time, the obtained results are very similar to those obtained in Study 1, thereby indicating that the perceptual activity of N-T Ss, closely resembled that of N-C Ss.

Violation Tasks. The presentation of the results of violation task data will follow the format adopted for Study 1.

Verbal responses to violation items clearly differentiated the groups. Significantly more N-T than N-NC Ss attributed the apparent conservation violations to legerdemain (M_{nt} = 73%, M_{nnc} = 16%; $z = 4.41$, $p < .0001$). Thus considerable support is provided for Hypothesis 3A.1.

N-T Ss showed significantly more "surprise reactions" than N-NC Ss (N-T = 43%, N-NC = 16%; $z = 2.25$, $p < .025$), thus supporting Hypothesis 3A.2. A similar trend to that obtained in Study 1 seems evident. The occurrence of "surprise reactions" again appears to be closely related to conservation violation recognition.

Within group analyses of Task III EM data in terms of the TE and NTE, which involved the use of correlated t tests, are summarized in Table 5 (page 75). N-T Ss showed more fixations on the TE ($t = 1.81$, $df = 14$, $p < .05$), an effect which was not noticeable for Task I and II (see Table 4). For N-NC Ss on Task III, a centration effect similar to that observed in the analyses of Task I and II EM data was evident. Inspection of Tables 4 and 5 shows that although only two inter-element differences are significant in Table 5, the larger mean measure of centrative perceptual activity in all cases is associated with the GE in both tables. None of the other inter-element differences for the N-T group was significant. The results for N-NC Ss are identical to those discussed in Study 1, since the same Ss were involved. Thus Hypothesis 3B.3 is supported in that N-T Ss showed an increase in the TE-NTE fixation ratio whereas N-NC Ss did not. The fact however, that the remaining 3B hypotheses were not supported suggests that the fixation finding should be interpreted with reservations.

Individual psychophysiological dependent variables as in Study 1, did not differentiate the groups, and again these findings seem to bear very little relationship to the Task III intergroup verbal response and "surprise reaction" differences reported in Study 2 (see Table A for specific mean values).

In comparison with Task I and II results, N-T Ss on Task III showed several changes in perceptual activity in relation to the TE and the NTE. Specifically, they no longer made more runs on the NTE, nor did they continue to have a shorter mean length of run, fixation and examination time period on the TE. Thus it appears that N-T Ss noticed the conservation violation and modified their perceptual behavior accordingly, whereupon their perceptual activity became very similar to that shown by the N-NC Ss. Mean length of fixation over both elements decreased for N-NC Ss and increased for N-T Ss during Task III. This result suggests that during Task III the perceptual activity of N-NC Ss may at that stage have been more variable in terms of foveation whereas it seems likely that N-T Ss had increased their perceptual activity on the TE. This contention receives considerable support from the previously discussed within group and exploratory between group analyses of EM data on Task III. Moreover these results seem consistent with those reported in Study 1.

In summarizing the results of Study 2, the following points seem important. Trained and untrained normal nonconservers showed predicted differences in general and centrative perceptual activity on conservation tasks. On conservation violation tasks, predicted inter-group differences in verbal and "surprise reactions" were also obtained, and in trained normal nonconservers these reactions were accompanied by one predicted change in centrative perceptual activity and by several changes in general perceptual activity.

Discussion

Strong support was obtained for Hypotheses 1A.1 - 1A.5, and 2A.1-2A.5 and for Hypotheses 1B.1 - 1B.5 and 2B.1 - 2B.5, from between and within group analyses of EM data on Tasks I and II. Consequently, in terms of corneally reflected EM indices, general and centrative perceptual activity clearly differentiated the groups. N-T Ss showed more active general perceptual behavior than N-NC Ss, and while N-NC Ss showed a marked tendency to "center" more often and for longer periods, on the element judged to be greater following the transformation, such a trend was not apparent with respect to either element, in N-T Ss. Postulates Ia, Ib, IIa and IIb thus appear to be tenable. Therefore, in addition to verbal response data, analyses of general and centrative perceptual activity during Tasks I and II, seem to provide considerable support for the contention that the conservation acceleration procedure had been effective in inducing a degree of cognitive structural change in the N-T Ss.

The predicted intergroup differences in verbal and "surprise reactions" to apparent conservation violations, which were obtained, provided strong support for Hypotheses 3A.1 and 3A.2, and for the effectiveness of the conservation acceleration procedure in terms of cognitive structural changes. Significantly more N-T than N-NC Ss recognized the apparent conservation violations, thus suggesting that prior to the transformation completion, the expectancies of N-T and N-NC Ss with respect to the transformation outcome, were very different. N-T Ss showed significantly more "surprise reactions" than N-NC Ss, and it seems very likely that this differential reflects a higher percentage of perceived violations of pretransformation expectancies on the part of N-T Ss.

Within group analyses of Task III EM data provided support for Hypothesis 3B.3. In comparison with Task I and II frequencies, N-T Ss showed an increase in fixations on the TE, but no such change was observed in N-NC Ss. This trend was also noted in exploratory analyses of general perceptual activity, and of perceptual activity in relation to the TE and the NTE. These results provide further supplementary evidence in support of the contention that the conservation acceleration training procedure was effective in terms of inducing cognitive structural changes.

With reference to Study 1 (Tasks I & II), general and centrative perceptual activity in N-T and N-C Ss appear essentially equivalent, and both contrast with that shown by N-NC Ss. In addition, verbal and "surprise reaction" frequencies were very similar in conservers and trained nonconservers, and again these frequencies were substantially greater than those shown by nonconservers. Conservers and trained nonconservers also showed somewhat similar EM patterns during Task III. The similarities were not as pronounced however, as those observed on Tasks I and II. Consequently, although cognitive structural development seems to have occurred as a function of conservation training, the levels attained by conservers and trained nonconservers were probably not equivalent. This supposition is also supported by the fact that only 80% of the N-T Ss attained conservation status on the tasks for which they received training, and only 47% attained conservation on the transfer tasks. Thus although training was effective, it clearly did not result in equivalent levels of cognitive functioning in N-C and N-T groups. It would appear then, that the natural acquisition of conservation could involve aspects of cognitive structural development not achieved by the present conservation acceleration training procedure.

The results of this study seem to have at least one clear implication for Piaget's (1947, 1970) theoretical position. It would appear that in terms of cognitive structural changes, the development of intelligence as evidenced by the acquisition of conservation, can be accelerated to a substantial degree in normal children. In the present study however, the levels of cognitive functioning reached by natural conservers and trained nonconservers were not entirely equivalent. A logical next step would be to investigate EMs and "surprise reactions" in Ss who actually attain conservation, generalize it in transfer tasks and retain it over a period of time. The present study examined the behavior of groups, and within the N-T group there were several Ss who clearly did not respond to training and this fact may have suppressed the overall effect of training in terms of the N-T mean values on the various EM and "surprise reaction" dependent variables. The extent to which the effectiveness of training might vary according to maturational level (cognitive development), and the extent to which it can be improved by a refinement and an extension of training procedures, require further investigation. In this connection, it is suggested that EMs and "surprise reactions" could provide useful supplementary evidence on cognitive structural development for such investigations.

Study 3: Perceptual Activity and Surprise Reactions in EMR Conservers and EMR Nonconservers

Results

Conservation Tasks. The following results of between group analyses of general perceptual activity involved the use of a Groups (R-C vs. R-NC) by Tasks (I & II) analysis of variance with repeated measures on Tasks. R-C in comparison with R-NC Ss, showed more runs (M_{rc} = 2.40, M_{rnc} = 1.70; F = 11.594, df = 1/28, $p < .01$), more fixations (M_{rc} = 12.00, M_{rnc} = 8.20; F = 27.814, df = 1/28, $p < .001$) and a shorter mean length of fixation in one tenth second units, over both elements (M_{rc} = 2.69, M_{rnc} = 3.73; F = 18.953, df = 1/28, $p < .001$) and both groups showed more fixations on Task I (M_{I} = 10.80, M_{II} = 9.40; F = 10.559, df = 1/28, $p < .01$). All other main and interaction effects were nonsignificant. Thus Hypotheses 1A.2, 1A.4 and 1A.5 and Hypotheses 2A.2, 2A.4 and 2A.5 are supported, indicating as with normal Ss that there were also differences between retarded conservers and nonconservers in terms of general perceptual activity. It should be pointed out however that these findings were not as strong as those reported for normal Ss, specifically since significant couplings and mean length of run effects were not observed. Table 6 presents mean values for Tasks I and II (calculated as in Studies 1 and 2) and correlated t tests. These within group analyses reveal that on the GE, R-NC Ss had more runs (t = 3.14, df = 14, $p < .01$), a greater mean length of run (t = 3.53, df = 14, $p < .01$), more fixations

Table 6

Summary of Correlated t Tests on Tasks I & II EM Data: EMR Ss

	Nonconservers				Trained Nonconservers				Conservers			
	$\overline{GEX}$[a]	$\overline{LEX}$[b]	t	p	$\overline{TEX}$[c]	$\overline{NTEX}$[d]	t	p	$\overline{TEX}$	$\overline{NTEX}$	t	p
Number of runs	1.73	0.93	3.14	**	1.80	1.68	0.53	NS	2.10	1.50	2.38	**
Mean length of run	20.06	8.91	3.53	**	16.70	11.76	1.77	*	17.20	12.63	1.49	NS
Number of fixations	8.07	4.68	3.60	**	9.35	8.08	1.13	NS	10.27	7.98	1.63	NS
Mean length of fixation	5.50	3.93	3.28	**	4.59	3.15	5.06	***	3.70	3.30	1.15	NS
Amount of Examination time	24.00	10.25	3.82	***	21.07	15.50	1.97	*	22.95	15.60	2.08	*

[a] $\overline{GEX}$ Mean value on element chosen as greater

[b] $\overline{LEX}$ Mean value on element chosen as lesser

[c] $\overline{TEX}$ Mean value on transformed element

[d] $\overline{NTEX}$ Mean value on non-transformed element

* $p < .05$

** $p < .01$

*** $p < .001$

($t = 3.60$, df = 14, $p < .01$), a shorter mean length of fixation ($t = 3.28$, df = 14, $p < .01$) and spent a greater amount of examination time in tenths of seconds ($t = 3.82$, df = 14, $p < .001$). At the same time, R-C Ss showed a greater frequency of runs ($t = 2.38$, df = 14, $p < .05$) and more examination time, on the TE ($t = 2.08$, df = 14, $p < .05$). All other inter-element differences were nonsignificant. Consequently, Hypotheses 1B.1 - 1B.5 and 2B.2 - 2B.4 are supported, and it appears that centrative perceptual activity differentiates R-C and R-NC Ss, although not to the extent it did in normal Ss where as predicted there were also no inter-element differences on frequency of runs and amount of examination time.

Exploratory analyses of perceptual activity which involved the Tasks by Groups analysis of variance design, were made. These results are presented in detail in Appendix B - Study 3. In brief it appears that conservers in general showed more perceptual activity in terms of fixations on the TE and NTE, and that their perceptual activity was directed at the TE to a lesser extent than was the case with non-conservers who tended to focus their attention on the GE. These findings are supportive of the between and within group analyses discussed above. In addition, these results are in agreement with those obtained from normal Ss in Study 1, although the present findings are not as consistent over all EM variables reported.

Violation Tasks. The apparent violations of conservation were attributed to legerdemain by more R-C than R-NC Ss (R-C = 97%, R-NC = 20%; $z = 5.98$, $p < .001$). "Surprise reactions" also differentiated the groups (R-C - 40%, R-NC = 13%; $z = 2.34$, $p < .01$). Hypotheses 3A.1 and 3A.2 were thus supported. Therefore as in Studies 1 and 2, the occurrence of surprise reactions seems to reflect conservation violation recognition.

The following results, summarized in Table 7, were obtained from within group analyses (using correlated t tests) of Task III centrative perceptual activity. Comparisons between elements for conservers revealed that these Ss had more runs ($t = 3.60$, $df = 14$, $p < .01$), a greater mean length of run ($t = 2.49$, $df = 14$, $p < .05$), more fixations ($t = 3.27$, $df = 14$, $p < .01$) and spent more examination time ($t = 3.46$, $df = 14$, $p < .01$), on the TE. Nonconservers on the other hand made more runs on the TE ($t = 2.30$, $df = 14$, $p < .05$) and showed a significantly longer mean length of fixation in one tenth second units on the TE ($t = 1.79$, $df = 14$, $p < .05$). None of the remaining inter-element differences were significant for either group, although all were in the predicted direction. Hypotheses 3B.2 and 3B.3 are thus supported. Thus for conservers, four of the five inter-element differences on Table 5 were significant, whereas only two were significant on Table 6. Increases in the TE-NTE ratio were observed on mean length of run and frequency of fixations on the part of R-C Ss, but R-NC Ss showed no such increases. This finding suggests that the conserver-nonconserver differences in EMR Ss are consistent with, but not as strong as those observed in normal Ss.

Table 7

Summary of Correlated t Tests on Task III EM Data: EMR Ss

Dependent Variable	Nonconservers				Trained Nonconservers				Conservers			
	$T\bar{EX}$[a]	$NT\bar{EX}$[b]	t	p	$T\bar{EX}$	$NT\bar{EX}$	t	p	$T\bar{EX}$	$NT\bar{EX}$	t	p
Number of runs	1.53	1.10	2.30	*	1.73	1.43	0.92	NS	2.07	0.97	3.60	**
Mean length of run	20.71	12.62	1.35	NS	19.30	11.63	1.51	NS	21.29	9.08	2.49	*
Number of fixations	8.40	5.53	1.75	NS	9.30	6.17	1.51	NS	13.13	6.83	3.27	**
Mean length of fixation	4.62	3.09	1.79	*	4.34	3.57	1.57	NS	3.38	2.60	1.27	NS
Amount of examination time	23.63	14.20	1.71	NS	23.40	14.50	1.67	NS	28.03	11.30	3.46	**

[a] $T\bar{EX}$ Mean value on transformed element

[b] $NT\bar{EX}$ Mean value on non-transformed element

* $p < .05$

** $p < .01$

NS result not significant at .05 level

No intergroup differences were obtained from the analysis of individual psychophysiological dependent variables (see Appendix A - Table B). Consequently, as in Studies 1 and 2, these findings do not seem to reflect the recognition of conservation violations.

Statistical data on general and inter-element perceptual activity during Task III are reported in Appendix B - Study 3. These data showed similar results to those obtained on Tasks I and II. Again, the data suggest that R-C Ss showed more perceptual activity than R-NC Ss. These findings are thus in agreement with those obtained from normal conservers and nonconservers. Conserver-non-conserver differences do not seem to be as strong in EMR Ss as they were in normal Ss however, in that fewer significant intergroup differences were obtained. Specifically it appears that although EMR Ss in Study 3 have similar conserver-nonconserver classifications to normals, their EM data may be reflecting differential cognitive activity.

In summary, EMR conservers in comparison with EMR nonconservers showed a number of predicted differences in general and centrative perceptual activity on conservation tasks. Predicted intergroup differences were obtained in verbal and "surprise reactions" to conservation violations, and in EMR conservers a predicted change in centrative perceptual activity and several changes in general perceptual activity, accompanied these reactions.

Discussion

Hypotheses 1A.2, 1A.4, 1A.5, 2A.2, 2A.4, and 2A.5 and Hypotheses 1B.1 - 1B.5 and 2B.2 - 2B.5 received strong support from between and within group analyses of Task I and II EM data. A series of distinct intergroup differences in general and centrative perceptual activity thus seems to be indicated. The general perceptual behavior of EMR conservers is considerably more active than that shown by EMR nonconservers. While a clear tendency to "center" more often and for longer periods on the element judged to be greater following transformation was apparent in R-NC Ss during Tasks I and II, this trend was observed only with respect to two dependent variables (frequency of runs and amount of examination time) in R-C Ss. Consequently it is concluded that Postulates Ia, Ib, IIa and IIb are tenable, although the findings are not as strong as in Study 1.

Verbal and "surprise reactions" to apparent violations of conservation, also differentiated the groups in the predicted direction and provided support for Hypotheses 3A.1 and 3A.2. The intergroup verbal response differences were in agreement with the contention that the transformation outcome expectancies of R-C and R-NC Ss prior to the transformation completion, were very different. Furthermore, it seems highly likely that the intergroup "surprise reaction" differences which were obtained, arose from the fact that a greater percentage of these expectancies were violated for R-C Ss.

Support was also obtained for Hypotheses 3B.2 and 3B.3. In comparison with mean length of run and fixation frequency ratios TE -

NTE ratios obtained on Tasks I and II, R-C Ss showed increases during Task III but R-NC Ss did not. Several changes in the R-C Ss general perceptual activity which were consistent with the above results, were also obtained (see Appendix B - Study 3).

In short, verbal responses indicate the presence of distinct cognitive structural differences between R-C and R-NC Ss. Supplementary evidence from the analyses of perceptual activity and "surprise reactions" during the decision period on conservation and conservation violation tasks, also point towards R-C and R-NC differences. Thus it is concluded that Postulate III is tenable.

Study 1 (N-C and N-NC Ss) and the present study seem to have resulted in the documentation of a number of similar intergroup differences, which presumably reflect differential (conserver-nonconserver) levels of cognitive structural development. Similar patterns of conserver-nonconserver verbal response differences were obtained from both normal and EMR Ss. Likewise, perceptual activity and "surprise reactions" from normal and EMR Ss clearly differentiated conservers from nonconservers. At the same time, while similar conserver-nonconserver perceptual activity differences were observed in normal and EMR Ss, they were not as strong in EMR Ss. Specifically, frequency of couplings, which clearly differentiated the general perceptual activity of normal conservers and nonconservers, and frequency of runs, which clearly differentiated the centrative perceptual activity of normal conservers and nonconservers, did not differentiate EMR conservers and nonconservers. Conserver-nonconserver differences in

EM activity during conservation violation tasks were also not equivalent in normal and EMR Ss. Whereas normal conservers showed marked changes in all measures of centrative perceptual activity during Task III, a similar change was observed on only two of these dependent variables with EMR conservers.

The inconsistencies in general and centrative perceptual activity results discussed above, may be due to a number of factors. They could be attributable to the fact that EMR Ss were considerably older than the normals, and this may have tended to reduce conserver-nonconserver general and centrative perceptual activity differences. Another possibility is that the above mentioned inconsistencies were reflecting an underlying normal - EMR attentional differential of the type postulated by House & Zeaman, 1963 and O'Connor & Hermelin, 1963. Finally a possibly more interesting supposition would be that the cognitive structural development of the EMR Ss had not reached a level equivalent to that shown by normal Ss. This supposition is in accord with an observation made by Inhelder (1963) who suggested that the closure of an operational system in mentally retarded children is of a different type from that found in normal children. While these latter possibilities are consistent with much previous research into learning and cognition with mentally retarded Ss, they are nevertheless speculative and further research is clearly necessary to disentangle the above-noted inconsistencies.

Study 4: Perceptual Activity and Surprise Reactions in Trained EMR Nonconservers and EMR Nonconservers

Results

Conservation Tasks. Between group analyses of Task I and II general perceptual activity were undertaken using a Groups (Trained EMR nonconservers and EMR nonconservers) by Tasks (I & II) analysis of variance with repeated measures on Tasks, and the following results were obtained. In comparison with EMR nonconservers (R-NC), the trained EMR nonconservers (R-T) showed over both elements more runs (M_{rt} = 2.20, M_{rnc} = 1.70; $F = 4.805$, $df = 1/28$, $p < .05$), more fixations (M_{rt} = 11.24, M_{rnc} = 2.80; $F = 11.336$, $df = 1/28$, $p < .01$) and a shorter mean length of fixation in one tenth second units, (M_{rt} = 2.95, M_{rnc} = 3.73; $F = 7.205$, $df = 1/28$, $p < .05$). Both groups showed, over both elements on Task I, more runs (M_{I} = 2.25, M_{II} = 1.65; $F = 18.705$, $df = 1/28$, $p < .001$), more fixations (M_{I} = 10.75, M_{II} = 8.69; $F = 17.394$, $df = 1/28$, $p < .001$) and a shorter mean length of fixation, (M_{I} = 3.00, M_{II} = 3.68; $F = 11.901$, $df = 1/28$, $p < .01$). All remaining analyses of general perceptual activity in terms of main and interaction effects were nonsignificant.

Hypotheses 1A.2, 1A.4 and 1A.5 (which refer to R-NC Ss and Hypotheses 2A.2, 2A.4 and 2A.5 (which refer to R-T Ss) were thus supported, while Hypotheses 1A.1, 1A.3, 2A.1 and 2A.3 were not. These results suggest that there are a number of differences between the groups with respect to general perceptual activity.

Within group analyses of Task I and II centrative perceptual activity were undertaken using correlated t tests and the following results were obtained (see Table 6, page 90). R-NC Ss showed more runs ($t = 3.14$, $df = 14$, $p < .01$), a greater mean length of run ($t = 3.53$, $df = 14$, $p < .01$), more fixations ($t = 3.60$, $df = 14$, $p < .01$), a greater mean length of fixation ($t = 3.28$, $df = 14$, $p < .01$) and a greater amount of examination time ($t = 3.82$, $df = 14$, p $.001$), on the GE. R-T Ss showed a greater mean length of run ($t = 1.77$, $df = 14$, $p < .05$), a greater mean length of fixation ($t = 5.06$, $df = 14$, $p < .001$) and spent a greater amount of examination time ($t = 1.97$, $df = 14$, $p < .05$) on the TE. All other differences were nonsignificant. Support was thus obtained for Hypotheses 1B.1 - 1B.5, 2B.1 and 2B.3, but not Hypotheses 2B.2, 2B.4 and 2B.5. Although Hypothesis 2B.1 received support in R-T Ss, no such support was obtained with R-C Ss in Study 3. Consequently, this result should be interpreted with reservations. These results indicate differential centrative perceptual activity in R-T and R-NC Ss.

Exploratory analyses discussed in Appendix B - Study 4, of EM data revealed that R-T Ss did not focus their perceptual activity on the TE to the extent shown by R-NC Ss. These findings are in partial agreement with the within group analyses discussed above and those reported for similar analyses in Study 2.

Violation Tasks. R-T and R-NC Ss were differentiated on the basis of their verbal responses to conservation violation items. Whereas 73% of R-T Ss attributed the apparent conservation violations to legerdemain, only 20% of the R-NC Ss responded in this way ($z = 5.41$,

$p < .001$). Hypothesis 3A.1 was thus supported. A similar trend was obtained with "surprise reactions". A significantly greater percentage of "surprise reactions" were shown by R-T Ss following the conservation violations (R-T = 36%, R-NC = 13%; $z = 2.09$, $p < .025$). Therefore Hypothesis 3A.2 was supported and as in Studies 1, 2 and 3, the occurrence of "surprise reactions" appears to reflect conservation violation recognition.

Within group analyses of Task III centrative perceptual activity indicated that R-NC Ss showed with respect to the TE and the NTE, more runs ($t = 2.30$, $df = 14$, $p < .01$) and a greater mean length of fixation ($t = 1.79$, $df = 14$, $p < .05$) on the TE. Whereas these results may not appear to be in complete agreement with those obtained from similar analyses of Task I and II data, they are nevertheless consistent with, but not as strong as those findings. Tasks I and II analyses for R-NC Ss resulted in significant GE-LE differences in favor of the GE, on all dependent variables. On Task III two of these differences were still significant, two were marginally significant and on the remaining dependent variable, the TE mean was higher than that of the NTE mean. None of the TE-NTE differences were significant for R-T Ss. These results provide no support for Hypotheses 3B.1 - 3B.5, since the perceptual activity of R-T Ss did not appear to increase on the TE as a function of the conservation violations. The above results are consistent with, but not as strong as those obtained on Study 2 with normal Ss.

The results of analyses of individual psychophysiological dependent variables failed to reveal any significant main or interaction effects (see Table B for mean values). Thus, psychophysiological activity during Task III, as in Studies 1, 2 and 3, does not appear to be related to Task III verbal response data.

Exploratory analyses of general perceptual activity suggested that R-T Ss were perceptually more active in terms of fixations than R-NC Ss. These results are consistent with those obtained on Tasks I and II, and did not seem to be a function of conservation violation recognition on the part of R-T Ss.

Further analyses of perceptual activity in relation to the TE and the NTE revealed results which were at variance with those reported for normal Ss. Whereas N-T Ss showed a tendency to increase perceptual activity on the TE following the conservation violations, the perceptual activity of the R-T Ss showed increases on the NTE, thus suggesting that N-T and R-T Ss may be reflecting differential cognitive activity/structural development. These results seem consistent with those obtained in Study 3, where a similar distinction between normal and EMR conservers was suggested by the data.

In summary, trained EMR nonconservers in comparison with EMR nonconservers, showed a number of predicted differences in general and centrative perceptual activity on conservation tasks. Predicted intergroup differences in verbal responses and "surprise reaction" to conservation violations, were also obtained, but predicted changes in centrative perceptual activity on the part of R-T Ss, were not. Thus while training appeared to induce a degree of cognitive structural development, it did not seem to be as effective with these Ss as it had been in Study 2 with normals.

Discussion

The between and within group analyses of Task I and II EM data clearly differentiated R-T and R-NC Ss, and provided strong support for Hypotheses 1A.2, 1A.4, 1A.5, 2A.2, 2A.4 and 2A.5, and for Hypotheses 1B.1 - 1B.5 and 2B.1 and 2B.3. Specifically it was found that in terms of corneally reflected EMs, R-T Ss showed more general perceptual activity, whereas R-NC Ss "centered" more often and for longer periods, on the element judged to be greater following transformation. It is thus concluded that Postulates Ia, Ib and IIa are tenable. Postulate IIb seems tenable with trained EMR nonconservers, but to a somewhat lesser extent than it was with normal conservers and trained nonconservers. Therefore, in addition to verbal response data, general and centrative perceptual activity during Tasks I and II, appear to offer considerable support for the contention that the conservation acceleration procedure had successfully induced a degree of cognitive structural change.

Analyses of verbal and "surprise reactions" during conservation violation tasks also yielded predicted intergroup differences, and accordingly provide support for Hypotheses 3A.1 and 3A.2. These results suggest that pretransformation expectancies with respect to the transformation outcome were very different in R-T and R-NC Ss. Indeed, it would appear that prior to the transformations, more R-T Ss than R-NC Ss had expected that quantity or length would remain invariant despite stimulus transformation. The fact that this transformation outcome was violated, seems likely to have led to the intergroup "surprise reaction" differences which were obtained. Support for Hypotheses 3B.1 - 3B.5 was not obtained however. Therefore Postulate III was supported for verbal responses and "surprise reactions," but not in terms of EM data.

At the same time, verbal and "surprise reaction" data during conservation violation tasks, seems to strengthen the claim that the conservation acceleration procedure had been effective in inducing cognitive structural change in EMR nonconservers. Thus from the standpoint of Piaget's (1947, 1970) theoretical position, it would appear that the development of intelligence as evidenced by the acquisition of conservation, can be accelerated to a substantial degree, in preoperational EMR children. This result is consistent with that obtained by Brison & Bereiter (1967), and with the findings of previous studies which have examined, using traditional intelligence tests, attempts to accelerate the intellectual development of mentally retarded Ss (e.g., Skeels & Dye, 1939; Kirk, 1958; Spicker, Hodges & McCandless, 1966).

These results may be somewhat conservative since the training was relatively ineffective for several of the R-T Ss. The present study examined the behavior of the group who received training, and as in Study 2 the data from Ss who did not acquire conservation as a function of training may have tended to attenuate trained-untrained nonconserver differences. With respect to the Ss who received conservation training, 80% of the normals and 100% of the EMR Ss showed logical conservation responses on Task I (the task on which they were trained), while only 47% of the normals and 57% of the EMR Ss showed logical conservation responses on Task II (transfer task). Since Task II requires actual conservation "competence" and since there was a considerable reduction in logical conservation responses from Task I to Task II in both normal and EMR Ss, it would appear that for a number of Ss, Task I behavior was reflecting "performance" rather than "competence" (Flavell & Wohlwill, 1969). If this is the case, research should be undertaken in which an attempt is made to examine the usefulness of EMs and "surprise reactions" in only those Ss who show conservation "competence."

In summary, perceptual activity during conservation tasks, and "surprise reactions" during conservation violation tasks, appear to have yielded strong evidence, which is consistent with and therefore a useful supplement to verbal response data, in indicating that the conservation acceleration procedure had successfully induced a degree of cognitive structural change in EMR nonconservers who received the training. The results of Studies 1 and 3 indicated that conserver/nonconserver differences were not equivalent in normal and EMR Ss. Studies 2 and 4 suggest that trained-untrained nonconserver differences were also not equivalent in normal and EMR Ss. Moreover, differences between normal and EMR Ss seemed somewhat greater than those reported in Studies 1 and 3.

CHAPTER 6

Integration, Conclusions and Implications

Integration

The results of Study 1 revealed a number of differences in EMs, verbal responses and "surprise reactions," between N-C and N-NC Ss. Table 8 summarizes the results of tests of between group hypotheses relating to general perceptual activity during conservation tasks. Inspection of this table with respect to Studies 1 and 3, reveals that more conserver-nonconserver differences were obtained from normal than from EMR Ss. These results suggest that although conserver-nonconserver differences were similar in normal and EMR Ss, they were not as strong in EMR Ss.

A summary of within group analyses of centrative perceptual activity during conservation tasks is presented in Table 9. An identical centration effect on the GE was apparent in both normal and EMR nonconservers (Hypotheses 1B.1 - 1B.5). With respect to Hypotheses 2B.1 - 2B.5, no significant inter-element differences were observed in normal Ss, but significant differences were observed in two out of five cases with EMR conservers. These results also suggest that conserver-nonconserver differences are not equivalent in normal and EMR Ss.

Analyses of verbal responses and "surprise reactions" during violation tasks, the two types of variables which seemed more crucial for identifying structural development, resulted in similar conserver-

Table 8

Summary of Tests of Hypotheses Involving Between Group Comparisons of Conservation Task Performance

Hypotheses		Studies			
No	Description	1	2	3	4
1A.1/2A.1[1]	N-C Ss will show fewer couplings than C or T Ss	S	S	N	N
1A.2/2A.2	N-C Ss will show fewer runs than C or T Ss	S	S	S	S
1A.3/2A.3	N-C Ss will show a greater $\bar{X}$ length of run than C or T Ss	S	S	N	N
1A.4/2A.4	N-C Ss will show a greater $\bar{X}$ length of fixation than C or T Ss	S	S	S	S
1A.5/2A.5	N-C Ss will show more fixations than C or T Ss	S	S	S	S

S Hypothesis supported at .05 level, or beyond

NS Hypothesis not supported at .05 level

1 Hypotheses 2A.1 - 2A.5 are the converse of 1A.1 - 1A.5

Table 9

Summary of Tests of Hypotheses Involving Within Group Comparisons of Conservation Task Performance

Hypotheses		Studies			
No	Description	1	2	3	4
1B.1[1]	N-C Ss will show more runs on GE	S	S	S	S
1B.2	N-C Ss will show greater $\bar{X}$ length run on GE	S	S	S	S
1B.3	N-C Ss will show more fixations on GE	S	S	S	S
1B.4	N-C Ss will show greater $\bar{X}$ length fixation on GE	S	S	S	S
1B.5	N-C Ss will show a greater amount of time on GE	S	S	S	S
2B.1	C or T Ss will show similar frequency of runs on both elements	S	S	N	S
2B.2	C or T Ss will show similar $\bar{X}$ length run on both elements	S	S	S	N
2B.3	C or T Ss will show similar frequency of fixations on both elements	S	S	S	S
2B.4	C or T Ss will show similar $\bar{X}$ length fixation on both elements	S	S	S	N
2B.5	C or T Ss will show similar amount of time on both elements	S	S	N	N

[1]Tests of Hypotheses 1B.1 - 1B.5 were identical in Studies 1 and 2 and Studies 3 and 4 since the same Ss were involved

S Hypothesis supported at .05 level, or beyond

NS Hypothesis not supported at .05 level nonconserver differences in normal and EMR Ss. Specifically, conservers made more verbal responses attributing conservation violations to legerdemain, and showed a greater percentage of "surprise reactions" during such tasks. The analyses of EM behavior on violation tasks, revealed in terms of centrative perceptual activity, more conserver-nonconserver differences associated with normal than EMR Ss (see Table 10). Again these results suggest differences between conservers and nonconservers in both normal and EMR Ss, with the stronger results associated with normal Ss.

In summary, the analyses of conservation task general and centrative perceptual activity, and of verbal responses, "surprise reactions" and centrative perceptual activity during violation tasks, showed clear conserver-nonconserver differences in both normal and EMR Ss. At the same time, these differences did not seem to be as strong in EMR Ss. The EM findings for normal Ss are in agreement with those reported by O'Bryan &Boersma (1970) despite the fact that the conservation question was asked prior to the transformation, and EM recording was undertaken as soon as the transformation outcome became observable.

Several factors could account for the observed variations in normal and EMR findings. The EMR Ss were considerably older than the normals (see Table 1, p. 51) and since perceptual activity changes are to some extent related to CA development (Piaget, 1956), the differential CA levels may have attenuated conserver-nonconserver perceptual activity differences on the part of EMR Ss. Since general

Table 10

Summary of Tests Involving Between and Within Group Comparisons of Violation Task Performance

Hypotheses		Studies			
No.	Description	1	2	3	4
3A.1	More C or T Ss than N-C Ss will attribute apparent conservation violations to legerdemain	S	S	S	S
3A.2	More C or T Ss than N-C Ss will show surprise reactions during TOP on conservation violation items	S	S	S	S
3B.1	N-C Ss will show similar inter-element run frequency ratios on Task III & Tasks I & II, whereas C or T Ss will show an increase during Task III	S	N	N	N
3B.2	N-C Ss will show similar inter-element $\overline{X}$ length run ratios on Task III & Tasks I & II, whereas C or T Ss will show an increase during Task III	S	N	S	N
3B.3	N-C Ss will show similar inter-element fixation frequency ratios on Task III & Tasks I & II, whereas C or T Ss will show an increase during Task III	S	S	S	N
3B.4	N-C Ss will show similar inter-element $\overline{X}$ length fixation ratios on Task III & Tasks I & II, whereas C or T Ss will show an increase during Task III	S	N	N	N
3B.5	N-C Ss will show similar inter-element amount of examination time ratios on Task III & Tasks I & II, whereas C or T Ss will show an increase during Task III	S	N	S	N

S hypothesis supported at .05 level, or beyond

NS hypothesis not supported at .05 level and centrative perceptual activity also seem to be related to cognitive functioning however, it seems equally and probably more likely that the above-mentioned variations could indicate differential levels of cognitive structural development in normal and EMR Ss, even though both groups gave similar verbal responses. The possibility of differential cognitive structural development on the part of normal and EMR Ss, has also been raised by Inhelder (1963). She has suggested that the EMR S does not proceed beyond the level of concrete operations, and that his cognitive activity reflects the acquisition of a "ceiling" rather than a "closure" of operational structures. An alternative, and equally interesting possibility, is that the EMR results may reflect a basic retardate attentional deficit of the type described by Zeaman & House (1963), O'Connor & Hermelin (1963) and Luria (1963). Since no formal evidence of organic impairment was obtained, the possibility of organicity effects can not be discounted. Quite clearly further research into these possibilities is necessary.

A number of EM, verbal response and "surprise reaction" differences between trained and untrained normal nonconservers were obtained in Study 2. While the training procedure seemed to be effective, with similar results obtained on the above-mentioned variables in both normal and EMR Ss, the findings were not as strong as those observed for natural conservers.

A summary of between group analyses of general perceptual activity during conservation tasks is presented in Table 8 (p. 106). It is apparent that more trained-untrained nonconserver differences were obtained from normal Ss (Study 2) than EMR Ss (Study 4). At the same time, a comparison of Studies 1 and 2 with 3 and 4 reveals that the results for conservers and trained nonconservers in both normal and EMR Ss were identical. Consequently, it appears that in both normal and EMR Ss the conservation training procedure resulted in patterns of general perceptual activity which were very similar to those observed in natural conservers.

Table 9 (p. 107) presents a summary of within group analyses of centrative perceptual activity. Normal and EMR nonconservers (Hypotheses 1B.1 - 1B.5) showed similar effects on the GE and as in Studies 1 and 3, normal trained nonconservers showed more nonsignificant inter-element effects than the EMR trained nonconservers (Hypotheses 2B.1 - 2B.5). In addition a comparison of Studies 1 and 2 with 3 and 4, reveals that whereas the results for N-T Ss closely parallel those for N-C Ss, the consistency of findings is not as great for R-T and R-C Ss.

Analyses associated with violation tasks are summarized in Table 10. A comparison of verbal responses and "surprise reactions" obtained in Studies 2 and 4 reveals similar patterns of conserver-nonconserver differences in normal and EMR Ss. Specifically, a significantly greater percentage of conservers and trained nonconservers attributed the conservation violations to legerdemain and showed "surprise reactions". Analyses of EM behavior during violation tasks in Studies 2 and 4 produced similar trained-untrained nonconserver differences in normal and EMR Ss. Here for all practical purposes, none of the hypotheses were supported.

Comparison of Studies 1 and 2 with 3 and 4 suggests that there are more conserver-nonconserver differences in both normal and EMR Ss. Furthermore, discrepancies between conservers and trained nonconservers in both normal and EMR Ss indicate that levels of cognitive structural development in natural conservers and trained nonconservers may not be equivalent. As discussed previously, the results of Studies 2 and 4 may be somewhat conservative, since approximately 50% of the trained nonconservers in both normal and EMR groups showed on transfer tasks, responses reflective of "performance" rather than "competence" (Flavell & Wohlwill, 1969). A logical next step would be to examine EM and "surprise reaction" data in only those Ss who show conservation generalization following training.

Limitations of the Present Study

Psychological research on cognitive functioning is necessarily concerned with factors which at present are still "inside the black box" and are not directly observable. Psychophysiological research seems however to offer an interesting means for further investigating such phenomena, even though interpretation of such results in relation to cognitive functioning is not without its limitations or difficulties.

The present investigation used corneally reflected EMs and found as did the study of O'Bryan & Boersma (1970) that these measures closely reflected conservation status in normal children. Similar although not as strong findings were obtained with EMR children. The exact significance of EMs in cognitive functioning however, is not yet clear. The present research showed concomitance between certain patterns of verbal behavior and EM patterns. It was also observed that this relationship held in normal and EMR trained and untrained nonconservers. On the basis of Piaget's emphasis on the transition from centration to decentration, which he claims accompanies cognitive development, it was suspected that such differences would be apparent. It is realized that by centration on a stimulus, Piaget means more than merely looking at a particular stimulus (Piaget, 1961). Until more is known about the processes of visual search and cognition, however, it would appear that attempts to detect an isomorphism between EMs and cognitive functioning will need to be postponed.

The usage of OR components to define a "surprise reaction" following the violation tasks, deviates considerably from the more usual experimental situation in which ORs are studied. It was for this reason that the term "surprise reaction" was used throughout this study. At the same time, the study of ORs in such a context does have some precedent (Lewis & Harwitz, 1969; Charlesworth, 1969).

The verbal (legerdemain) responses and "surprise reactions" also clearly differentiated conservers and nonconservers, and trained and untrained nonconservers, and considerable agreement between the two measures was apparent. The fact that several nonconservers gave legerdemain responses and showed "surprise reactions" is somewhat puzzling. It seems highly likely that these Ss were functioning at a different level from other nonconservers, and that notwithstanding their verbal responses on conservation tasks, they may have "acquired conservation". If this is the case, violation tasks may not only be useful supplementary data, but may also provide a new means for assessing cognitive structural development. At the same time, the exact relationship between such psychophysiological data and cognitive functioning, is not completely clear.

Since children normally acquire conservation around seven years of age, it may be desirable to examine EM behavior and the effectiveness of the present training procedure with younger children. The nature of the EM recording equipment used in the present study, however necessitated the use of children of at least six years of age, and consequently conclusions regarding EM behavior and the effectiveness of training can only be generalized to similar samples. On the other hand, it is also likely that conserver-nonconserver differences would have been stronger if younger nonconservers had been used as Ss.

The major limitation of the present study is associated with the analysis of data from the Ss who received training. Here for both normal and EMR Ss the total sample per group was used to evaluate training effects, even though in both normal and EMR groups there were several Ss who did not show conservation behavior on transfer tasks. The suggestion was made that for these Ss, training probably resulted in conservation "performance" rather than "competence" (Flavell & Wohlwill, 1969). It seems clear that the data from these Ss could have attenuated the trained-untrained nonconserver differences, and a logical next step would be to examine the training data for only those Ss who show conservation "competence" following training.

In summary, conservation training seemed to be effective in both normal and EMR Ss. Consequently, from a Piagetian theoretical position, it appears that intellectual development in terms of conservation acquisition, can be accelerated in preoperational normal Ss within the six to eight years age range, and in undifferentiated EMR Ss within the eight to twelve years age range. Further research will be necessary to establish whether or not acceleration of conservation can be achieved in younger children, and whether earlier or later stages of intellectual development can also be accelerated.

Implications for Piaget's Theoretical Position

To the extent that a clear distinction was obtained between conservers and nonconservers in EMs, verbal (legerdemain) responses and "surprise reactions", the results of Studies 1 and 3 provide considerable support for Piaget's (1947, 1970) distinctions between preoperational and operational cognitive functioning. Study 1 EM results were highly consistent with those obtained by O'Bryan & Boersma (1970) despite several methodological differences. Analyses of "surprise reaction" data tended to be in agreement with the EM findings and appeared to strengthen the evidence for differential cognitive structural development on the part of conservers and nonconservers. Thus conservation acquisition as Piaget (1947, 1970) has emphasized, appears to involve more than verbal response changes, and since psychophysiological responses are presumably mediated by cortical functioning, differential cognitive activity on the part of conservers and nonconservers seems indicated. These results therefore appear to be strongly supportive of Piaget's theoretical position.

The EM and "surprise reaction" data from EMR Ss (Study 3) also clearly differentiated conservers and nonconservers. Intergroup differences were not as strong, however, as those shown by normal Ss. These data support Piaget's theoretical position with respect to EMR Ss and also support Inhelder's (1963) observation that operational structures in EMR and normal Ss may show differential characteristics. She maintains that these differences may arise because the stage of concrete operations in normal Ss is a foundation for later development towards the formal operational level, whereas in EMR Ss, the achievement of concrete operations represents a ceiling of cognitive development.

Trained and untrained normal (Study 2) and EMR (Study 4) nonconservers showed intergroup EM and "surprise reaction" differences which were similar to those observed between conservers and nonconservers. At the same time, it was also noted that a number of Ss in both normal and EMR groups failed to show conservation behavior on transfer tasks. It was suggested that for these Ss, conservation training probably resulted in conservation "performance" rather than "competence" (Flavell & Wohlwill, 1969). Consequently the effects of training in terms of group means, may have been somewhat attenuated by the inclusion of data from these Ss. The present findings suggest that intellectual development as evidenced by the acquisition of conservation, can be accelerated in normal and EMR preoperational Ss. These results are consistent with those obtained by Gelman (1969) with normal Ss. Since the present training procedure was not successful with all experimental Ss however, it seems likely that Ss had entered the study with differential levels of cognitive structural development. Further research is needed to determine whether or not the effectiveness of the training procedure used in the present study can be increased with respect to those Ss who appeared to show conservation "performance" responses.

Implications for Mental Retardation

A comparison of Studies 1 and 3 indicates that conserver-nonconserver differences in EMR Ss were similar although not as consistent as those shown by normal Ss. Inhelder (1963) argued that because EMR Ss do not proceed beyond the level of concrete operations, their structural development tends to be characterized by a different type of closure of operational structures. She maintains that whereas the normal child's structural development is characterized by "closure" in that elements become integrated into a coordinated operational system which later undergoes further modifications leading eventually to the level of formal operations, the structural development of the EMR child reflects the attainment of a "ceiling" in cognitive development. The close similarity of verbal responses together with the inconsistencies noted in EM and "surprise reaction" data between normal and EMR Ss is also supportive of Shif's (1969) contention that language and thinking are differentially related in normal and EMR Ss.

Normal and EMR conservation comparisons are difficult to interpret however, since they may be a function of uncontrolled factors. For example, there are wide differences between normal and EMR Ss with respect to the ages at which Piagetian stages are reached (Inhelder, 1963; Woodward, 1963); furthermore, since the "intelligence" measure of most interest in conservation research is conservation status, neither CA nor MA matching seems a suitable procedure. Thus although conservation status provides an index of intellectual development, albeit a dichotomous one, wide variation within the "conserver" and "nonconserver" groups is likely.

If there are normal - EMR cognitive structural differences, as Inhelder (1963) and Shif (1969) have argued and the present findings suggest, a number of basic questions arise. For example, "why do such differences occur?", "what is the nature of such differences?", and "to what extent can these differences be eliminated by appropriate learning experiences?"

The conservation training procedure seemed to be effective in accelerating conservation acquisition in the normal and EMR Ss. Trained and untrained EMR nonconservers showed similar differences to those observed between natural conservers and nonconservers. Consequently, in terms of Piaget's theoretical position, it would appear that intellectual development in terms of conservation acquisition, can be accelerated in preoperational EMR Ss.

Clearly, if intellectual development can be accelerated, it can also be depressed by unfavorable environmental factors. It thus seems important to determine the extent of environmental contributions to intellectual development in undifferentiated (non-organic) EMR children. McCandless, (1964) has surveyed research in this area and has argued that such a contribution would probably be substantial. Much more needs to be known about the process of intellectual development in both normal and EMR Ss, however, before any definitive answers are possible. At the same time, if environmental factors do have a significant influence on the intellectual development of undifferentiated EMR Ss, as seems likely, their influence probably begins very early in life. Consequently, it seems equally important to examine the nature of the environmental experiences of EMR infants, e.g., mother-child and family verbal and nonverbal interactions, manipulative play activities, etc. Information from studies such as these, may lead to a more adequate understanding of the process of intellectual development in EMR Ss, and contribute to the development of more powerful means of accelerating such development.

Implications for Education

The extent to which the present findings may be regarded as having significant educational implications, must rest on the proposition that Piaget's theoretical position itself has important educational implications. Although intellectual development is of basic concern to educators, particularly those responsible for the education of the mentally retarded, relatively little empirical data on the process is available. The work of Piaget and his collaborators has resulted in a theoretical and methodological framework which appears likely to lead to substantial increases in psychological understanding of intellectual development, and thus seems at least potentially capable of making a sizable impact on educational theory and practice.

The findings of the present investigation provide considerable support for Piaget's theory of intelligence, and indicate that the acquisition of conservation (or the onset of operational thinking) can be accelerated in preoperational normal and EMR children. If the validity of Piaget's theoretical position is acceptable, it would appear that the intellectual development of EMR children can be accelerated through perceptual/attentional training. The acceleration findings are thus in agreement with the results of a number of investigations which have shown increases in traditional intelligence test scores on the part of EMR children following special education program participation (Kirk, 1964). One important question which was not answered by the present investigation, concerns the extent to which the acceleration of intellectual development is possible in EMR children (see Bayley, 1970, for further discussion of this point). At the same time, the present investigation offers a research strategy which could lead to a more adequate answer to this question than has heretofore been obtained.

CHAPTER 7

Summary

The present investigation was concerned with the question of whether or not the intellectual development, as defined by Piaget (1947), of mentally retarded children can be accelerated by training. Previous attempts to examine this question have involved the use of traditional intelligence tests, which are relative measures based on interindividual comparisons, and the findings are difficult to interpret (Jones, 1954; Kirk, 1964; Clarke & Clarke, 1965; Reese & Lipsett, 1970). Since investigations of this nature are probably more concerned, especially on the part of EMR children, with changes within a given child, Piaget's theory of intelligence which is concerned with intraindividual intellectual development (Elkind, 1969) seems a more promising approach.

Within Piaget's (1947) theory, successful acceleration of conservation acquisition implies an acceleration of intellectual development (Piaget, 1953). The present investigation addressed itself to an examination of the effectiveness of a conservation acceleration procedure in EMR and normal *Ss*.

A number of previous studies with normal *Ss*, and at least one with EMR *Ss*, have attempted to accelerate the acquisition of conservation. Despite the fact that several of these studies have successfully incorporated two of Piaget's (1964a) criteria for evaluating training (permanence and generalizability of behavioral changes), attempts to use a third criterion (specification of cognitive structural changes) have been differentially interpreted and much controversy still surrounds the issue (Beilin, 1969; Reese & Lipsitt, 1970). Attempts to specify cognitive structural changes have usually involved the use of verbal responses, and since there is considerable disagreement among psychologists regarding the relationships between language and thinking (Berlyne, 1965), the above mentioned controversy is not surprising. Consequently, it seemed necessary to supplement verbal evidence of cognitive structural development with relevant nonverbal data.

Considerable research evidence is available which suggests that eye movement patterns and "surprise reactions" are useful non-verbal indices of cognitive functioning (e.g., Reese & Lipsitt, 1970; Charlesworth, 1969). In view of the importance of attentional behavior within Piaget's theoretical position (Piaget, 1936, 1947), these indices seemed particularly pertinent to the present investigation. Moreover, one previous study (O'Bryan & Boersma, 1970) has documented a variety of clear differences in terms of EM patterns between conservers and nonconservers.

The present investigation thus used eye movements (EMs), verbal responses, and "surprise reactions" (the simultaneous occurrence of a GSR conductance increase, a cephalic blood volume increase and a heart-rate decrease) as indices supposedly reflective of cognitive structural development. It was hypothesized that differences would be obtained between conservers and nonconservers and between trained and untrained nonconservers, in both normal and EMR

Ss, with respect to general and centrative perceptual activity during conservation tasks, and verbal legerdemain responses (i.e., conservation violations are attributed to legerdemain), "surprise reaction" frequency and perceptual activity changes, during conservation violation tasks.

A series of four studies were undertaken. The conserver/ nonconserver dichotomy (Study 1) and the effectiveness of the conservation acceleration procedure (Study 2), were examined in normal Ss, and subsequently, in EMR Ss (Studies 3 & 4).

On the basis of number and length conservation pretests, 90 elementary school children (45 normal and 45 EMR) attending regular first and second grades and opportunity (special) classes in Edmonton Public Schools, were classified as conservers (15 normal and 15 EMR) and nonconservers (30 normal and 30 EMR). Nonconservers were assigned at random to a training condition and were given two training sessions at school on consecutive days. All Ss were transported to the University where conservation and conservation violation tasks were presented in movie form. During the movie presentation, verbal responses, EMs and "surprise reactions" were recorded.

EMs clearly differentiated normal conservers and nonconservers (Study 1). During the conservation tasks, the general perceptual behavior of nonconservers was considerably less active than that of conservers, and whereas nonconservers showed a distinct tendency to "center" on the element perceived as greater following transformation, conservers did not. Conservers also gave more "surprise reactions" than nonconservers following apparent conservation violations. Moreover the occurrence of "surprise reactions" appeared to be a function of violation recognition. Similar differences in EMs and "surprise reactions" were observed between normal nonconservers who received the conservation acceleration procedure and those who did not (Study 2), and these differences seemed to closely parallel intergroup verbal response differences. Verbal responses and EMs showed similar patterns on both posttests and transfer tasks (Task I & Task II), and intergroup verbal (conservation) response differences in terms of Task I and II were still apparent three weeks after training. A clear trained-untrained nonconserver difference was also apparent in terms of verbal responses and "surprise reactions" on violation tasks. It was thus concluded that the conservation acceleration procedure had been effective with normal children in terms of the indices of cognitive structural changes which were used.

While clear conserver-nonconserver differences in EMs, verbal (legerdemain) responses and "surprise reactions" were also obtained in EMR Ss (Study 3), they were not as consistently strong as those shown by normals. These results suggested differential cognitive structural development and/or attentional activity on the part of the EMR Ss. At the same time, EMs and "surprise reactions" again seemed a useful source of supplementary data on cognitive structural development which could be used in evaluating conservation training.

EMR nonconservers who received training and those who did not (Study 4), showed a pattern of differences which closely approximated those observed in EMR conservers and nonconservers. Verbal conservation and EM data was similar on both posttests and transfer tasks (Tasks I & II) and Task III verbal (legerdemain) responses and "surprise reactions" differentiated the trained and untrained nonconservers and verbal (conservation) response differences in terms of Tasks I and II were still apparent three weeks after training. Accordingly it was concluded that training had resulted in successful acceleration of conservation in the EMR Ss. Consequently, from Piaget's (1947, 1970) theoretical standpoint, it would appear that in terms of EM, verbal and "surprise reaction" indices of cognitive structural changes, that intellectual development can be accelerated in preoperational EMR Ss through perceptual/attentional training.

In summary, the following points seem evident. Normal and EMR conservers and nonconservers showed differences in general and centrative perceptual activity during conservation tasks, and during violation tasks, differences in verbal (legerdemain) responses and "surprise reactions". Conserver-nonconserver differences in EMR Ss while similar to those observed in normal Ss, were not as strong. Conservation training seemed effective in both normal and EMR Ss although trained-untrained nonconserver differences were not as strong as those observed between natural conservers and nonconservers. The wide difference in CA between the normal and the EMR Ss, and the possibility of differential cognitive structural development and/or attention behavior on the part of normal and EMR Ss were suggested to account for the apparent variation in the results which were obtained from the normal and the EMR Ss. It was also noted that the apparent effects of training may have been somewhat attenuated because of the inclusion in the data from the training groups of several Ss who did not show conservation behavior on transfer tasks. The suggestion was made that for these Ss, training probably resulted in conservation "performance" rather than "competence" (Flavell & Wohlwill, 1969) and future research in which an examination is made of data from only those Ss who show conservation "competence" following training, seems necesary.

The present conservation acceleration findings appeared to support previous studies which have shown increases in intelligence test scores on the part of EMR children following their participation in special educational programs (Kirk, 1964).

R E F E R E N C E S

REFERENCES

Anastasi, A. Heredity, environment and the question 'how?' Psychological Review, 1958, 65, 197-208.

Baumeister, A. A. Learning abilities of the mentally retarded. In A. A. Baumeister (Ed.), Mental retardation: Appraisal, education, and rehabilitation. Chicago: Aldine, 1967.

Bayley, N. Development of mental abilities. In P. H. Mussen, Carmichael's manual of child psychology (3rd ed.). New York: John Wiley and Sons, Inc., 1970. Pp. 1163-1209.

Berlyne, D. E. Conflict, arousal and curiosity. New York: McGraw-Hill, 1960.

Berlyne, D. E. Motivational problems raised by exploratory and epistemic behavior. In S. Koch (Ed.), Psychology a study of a science. Vol. 5. New York: McGraw-Hill, 1963, Pp. 284-364.

Berlyne, D. E. Structure and direction in thinking. New York: Wiley, 1965.

Berlyne, D. E. Arousal and reinforcement. In D. Levine (Ed.), Nebraska Symposium on motivation. Lincoln, Nebraska: University of Nebraska Press, 1967. Pp. 1-110.

Berlyne, D. E. Attention as a problem in behavior theory. In D. Mostofsky (Ed.), Attention: Contemporary theory and analysis. New York: Appleton-Century Crofts, 1970(a). Pp. 25-50.

Berlyne, D. E. Children's reasoning and thinking. In P. H. Mussen, Carmichael's manual of child psychology (3rd ed.). New York: John Wiley and Sons, Inc., 1970, Pp. 939-981; (b).

Binet, A. Les idees modernes sur les enfants. Paris: Ernest Flamarion, 1909. (cited by Peterson, 1925).

Binet, A., & Simon, T. Le development de l' intelligence chez les enfants. L' Anee Psychologique, 1908, 14, 1-90. (The development of intelligence in children. Baltimore: Williams & Wilkins, 1916).

Boersma, F. J., Muir, W., Wilton, K. & Barham, R. Eye movements during embedded figure tasks. Perceptual and Motor Skills, 1969, 28, 271-274.

Braine, M. D. S. The ontogeny of certain logical operations: Piaget's formulation examined by non-verbal methods. Psychological Monographs, 1959, 73 (Whole No. 475).

Brison, D. W., & Bereiter, C. Acquisition of conservation of substance in normal, retarded and gifted children. In D. W. Brison & E. V. Sullivan (Eds.), Recent research on the acquisition of conservation of substance. Toronto: Ontario Institute for Studies in Education, 1967. Pp. 53-72.

Brown, C. C. The technique of plethysmography. In C. C. Brown (Ed.), Methods in psychophysiology. Baltimore: Williams & Wilkins, 1967. Pp. 54-74.

Bruner, J. S. The course of cognitive growth. American Psychologist, 1964, 19, 1-15.

Bruner, J. S. On cognitive growth. In J. S. Bruner et al., Studies in cognitive growth. New York: Wiley, 1966. Pp.1-67(a).

Bruner, J. S. Towards a theory of instruction. Cambridge, Massachusetts: Harvard University Press, 1966 (b).

Bruner, J. S. On the conservation of liquids. In J. S. Bruner et al., Studies in cognitive growth. New York: Wiley, 1966. Pp. 183-207(c).

Burt, C. The factors of the mind. London: University of London Press, 1956.

Campbell, D. T., & Stanley, J. C. Experimental and quasi-experimental designs for research. Chicago: Rand McNally, 1963.

Charlesworth, W. R. The growth of knowledge of the effects of rotation and shaking on the linear order of objects. Unpublished doctoral dissertation, Cornell University, 1962.

Charlesworth, W. R. Development and assessment of cognitive structures. In R. E. Ripple & V. N. Rockcastle (Eds.), Piaget-Rediscovered. Ithaca: School of Education, Cornell University, 1964. Pp. 85-91(a).

Charlesworth, W. R. Instigation and maintenance of curiosity behavior as a function of surprise versus novel and familiar stimuli. Child Development, 1964, 35, 1169-1186(b).

Charlesworth, W. R. Persistence of orienting and attending behavior in infants as a function of stimulus locus uncertainty. Child Development, 1966, 37, 473-491.

Charlesworth, W. R. The role of surprise in cognitive development. In D. Elkind & J. H. Flavell (Eds.), Studies in cognitive development: Essays in honor of Jean Piaget. New York: Oxford University Press, 1969. Pp. 257-314.

Creelman, M. B. The experimental investigation of meaning. New York: Springer, 1966.

Crosby, K. G., & Blatt, B. Attention and mental retardation. Journal of Education, 1968, 150, 67-81.

Denny, M. R. Research in learning and performance. In R. Heber & H. Stevens (Eds.), Mental retardation: A review of research. Chicago: University of Chicago Press, 1964. Pp. 100-142.

Descoeudres, A. The education of mentally defective children. (2nd ed.) Boston: Heath, 1928. (cited by Robinson & Robinson, 1965)

Doll, E. A. The essentials of an inclusive concept of mental deficiency. American Journal of Mental Deficiency, 1941, 46, 214-219.

Elkind, D. Piagetian and psychometric conceptions of intelligence. Harvard Educational Review, 1969, 39, 319-337.

Elkonin, D. B. Some results of the study of the psychological development of preschool-age children. In M. Cole & I. Maltzman (Eds.), A handbook of contemporary Soviet psychology. New York: Basic Books, 1969. Pp. 163-208.

Elley, W. B. A comparative analysis of the socio-economic bias in selected intelligence tests. Unpublished doctoral dissertation, University of Alberta, 1961.

Eysenck, H. J. Uses and abuses of psychology. Middlesex: Penguin Books, 1953.

Flavell, J. H. The developmental psychology of Jean Piaget. Princeton, New Jersey: Van Nostrand, 1963.

Flavell, J. H. & Wohlwill, J. F. Formal and functional aspects of cognitive development. In J. H. Flavell, & D. Elkind (Eds.), Studies in cognitive development: Essays in honor of Jean Piaget. New York: Oxford University Press, 1969. Pp. 67-120.

Furth, H. G. Thinking without language: Psychological implications of deafness. New York: The Free Press, 1966.

Gelman, R. Conservation acquisition: A problem of learning to attend to relevant attributes. Journal of Experimental Child Psychology, 1969, 167-187.

Goddard, H. H. The Kallikak family. New York: Macmillan, 1912.

Goodenough, F. The measurement of mental growth in childhood. In L. Carmichael (Ed.), Manual of child psychology (2nd ed.) New York: John Wiley and Sons, Inc., 1954. Pp. 459-491

Graham, F., & Clifton, R. Heart-rate change as a component of the orienting response. Psychological Bulletin, 1966, Vol. 65, No. 5, 305-320.

Gray, J. A. Attention, consciousness and voluntary control of behavior in Soviet psychology: Philosophical roots and research branches. In N. O'Connor (Ed.), Present day Russian psychology. Oxford: Pergamon Press, 1966. Pp. 1-38.

Gruen, G. E. Experiences affecting the development of number conservation in children. Child Development, 1965, 36, 963-979.

Gruen, G. E. Note on conservation: Methodological and definitional considerations. Child Development, 1966, 36, 977-983.

Guilford, J. P. The nature of human intelligence. New York: McGraw-Hill, 1967.

Hood, H. B. An experimental study of Piaget's theory of the development of number in children. British Journal of Psychology, 1962, 53, 273-286.

Hunt, J. McV. Intelligence and experience. New York: Ronald Press, 1961.

Hunt, J. McV. Has compensatory education failed? Has it been attempted? Harvard Educational Review, 1969, 39, 278-300.

Inhelder, B. Le diagnostic du raisonnement chez les debiles mentaux. (2nd ed.) Neuchatel: Delachaux & Niestle, 1963., (The diagnosis of reasoning in the mentally retarded.) New York: John Day, 1968.

Inhelder, B. Cognitive development and its contribution to the diagnosis of some phenomena of mental deficiency. Merrill-Palmer Quarterly, 1966, 12, 299-319.

Inhelder, B., Bovet, M., Sinclair, H., & Smock, C. D. On cognitive development. American Psychologist, 1966, 21, 160-164.

Itard, J. M. G. Rapports et memoires sur le sauvage de L'Aveyran. Paris. 1806. (The wild boy of Averyon. New York: Appleton-Century Crofts, 1932).

Jeffery, W. E. The orienting reflex and attention in cognitive development. Psychological Review, 1968, 75, 323-334.

Jensen, A. R. How much can we boost IQ and scholastic achievement? Harvard Educational Review, 1969, 39, 1-123.

Jones, H. E. The environment and mental development. In L. Carmichael (Ed.), Manual of child psychology (2nd ed.) New York: John Wiley and Sons, Inc., 1954. Pp. 631-696.

Kelley, T. L. Crossroads in the mind of man. Stanford University, Calif.: Stanford University Press, 1928.

Kingsley, R. C., & Hall, V. C. Training conservation through the use of learning sets. Child Development, 1967, 38, 1111-1126.

Kingsley, R. C., & Hall, V. C. Conservation and equilibration theory. Journal of Genetic Psychology, 1968, 113, 195-213.

Kirk, S. A. Early education of the mentally retarded. Urbana, Illinois: University of Illinois Press, 1958.

Kirk, S. A. Research in education. In R. Heber & H. A. Stevens (Eds.), Mental retardation: A review of research. Chicago: University of Chicago Press, 1964. Pp. 57-99.

Kuhlmann, F. Experimental studies in mental deficiency. American Journal of Psychology, 1904, 15, 391-446.

Lader, M. H. Pneumatic plethysmography. In P. H. Venables & I. Martin (Eds.), Manual of psychophysiological methods. New York: John Wiley & Sons, 1967. Pp. 159-183.

Lefrancois, G. The acquisition of concepts of conservation. Unpublished doctoral dissertation, University of Alberta, 1966.

Lewis, M., & Goldberg, S. The acquisition and violation of expectancy: An experimental paradigm. Journal of Experimental Child Psychology, 1969, 7, 70-80.

Lewis, M., & Harwitz, M. The meaning of an orienting response: A study in the hierarchical order of attending. Paper presented at the meeting of the Society for Research in Child Development, Symposium on "The Orienting Response: Issues in Developmental Inquiry," Santa Monica, California: March, 1969.

Lindsley, D. B. Psychophysiology and motivation. In M. R. Jones (Ed.), Nebraska Symposium on motivation. Lincoln, Nebraska: University of Nebraska Press, 1957. Pp. 44-105.

Lipman, R. S. Learning: Verbal, perceptual-motor and classical conditioning. In N. R. Ellis (Ed.), Handbook of mental deficiency. New York: McGraw-Hill, 1963. Pp. 391-423.

Luria, A. R. The mentally retarded child. Oxford: Pergamon Press, 1963.

Luria, A. R. Speech development and the formation of mental processes. In M. Cole & I. Maltzman (Eds.), A handbook of contemporary Soviet psychology. New York: Basic Books, 1969. Pp. 121-162.

Lykken, D. T. Properties of electrodes used in electrodermal measurement. Journal of Comparative and Physiological Psychology, 1959, 52, 629-634.

Lynn, R. Attention, arousal and the orientation reaction. Oxford: Pergamon Press, 1966.

McCandless, B. R. Relation of environment to intellectual functioning. In R. Heber & H. A. Stevens (Eds.), Mental retardation: A review of research. Chicago: University of Chicago Press, 1964. Pp. 175-213.

MacNemar, Q. A critical examination of the University of Iowa studies of environmental influences upon the IQ. Psychological Bulletin, 1940, 37, 63-92.

Mackworth, N. H. A stand camera for line-of-sight recording. Perception and Psychophysics, 1967, 2, 119-127.

Maltzman, I. Individual differences in "attention": The orienting reflex. In R. Gagne (Ed.), Learning and individual differences. Columbus, Ohio: Merrill, 1967. Pp. 94-112.

Montessori, M. The Montessori method. New York: Stokes, 1912.

O'Bryan, K. G., & Boersma, F. J. Eye movements and conservation. Unpublished monograph, University of Alberta, 1970.

O'Bryan, K. G., & Boersma, F. J. Movie presentation of Piagetian tasks: A procedure for the assessment of conservation attainment. Journal of Genetic Psychology, 1971, in press.

O'Connor, N., & Hermelin, B. Speech and thought in severe subnormality. Oxford: Pergamon Press, 1963.

Peterson, J. Early conceptions and tests of intelligence. New York: World Book, 1925.

Piaget, J. La naissance de l'intelligence chez l'enfant. Neuchatel, Paris: Delachaux et Niestle, 1936. (The origins of intelligence in children. New York: International University Press, 1952).

Piaget, J. La psychologie de l'intelligence. Paris: Colin, 1947. (The psychology of intelligence. London: Routledge & Kegan Paul, 1950.

Piaget, J. Le probleme neurologique de l'interiorisation des actions en operations reversibles. Archives de psychologie (Geneve), 1949, 32, 241-258. (cited by Hunt, 1961).

Piaget, J. Logic and psychology. Manchester: University of Manchester Press, 1953.

Piaget, J. Language and thought from the genetic point of view. Acta Psychologica, 1954, 10, 51-60.

Piaget, J. Les stades du developpment intellectual de l'enfant et de l'adolescent. In P. Osterrieth et al., Le probleme des stades en psychologie de l'enfant. Paris: Presses Universitaires de France, 1955. Pp. 33-113. (cited by Flavell, 1963).

Piaget, J. (Problems of genetic psychology.) Voprosy Psikhologii, 1956. In D. Elkind (Ed.), Six etudes de psychologie. Geneva: Gonthier, 1964 (Six psychological studies. New York: Random House, 1967. Pp. 116-142.)

Piaget, J. The role of the concept of equilibrium in psychological explication. Acta Psychologica, 1959, 15, 51-62. In D. Elkind (Ed.), Six etudes de psychologie. Geneva: Gonthier, 1964 (six psychological studies. New York: Random House, 1967. Pp. 100-115).

Piaget, J. Equilibration and the development of logical structures. In J. Ranner & B. Inhelder (Eds.), Discussions on child development. London: Tavistock Publications, 1960. Pp. 98-115.

Piaget, J. Les mecanismes perceptifs: modeles probabilistes, analyse genetique, relations avec l'intelligence. Paris: Presses Universitaires de France, 1961. (The mechanisms of perception. London: Routledge & Kegan Paul, 1969).

Piaget, J. The stages of the intellectual development of the child. Bulletin of the Menninger Clinic, 1962, 26, 120-128.

Piaget, J. The thought of the young child. Lecture given at the Institute of Education, University of London (1963). In D. Elkind (Ed.), Six etudes de psychologie. Geneva: Gonthier, 1964 (Six psychological studies. New York: Random House, 1967. Pp. 77-86. (a))

Piaget, J. Le langage et les operation intellectuelles. In Problèmes de psycholinguistique: Symposium de l'association de psychologie scientifique de langue francaise. Paris: Presses Universitaires de France, 1963 (Language and intellectual operations. In H. G. Furth (Ed.), Piaget and knowledge. Englewood Cliffs, New Jersey: Prentice-Hall, 1969. Pp. 121-130). (b)

Piaget, J. Development and learning. In R. E. Ripple & V. N. Rockcastle (Eds.), Piaget rediscovered: A report of the conference on cognitive studies and curriculum development. Ithaca: School of Education, Cornell University, 1964. Pp. 7-20. (a)

Piaget, J. The development of mental imagery. In R. E. Ripple & V. N. Rockcastle (Eds.), Piaget rediscovered: A report of the conference on cognitive studies and curriculum development. Ithaca: School of Education, Cornell University, 1964. Pp. 21-39. (b)

Piaget, J. Reviews of J. S. Bruner, R. R. Olver, P. M. Greenfield, et al, Studies in cognitive growth. Contemporary Psychology, 1967, 12, 532-533.

Piaget, J. Explanation in psychology and psychophysiological parallelism. In J. Piaget, P. Fraisse & M. Reuchlin (Eds.), Traite de psychologie experimentale I: Histoire et methode. Paris: Presses Universitaires de France, 1963. (Experimental psychology: its scope and method. London: Routledge & Kegan Paul, 1968). Pp. 153-191.

Piaget, J. Piaget's theory. In P. H. Mussen, Carmichael's manual of child psychology (3rd ed.). New York: John Wiley and Sons, Inc., 1970. Pp. 703-732.

Piaget, J., & Inhelder, B. Diagnosis of mental operations and theory of the intelligence. American Journal of Mental Deficiency, 1947, 51, 401-406.

Piaget, J., & Inhelder, B. Le developpement des quantites physiques chez l'enfant: Conservation et atomisme. (2nd ed.) Neuchatel: Delachaux et Niestlé, 1962.

Piaget, J., & Inhelder, B. La psychologie de l'enfant. Collection "Que sais-je" No. 369. Paris: Presses Universitaires de France, 1966. (The psychology of the child. New York: Basic Books, 1969).

Piaget, J., Inhelder, B., & Szeminska, A. La geometrie spontanee chez l'enfant. Paris: Presses Universitaires de France, 1948. (The child's conception of geometry. New York: Basic Books, 1960).

Piaget, J., & Szeminska, A. La genese du nombre chez l'enfant. Neuchatel: Delachaux et Niestlé, 1941. (The child's conception of number. New York: Humanities Press, 1952).

Razran, G. The observable unconscious and the inferable conscious in current Soviet psychophysiology: Interoceptive conditioning, semantic conditioning, and the orienting reflex. Psychological Review, 1961, 68, 81-147.

Reese, H. W., & Lipsitt, L. P. Experimental child psychology. New York: Academic Press, 1970.

Robinson, H. B., & Robinson, N. M. The mentally retarded child: A psychological approach. New York: McGraw-Hill, 1965.

Rosenthal, R. Experimenter effects in behavioral research. New York: Appleton-Century-Crofts, 1966.

Rosenthal, R., & Jacobsen, L. Pygmalion in the classroom: Teacher expectation and pupils' intellectual development. New York: Holt, Rinehart & Winston, 1968.

Seguin, E. Idiocy, and its treatment by the physiological method. Albany, New York: Brandow, 1866. (cited by Robinson & Robinson, 1965).

Shaw, J. C. Quantification of biological signals using integration techniques. In P. H. Venables & I. Martin (Eds.), A manual of psychophysiological methods. Amsterdam: North Holland Publishing Company, 1967. Pp. 403-466.

Shif, Z. Development of children in schools for the mentally retarded. In M. Cole & I. Maltzman (Eds.), A handbook of contemporary Soviet psychology. New York: Basic Books, 1969. Pp. 326-353.

Sigel, I. E., Roeper, A., & Hooper, F. H. A training procedure for acquisition of Piaget's conservation of quantity: A pilot study and its replication. British Journal of Educational Psychology, 1966, 36, 301-311.

Skeels, H. M., & Dye, H. B. A study of the effects of differential stimulation on mentally retarded children. Journal of Psycho-Asthenics, 1939, 44, 114-136.

Smedslund, J. The acquisition of conservation of substance and weight in children. Scandinavian Journal of Psychology, 1961, 2, 11-20.

Sokolov, Ye. N. Vospriyatiye i uslovnyi refleks. Moscow: Moscow University Press, 1958. (Perception and the conditioned reflex. Oxford: Pergamon Press, 1963).

Sokolov, Ye. N. Higher nerve functions: The orienting reflex. Annual Review of Physiology, 1963, 25, 545-580.

Sokolov, A. N. Studies of the speech mechanisms of thinking. In M. Cole & I. Maltzman (Eds.), A handbook of contemporary Soviet psychology. New York: Basic Books, 1969. Pp. 531-573.

Spearman, C. 'General intelligence', objectively determined and measured. American Journal of Psychology, 1904, 15, 201-293.

Spicker, H. H., Hodges, W. L., & McCandless, B. R. A diagnostically based curriculum for psycho-socially deprived preschool mentally retarded children. Exceptional Children, 1966, 33, 215-220.

Staats, A. W., & Staats, C. K. Complex human behavior: A systematic extension of learning principles. New York: Holt, Rinehart & Winston, 1963.

Stein, Z., & Susser, M. Mutability of intelligence and epidemiology of mild mental retardation. Review of Educational Research, 1970, 40, 29-68.

Strauss, A. A., & Werner, H. The mental organization of the brain-injured mentally defective child: The mentally crippled child. American Journal of Psychiatry, 1941, 97, 1194-1203.

Terman, L., & Merrill, M. Stanford-Binet intelligence scale: Manual for the third revision. Form L-M. Boston: Houghton-Mifflin, 1960.

Thorndike, E. L. Intelligence and its measurement. Journal of Educational Psychology, 1921, 12, 124-127.

Thurstone, L. L. Primary mental abilities. Chicago: University of Chicago Press, 1938.

Towler, J. O. Training effects and concept development: A study of the conservation of continuous quantity in children. Unpublished doctoral dissertation, University of Alberta, 1967.

Trabasso, T., & Bower, G. H. Attention in learning: Theory and research. New York: Wiley, 1968.

Vernon, P. E. The structure of human abilities. (2nd ed.) London: Methuen, 1961.

Vygotsky, L. S. Myshlenie i rech'. Moscow: Academy of Pedagogical Sciences, 1956. (Thought and language. Cambridge, Massachusetts: MIT Press, 1962).

Wallace, J. G. An approach to the acceleration of number conservation in children. Educational Review, 1968, 20, 224-238.

Watson, J. G. Conservation: An S-R analysis. In I. E. Sigel & F. H. Hooper, Logical thinking in children; research based on Piaget's theory. New York: Holt, Rinehart & Winston, 1968. Pp. 447-460.

Wechsler, D. Wechsler Intelligence Scale for Children: manual. New York: Psychological Corporation, 1949.

Weinman, J. Photoplethysmography. In P. H. Venables & I Martin, (Eds.), A manual of psychophysiological methods. Amsterdam: North Holland Publishing Company, 1967. Pp. 185-218.

Welch, B. L. The generalization of student's problems when several different population variances are involved. Biometrika, 1947, 34, 28-35.

Winer, B. J. Statistical principles in experimental design. New York: McGraw-Hill, 1962.

Winer, G. A. Induced set and acquisition of number conservation. Child Development, 1968, 39, 195-205.

Wohlwill, J. From perception to inference: A dimension of cognitive development. In W. Kessen & C. Kuhlman (Eds.), Thought in the young child. Monographs of the Society for Research in Child Development, 1962, 27(2), Serial No. 83, 87-107.

Wohlwill, J. Piaget's theory of the development of intelligence in the concrete-operations period. In Cognitive models and development in mental retardation. Monograph supplement to American Journal of Mental Deficiency, 1966, 70, No. 4, 57-78.

Woodward, M. The application of Piaget's concepts to mental deficiency. In B. W. Richards (Ed.), Proceedings of the London conference on the scientific study of mental deficiency. Dagenham, England: May & Bakes, 1959. Pp. 437-443.

Woodward, M. The application of Piaget's theory to research in mental deficiency. In N. R. Ellis (Ed.), Handbook of mental deficiency. New York: McGraw-Hill, 1963. Pp. 297-324.

Wright, J. C. Toward the assimilation of Piaget. Merrill Palmer Quarterly, 1963, 9, 277-285.

Zeaman, D., & House, B. J. The role of attention in retardate discrimination learning. In N. R. Ellis (Ed.), Handbook of mental deficiency. New York: McGraw-Hill, 1963. Pp. 159-223.

Zigler, E. Mental retardation: Current issues and approaches. In L. W., & M. L. Hoffman (Eds.), Review of child development research. Vol. 2. New York: Russell Sage Foundation, 1966. Pp. 107-168.

A P P E N D I C E S

APPENDIX A

Mean Dependent Variable Scores

Key to Tables A and B

EM Data (to 2 decimal places)

1		frequency of couplings
2	a	frequency of runs on TE
	b	frequency of runs on NTE
	c	frequency of runs over both elements
3	a	mean length of run on TE
	b	mean length of run on NTE
	c	mean length of run over both elements
4	a	frequency of fixations on TE
	b	frequency of fixations on NTE
	c	frequency of fixations over both elements
5	a	mean length of fixation on TE
	b	mean length of fixation on NTE
	c	mean length of fixation over both elements
6	a	amount of examination time on TE
	b	amount of examination time on NTE

Psychophysiological Data (to 3 decimal places)

7	maximum conductance change
8	blood volume change (BV)
9	blood volume pulse change (BVP)

10 heart rate change

11 prefilm conductance level

12 conductance difference

13 latency to BSR onset

14 latency to GSR peak

15 percentage of surprise-reactions

<u>Performance Data (to 2 decimal places)</u>

16 latency to task decision

17 frequency of unscorable frames

18a percentage of logical conservation responses (laboratory)

b percentage of logical conservation responses (3 week retention tests--not applicable to conservers)

19 percentage of verbal responses attributing conservation violation to legerdemain

TABLE A MEAN DEPENDENT VARIABLE SCORES FOR TASKS AND TREATMENT: Normals

		Ia			Ib			IIa		
		C	T	NC	C	T	NC	C	T	NC
EM Data										
1		4.67	3.27	1.87	3.60	2.73	1.67	2.67	2.93	1.60
2	a	1.13	1.33	1.20	0.93	0.93	0.73	0.87	1.13	1.07
	b	0.73	0.93	0.67	1.07	1.07	0.93	1.20	1.13	0.73
	c	1.80	2.27	1.87	2.20	2.00	1.67	2.07	2.27	1.80
3	a	8.12	10.57	16.82	6.03	8.00	9.40	5.88	11.00	14.62
	b	3.67	5.63	5.75	11.97	13.80	14.07	14.03	10.08	7.91
	c	10.63	13.14	19.13	14.19	13.98	18.78	14.71	14.01	18.51
4	a	5.60	7.33	5.40	4.73	4.60	4.53	4.47	5.73	4.33
	b	3.87	4.33	2.47	7.47	6.60	4.67	6.33	5.00	3.40
	c	9.47	11.67	7.87	12.20	11.20	9.20	10.80	10.73	7.73
5	a	3.89	2.79	4.29	2.14	2.25	2.95	2.59	3.03	5.17
	b	2.63	2.15	2.30	2.33	2.87	3.43	2.89	2.57	1.99
	c	3.95	2.76	4.53	2.54	2.89	3.69	3.11	3.47	4.55
6	a	12.73	17.00	19.60	8.93	9.47	10.60	8.80	12.53	16.60
	b	5.13	8.07	6.80	14.93	15.33	15.53	16.33	12.53	8.67
Psychophysiological Data										
7		0.003	0.002	0.006	0.004	0.011	0.005			
8		0.736	0.319	0.028	0.168	0.178	0.385			
9		0.104	-0.049	0.195	-0.027	0.024	0.182			
10		-1.433	-0.472	-0.856	0.430	-1.005	-0.150			
11		-1.679	-1.620	-1.533	-1.655	-1.603	-1.540			
12		-0.002	0.033	0.023	0.012	0.015	0.018			
13		2.347	1.960	1.653	2.467	2.887	1.260			
14		8.507	2.653	2.380	3.093	3.887	1.653			
15		0.467	0.267	0.067	0.133	0.533	0.133			
Performance Data										
16		16.55	15.76	9.12	10.51	9.55	9.13	12.41	7.92	9.00
17		1.00	0.00	0.00	0.67	0.47	0.33	0.00	0.00	1.60
18	a	1.00	0.80	0.00	1.00	0.80	0.00	1.00	0.53	0.00
	b		0.87	0.07		0.67	0.00		0.53	0.00
19										

		IIb			IIIa			IIIb		
		C	T	NC	C	T	NC	C	T	NC
EM Data										
1		2.73	2.67	2.00	1.93	1.53	0.93	2.67	3.27	2.60
2	a	1.40	1.07	1.07	1.20	1.00	0.73	1.67	1.07	1.40
	b	1.07	1.07	0.33	0.67	0.80	0.73	1.00	0.87	0.73
	c	2.47	2.13	1.40	1.87	2.27	1.47	2.53	1.93	2.13
3	a	11.53	8.47	15.63	17.55	14.75	16.20	14.71	14.10	13.40
	b	6.61	7.47	3.40	7.47	9.84	9.77	3.09	4.90	2.98
	c	11.75	11.24	16.85	19.61	17.90	22.87	14.45	14.89	12.28
4	a	6.87	4.60	6.20	8.13	6.47	5.00	9.27	6.27	7.20
	b	4.13	4.00	1.60	3.87	4.13	3.73	3.60	4.13	3.00
	c	11.00	8.60	7.80	12.00	10.60	8.73	12.87	10.40	10.20
5	a	2.81	4.11	3.64	2.53	2.73	2.73	2.63	3.47	2.97
	b	3.02	3.13	3.88	1.59	2.19	1.95	1.61	2.05	1.76
	c	2.91	3.99	4.05	2.77	3.27	3.57	2.50	3.20	2.79
6	a	16.07	11.67	18.07	19.67	15.47	16.20	21.40	15.60	19.60
	b	9.47	11.07	4.13	8.20	11.13	12.53	6.07	6.80	4.53
Psychophysiological Data										
7					0.005	0.009	0.009	0.007	0.006	0.005
8					0.250	2.759	-0.032	0.032	0.331	0.329
9					0.066	0.468	0.036	0.125	0.309	0.226
10					-0.349	-0.170	-0.433	-0.962	-0.664	-0.242
11					-1.756	-1.664	-1.606	-1.775	-1.673	-1.612
12					0.010	0.003	0.016	0.011	0.020	0.000
13					3.300	3.367	4.320	2.500	2.800	2.573
14					4.133	4.133	5.200	4.387	3.820	3.367
15					0.333	0.467	0.267	0.733	0.400	0.067
Performance Data										
16		10.19	7.46	6.93	15.62	11.87	9.04	10.19	7.98	7.05
17		0.53	1.20	1.40	0.60	0.00	0.53	0.20	0.47	2.00
18	a	1.00	0.40	0.00						
	b		0.53	0.00						
19					1.00	0.66	0.20	1.00	0.80	0.13

		ΣI/2			ΣII/2			ΣIII/2		
		C	T	NC	C	T	NC	C	T	NC
EM Data										
1		4.13	3.00	1.77	2.70	2.80	1.80	2.30	2.40	1.77
2	a	1.10	1.13	0.97	1.13	1.10	1.07	1.37	1.03	1.07
	b	0.90	1.00	0.80	1.13	1.10	0.53	0.83	0.83	0.73
	c	2.00	2.13	1.77	2.27	2.20	1.60	2.20	2.10	1.80
3	a	7.08	9.29	13.11	8.72	9.75	15.13	16.13	14.43	14.81
	b	7.83	9.73	9.90	10.33	8.79	5.65	5.28	7.38	6.37
	c	12.41	13.57	18.96	13.25	12.63	17.69	17.02	16.39	17.59
4	a	5.17	5.97	4.97	5.67	5.17	5.27	8.70	6.37	6.10
	b	5.67	5.47	3.57	5.23	4.50	2.50	3.73	4.13	3.37
	c	10.83	11.43	8.53	10.90	9.67	7.77	12.43	10.50	9.47
5	a	3.00	2.51	3.61	2.69	3.56	4.39	2.56	3.09	2.84
	b	2.46	2.49	2.86	2.94	2.84	2.93	1.59	2.11	1.86
	c	3.22	2.81	4.09	2.99	3.72	4.28	2.63	3.21	3.15
6	a	10.83	13.23	15.10	12.43	12.10	17.33	20.53	15.53	17.90
	b	10.03	11.70	11.17	12.90	11.80	6.40	7.13	8.97	8.53
Psychophysiological Data										
7		0.003	0.006	0.005				0.006	0.007	0.007
8		0.752	0.058	0.028				0.217	2.824	-0.032
9		0.082	-0.099	0.195				-0.037	0.456	0.036
10		-1.107	-0.561	-0.866				0.010	-0.299	-0.433
11		-1.667	-1.611	-1.536				-1.765	-1.668	-1.609
12		0.005	0.024	0.021				0.010	0.011	0.008
13		2.393	2.407	1.447				2.887	3.073	3.433
14		5.793	3.253	2.020				4.420	4.200	4.453
15		0.300	0.400	0.100				0.533	0.433	0.167
Performance Data										
16		19.30	18.03	11.18	15.50	9.65	10.47	15.97	11.11	7.82
17		0.83	0.23	0.17	0.27	0.60	1.50	0.40	0.23	1.27
18	a	1.00	0.80	0.00	1.00	0.47	0.00			
	b		0.77	0.03		0.53	0.00			
19								1.00	0.73	0.16

TABLE 8 MEAN DEPENDENT VARIABLE SCORES FOR TASKS AND TREATMENT: Retardates

	Ia			Ib			IIa			IIb		
EM Data	C	T	NC	C	T	NC	C	T	NC	C	T	NC
1	3.53	2.60	2.33	2.93	3.93	3.07	2.33	2.47	2.07	3.47	3.40	2.33
2 a	1.47	1.27	1.27	1.33	1.33	1.13	1.33	0.93	0.87	1.47	1.07	1.27
b	0.80	0.87	0.53	1.20	1.67	0.93	0.93	1.00	0.40	1.07	0.67	0.40
c	2.27	2.13	1.80	2.53	3.00	2.07	2.27	1.93	1.27	2.53	1.73	1.67
3 a	10.77	12.87	14.35	10.08	7.65	12.23	16.01	13.23	15.60	11.07	12.47	12.21
b	7.43	9.22	6.87	10.47	8.17	6.23	6.55	5.92	4.90	8.13	6.33	3.73
c	13.93	17.03	16.07	14.28	9.55	13.38	16.29	14.41	19.22	10.73	12.09	11.63
4 a	7.73	6.80	5.73	5.87	5.93	5.73	6.53	5.87	4.80	7.33	6.07	4.67
b	4.73	5.93	2.67	6.67	6.13	4.07	3.93	4.33	2.53	5.20	3.87	2.60
c	12.47	12.73	8.40	12.53	12.07	9.80	10.47	10.20	7.33	12.53	9.93	7.27
5 a	2.33	2.61	3.76	2.23	2.97	2.83	3.33	3.45	4.00	2.50	3.80	4.23
b	2.37	1.64	2.87	1.98	2.25	2.75	2.09	2.31	2.78	2.53	2.61	2.43
c	2.55	2.51	3.78	2.50	2.63	3.15	3.34	3.07	4.25	2.47	3.65	3.81
6 a	15.87	16.80	17.67	12.93	11.00	14.67	19.07	15.33	17.00	15.13	13.33	15.13
b	9.07	10.60	6.87	12.93	12.53	8.53	8.47	9.00	5.67	9.93	6.73	3.73
sychophysio-gical Data												
7	0.005	0.007	0.004	0.007	0.002	0.013						
8	0.224	0.163	0.161	0.185	0.022	0.038						
9	0.303	-0.115	-0.070	0.141	0.119	-0.112						
10	-0.168	0.267	-0.322	0.132	-0.069	0.611						
11	-1.615	-1.790	-1.742	-1.632	-1.807	-1.733						
12	0.009	0.009	0.014	0.008	0.002	0.007						
13	1.287	3.367	2.567	2.213	1.633	3.000						
14	1.707	4.247	3.433	2.873	2.160	4.060						
15	0.133	0.133	0.267	0.133	0.133	0.200						
erformance Data												
16	9.58	12.05	10.15	9.50	9.71	9.06	7.87	11.18	6.84	8.22	10.87	7.79
17	0.20	0.00	0.00	0.00	0.27	0.67	0.00	1.27	1.33	0.20	1.60	4.73
18 a	1.00	1.00	0.00	1.00	1.00	0.00	1.00	0.60	0.00	1.00	0.53	0.00
b		1.00	0.13		0.93	0.07		0.73	0.07		0.87	0.07
19												

	IIIa			IIIb			ΣI /2			ΣII /2			ΣIII /2		
EM Data	C	T	NC	C	T	NC	C	T	NC	C	T	NC	C	T	NC
1	2.33	1.80	2.00	3.40	3.33	2.73	3.23	3.27	2.70	2.90	2.93	2.20	2.87	2.57	2.37
2 a	1.40	1.00	0.80	1.33	1.47	1.47	1.40	1.30	1.20	1.40	1.00	1.07	1.37	1.23	1.13
b	0.47	0.73	0.73	1.00	1.40	0.73	1.00	1.27	0.73	1.00	0.83	0.40	0.73	1.07	0.73
c	1.87	1.73	1.53	2.33	2.87	2.20	2.40	2.57	1.93	2.40	1.83	1.47	2.10	2.30	1.87
3 a	16.88	14.42	12.67	8.81	9.75	16.09	10.43	10.27	13.30	13.53	12.86	13.91	12.85	12.09	14.38
b	4.47	8.02	11.27	9.23	7.21	2.70	8.95	8.70	6.55	7.35	6.13	4.32	6.86	7.62	6.99
c	19.75	19.85	21.12	13.45	11.28	15.30	14.11	13.29	14.73	13.51	13.26	15.43	16.59	15.56	18.21
4 a	9.73	6.47	4.87	6.80	5.67	7.07	6.80	6.37	5.73	6.93	5.97	4.73	8.27	6.07	5.97
b	3.27	3.80	4.07	7.13	4.73	2.93	5.70	6.03	3.37	4.57	4.10	2.57	5.20	4.27	3.50
c	13.00	10.27	8.93	13.93	10.40	10.00	12.50	12.40	9.10	11.50	10.07	7.30	13.47	10.33	9.47
5 a	2.46	2.89	2.94	1.83	2.90	3.37	2.25	2.79	3.27	2.89	3.61	4.11	2.11	2.88	3.13
b	1.63	2.17	2.27	1.94	2.81	1.65	2.15	1.92	2.80	2.29	2.46	2.60	1.77	2.47	1.95
c	2.78	3.19	3.67	2.19	2.85	3.18	2.49	2.56	3.44	2.89	3.34	4.01	2.47	3.01	3.41
6 a	21.27	16.73	13.53	13.53	13.33	20.20	14.40	13.90	16.17	17.10	14.33	16.07	17.40	15.03	16.87
b	5.93	9.20	11.80	10.73	10.60	4.80	11.00	11.57	7.70	9.20	7.87	4.70	8.33	9.90	8.30
sychophysio-gical Data															
7	0.003	0.006	0.006	0.010	0.011	0.003	0.006	0.004	0.008				0.006	0.009	0.004
8	2.276	0.233	-0.066	0.646	0.499	0.240	0.192	0.211	0.161				0.893	0.232	-1.934
9	0.266	0.121	0.094	0.211	0.200	0.185	0.226	0.000	-0.070				0.192	0.016	0.094
10	-0.162	-0.358	0.145	-0.015	-0.837	-0.328	-1.679	0.338	-1.678				-1.608	-1.790	0.145
11	-1.667	-1.850	-1.763	-1.657	-1.832	-1.803	-1.624	-1.798	-1.737				-1.662	-1.841	-1.783
12	-0.154	0.001	0.002	0.009	0.002	0.007	0.009	0.005	0.010				-0.072	0.002	0.004
13	1.740	3.420	3.107	1.820	1.553	1.427	1.747	2.487	2.767				1.767	2.473	2.253
14	2.333	4.133	3.733	2.893	2.753	2.200	2.273	3.193	3.740				2.720	3.593	3.167
15	0.400	0.333	0.067	0.400	0.400	0.200	0.133	0.133	0.233				0.400	0.367	0.133
erformance Data															
16	12.78	13.85	10.74	8.74	8.21	5.25	11.83	14.41	12.18	9.98	14.61	8.74	12.40	13.21	8.79
17	0.00	0.20	0.00	1.80	2.40	1.40	0.10	0.13	0.33	0.10	1.43	3.03	0.90	1.30	0.70
18 a							1.00	1.00	0.00	1.00	0.57	0.00			
b								0.97	0.10		0.80	0.07			
19	1.00	0.66	0.07	0.93	0.80	0.33							0.97	0.73	0.20

APPENDIX B

Exploratory Analyses

Study 1

Conservation Tasks

The Tasks by Groups analysis of variance design used for analyses of general perceptual activity was used for exploratory between group analyses of EM data in terms of the TE and the NTE (see Appendix B - Study 1). The resulted indicated that conservers in comparison with nonconservers made more runs on the NTE ($M_{nc} = 1.02$, $M_{nnc} = 0.67$; $F = 5.003$, $df = 1/28$, $p < .05$), and had a shorter mean length of run in one tenth second units on the TE ($M_{nc} = 7.90$, $M_{nnc} = 14.12$; $F = 12.183$, $df = 1/28$, $p < .01$), showed more fixations on the NTE ($M_{nc} = 5.45$, $M_{nnc} = 3.04$; $F = 16.828$, $df = 1/28$, $p < .0001$), had a shorter mean length of fixation in one tenth second units on the TE ($M_{nc} = 2.85$, $M_{nnc} = 4.00$; $F = 6.558$, $df = 1/28$, $p < .05$), and spent less time (in one tenth second units) examining the TE ($M_{nc} = 11.63$, $M_{nnc} = 16.22$, $F = 5.473$, $df = 1/28$, $p < .05$). The remainder of the main and interaction effects from the above analyses were nonsignificant. All other analyses of EM dependent variables failed to yield significant main or interaction effects. These results suggested that the perceptual activity of conservers and nonconservers differed in relation to the TE and the NTE.

Violation Tasks

Analyses of data on individual psychophysiological dependent variables involved a Group by Tasks (I and III) analysis of variance with repeated measures on Tasks (see Table A for individual means). No significant main or interaction effects were obtained, except in the case of mean BVP change where a significantly greater change was observed for nonconservers (M_{nnc} = 0.12, M_{nc} = 0.02; F = 4.500, df = 1/28, $p < .05$) and a greater change was obtained on Task I (M_{I} = 0.14, M_{III} = -0.001; F = 5.526, df = 1/28, $p < .05$). Neither of these results seems to be a function of violation recognition since they are in the opposite direction to that predicted.

Exploratory between group analyses in terms of general perceptual activity were undertaken using the Groups by Tasks analysis of variance design described for individual psychophysiological dependent variables. Significant interaction effects were obtained on the frequency of couplings (Task I: M_{nc} = 4.13, M_{nnc} = 1.77; Task III: M_{nc} = 2.30, M_{nnc} = 1.77; F = 4.206, df = 1/28, $p < .05$) and on mean length of run in one tenth second units over both elements (Task I: M_{nc} = 12.41, M_{nnc} = 18.96; Task III: M_{nc} = 17.02, M_{nnc} = 17.59; F = 4.212, df = 1/28, $p < .05$). Inspection of individual means reveals that conservers showed a decrease in couplings and an increase in mean length of run over both elements on Task III, whereas nonconservers showed little or no changes.

Conservers in comparison with nonconservers (summed over Tasks I and III) also showed more fixations (M_{nc} = 11.63, M_{nnc} = 9.00; F = 10.630, df = 1/28, $p < .01$) and a shorter mean length of fixation in one tenth second units, over both elements (M_{nc} = 2.93, M_{nnc} = 3.62; F = 6.890, df = 1/28, $p < .05$). Task III in comparison with Task I (summed over conservers and nonconservers) revealed over both elements more fixations (M_{III} = 10.95, M_I = 9.68; F = 4.909, df = 1/28, $p < .05$) and a shorter mean length of fixation on Task III (M_{III} = 2.89, M_I = 3.66; F = 6.693, df = 1/28, $p < .05$). The remaining main and interaction effects from these analyses were not significant. The above analyses suggest that while the general perceptual activity of conservers continued to show a number of the characteristics which differentiated it from that of nonconservers on Tasks I and II, several changes occurred during Task III. Specifically, it appears that conservers showed less perceptual activity on Task III.

Additional exploratory between group analyses of EM data using the Groups by Tasks analysis of variance described above revealed several interaction effects. Specifically, conservers in comparison with nonconservers showed a significantly greater increase in frequency of fixations on the TE from Task I to Task III (Task I: M_{nc} = 5.17, M_{nnc} = 4.97; Task II: M_{nc} = 8.70, M_{nnc} = 6.10; F = 4.206, df = 1/28, $p < .05$), a greater increase in mean length of run on the TE from Task I to Task III (Task I: M_{nc} = 7.08, M_{nnc} = 13.11; Task III: M_{nc} = 16.13, M_{nnc} = 14.81; F = 3.621, df = 1/28, p = .06) and a greater increase in amount of examination time on the TE (Task I: M_{nc} = 10.85, M_{nnc} = 15.10; Task III: M_{nc} = 20.53, M_{nnc} = 17.90; F = 3.594, df = 1/28, p = .06). In terms of main effects conservers also showed more fixations on the NTE than nonconservers (M_{nc} = 4.70, M_{nnc} = 3.47; F = 4.203, df = 1/28, $p < .05$). A significant task effect was also observed with Task I eliciting more fixations on the NTE than Task III ($M_{III} = 3.55$, $M_I = 4.70$; $F = 4.621$, $df = 1/28$, $p < .05$). No other significant main or interaction effects were obtained. These results suggest in terms of the TE and NTE, that the perceptual activity of conservers changed markedly in comparison with that of nonconservers during Task III. The changes noted here closely reflect those reported in Chapter 5 for within group comparisons of Task III EM data. Both sets of analyses indicate that during Task III, conservers showed a substantial increase in perceptual activity on the TE whereas nonconservers did not.

Study 2

Conservation Tasks

The Groups by Tasks analysis of variance design was used for exploratory between group analyses of EM data in relation to the TE and the NTE. These analyses revealed that in comparison with N-NC Ss, N-T Ss made more runs on the NTE ($M_{nt} = 1.05$, $M_{nnc} = 0.67$; $F = 6.519$, $df = 1/28$, $p < .05$), had a shorter mean length of run in one tenth second units on the TE ($M_{nt} = 9.52$, $M_{nnc} = 14.12$; $F = 7.348$, $df = 1/28$, $p < .05$), made more fixations on the NTE ($M_{nt} = 4.99$, $M_{nnc} = 3.04$; $F = 9.977$, $df = 1/28$, $p < .01$), showed a marginally shorter mean length of fixation, in one tenth second units, on the TE ($M_{nt} = 3.04$, $M_{nnc} = 4.00$; $F = 3.873$, $df = 1/28$, $p = .06$) and spent a marginally smaller amount of time (tenths of seconds) examining the TE ($M_{nt} = 12.67$, $M_{nnc} = 16.22$; $F = 3.772$, $df = 1/28$, $p = .06$). All other analyses of EM dependent variables, and the remaining EM dependent variables which were analysed, were nonsignificant. The above results indicated differential perceptual activity in terms of the TE and the NTE, on the part of N-T and N-NC Ss. Again these results are highly consistent with those obtained from N-C Ss.

Violation Tasks

Individual psychophysiological dependent variables were analysed using the Groups by Tasks analysis of variance design. None of the main or interaction effects from these exploratory analyses were significant (see Table A for specific mean values), a result which is consistent with that obtained in Study 1. Thus in this study differences in individual psychophysiological dependent variable measures during TOP do not seem to be related to the acquisition of conservation.

Exploratory between group analyses of general perceptual activity were also undertaken. These involved the use of a Groups (NT vs NCC) by Tasks (I & III) analysis of variance design with repeated measures on Tasks. A significant interaction effect was obtained from the analysis of mean length of fixation over both elements (Task I: $M_{nt} = 2.81$, $M_{nnc} = 4.81$; Task III: $M_{nt} = 3.21$, $M_{nnc} = 3.15$; $F = 9.246$, $df = 1/28$, $p < .01$). Inspection of these means reveals that whereas NNC Ss showed a decrease in mean length of fixation during Task III, an increase was observed on the part of NT Ss. NT Ss also showed more couplings ($M_{nt} = 2.70$, $M_{nnc} = 1.77$; $F = 5.747$, $df = 1/28$, $p < .05$) and more fixations over both elements ($M_{nt} = 10.97$, $M_{nnc} = 9.00$; $F = 5.241$, $df = 1/28$, $p < .05$). No other main or interaction effects were significant. The above results on Task III reveal that N-T and N-NC Ss again showed several differences in general perceptual activity.

Additional exploratory analyses of EM data using the same Groups by Tasks analysis of variance design indicated that N-T Ss made more fixations irrespective of task on the NTE ($M_{nt} = 4.80$, $M_{nnc} = 3.47$; $F = 4.755$, $df = 1/28$, $p < .05$). It was also found that N-T and N-NC Ss had a shorter mean length of fixation on the NTE, during Task III ($M_{I} = 2.68$, $M_{III} = 1.99$; $F = 5.325$, $df = 1/28$, $p < .05$), thus suggesting as in Study 1 that the perceptual activity of N-T *Ss* during Task III now tended to be directed at the area in which the violation occurred. All other exploratory analyses failed to yield significant main or interaction effects.

Study 3

Conservation Tasks

The Groups by Tasks analysis of variance design mentioned in Chapter 5 - Study 3 was also used for additional exploratory analyses of EM behavior in terms of the TE and NTE. Here RC Ss in comparison with RNC Ss showed more fixations on the TE (M_{rc} = 6.87, M_{rnc} = 5.23; $F = 4.812$, df = 1/28, $p < .05$), more fixations on the NTE (M_{rc} = 5.14, M_{rnc} = 2.97; $F = 14.532$, df = 1/28, $p < .001$), a shorter mean length of fixation in one tenth second units on the TE (M_{rc} = 2.57, M_{rnc} = 3.69; $F = 12.772$, df = 1/28, $p < .01$), more runs on the NTE (M_{rc} = 1.00, M_{rnc} = 0.57; $F = 6.519$, df = 1/28, $p < .05$) and spent a larger amount of time in one tenth second units, on the NTE (M_{rc} = 10.10, M_{rnc} = 6.20; $F = 5.326$, df = 1/28, $p < .05$). These results suggest that R-C and R-NC Ss showed differential patterns of perceptual activity in relation to the TE and the NTE.

Violation Tasks

Analyses were made of individual psychophysiological dependent variables using the Groups by Tasks analysis of variance design. No significant main or interaction effects resulted from these analyses (see Table B for specific mean values). These results are consistent with those obtained in Studies 1 and 2, and again differences in individual psychophysiological dependent variables do not seem to reflect conservation status.

A Groups (R-C & R-NC) by Tasks (I & III) analysis of variance with repeated measures on Tasks, was used for exploratory analyses of general perceptual activity, and the following results were obtained. R-C Ss in comparison with R-NC Ss showed more fixations over both elements (M_{rc} = 12.99, M_{rnc} = 9.29; F = 21.016, df = 1/28, $p < .001$) and a shorter mean length of fixation in one tenth second units, over both elements (M_{rc} = 2.98, M_{rnc} = 3.43; F = 32.173, df = 1/28, $p < .001$). Both groups showed a shorter mean length of run over both elements on Task I (M_I = 14.42, M_{III} = 17.40; F = 5.741, df = 1/28, $p < .05$). No other significant main or interaction effects were obtained. The above results suggest that although two aspects of general perceptual activity)frequency and duration of fixations) continued to differentiate the groups, three others (frequency of couplings and frequency and duration of runs) did not.

The following results were obtained from additional exploratory analyses of Task III EM data. R-C Ss showed more fixations on the TE (M_{rc} = 7.54, M_{rnc} = 5.85; F = 7.430, df = 1/28, $p < .05$) and more fixations on the NTE (M_{rc} = 5.45, M_{rnc} = 3.44; F = 10.615, df = 1/28, $p < .01$). Both groups showed shorter mean length of fixation on the NTE during Task III (M_{III} = 1.86, M_I = 2.48; F = 7.796, df = 1/28, $p < .01$). These results seem consistent with those obtained from the above exploratory analyses of Task I and II EM data in that conservers appear to show generally more active perceptual behavior than non-conservers.

Study 4

Conservation Tasks

The Tasks by Groups analysis of variance design mentioned in Chapter 5 - Study 4 was also used for additional exploratory analyses of EM behavior in terms of the TE and NTE. These analyses indicated that RT Ss made more fixations on the NTE (M_{rt} = 5.06, M_{rnc} = 2.97; F = 12,636, df = 1/28, $p < .01$) and more runs on the NTE (M_{rt} = 1.05, M_{rnc} = 0.57; F = 8.234, df = 1/28, $p < .01$). Both groups showed more runs on the NTE during Task I (M_{I} = 1.00, M_{II} = 0.62; F = 8.359, df = 1/28, $p < .01$), but the remaining main and interaction effects were nonsignificant. This Task effect was not observed in any of the other studies and no explanation for the finding is apparent. All other exploratory analyses failed to yield significant main or interaction effects. These results suggested that the perceptual activity of RT and RNC Ss differed somewhat in relation to the TE and NTE.

Violation Tasks

The Groups by Tasks analysis of variance design was used for analyses of individual psychophysiological dependent variables. No significant main or interaction effects were obtained from these analyses (see Table B for specific mean values). These results seem consistent with those obtained in Studies 1, 2, and 3, in that differences on these dependent variables during TOP did not seem to be related to conservation status.

Exploratory between group analyses of general perceptual activity, which involved a Groups (RT vs. RNC) by Tasks (I & III) analysis of variance, with repeated measures on Tasks, were undertaken. A significant interaction effect was obtained on frequency of fixations over both elements (Task I: $M_{rt} = 12.40$, $M_{rnc} = 9.10$; Task III: $M_{rt} = 10.33$, $M_{rnc} = 9.47$; $F = 6.538$, $df = 1/28$, $p < .05$). Examination of these means reveals that whereas R-T Ss showed a decrease in frequency of fixations during Task III, a slight increase was observed on the part of R-NC Ss. Though differential R-T/R-NC general perceptual activity in terms of fixations is evident here, the decrease in fixations shown by R-T Ss during Task III, is less than the decrease shown by these Ss on Task II. Hence the result does not seem to be conservation violation task specific.

Further exploratory analyses of general perceptual activity indicated that R-T Ss, in comparison with R-NC Ss, made more runs ($M_{rt} = 2.44$, $M_{rnc} = 1.90$; $F = 6.184$, $df = 1/28$, $p < .05$) and showed a shorter mean length of fixation ($M_{rt} = 2.79$, $M_{rnc} = 3.43$; $F = 13.197$, $df = 1/28$, $p < .01$) over both elements. These results are comparable with those obtained on Task I and II analyses, in that they suggest in terms of fixations (over both elements) that R-T Ss are perceptually more active.

The above-mentioned Groups by Tasks repeated measures analysis of variance design was also used for additional exploratory analyses of Task III perceptual activity in relation to the TE and NTE. Whereas R-T Ss showed an increase in mean length of fixation (in one tenth second units) on the NTE, R-NC Ss showed a decrease (Task I:

M_{rt} = 1.92, M_{rnc} = 2.80; Task III: M_{rt} = 2.47, M_{rnc} = 1.953; $F = 7.056$, $df = 1/28$, $p < .05$). R-T Ss also showed more fixations (M_{rt} = 5.15, M_{rnc} = 3.44; $F = 12.719$, $df = 1/28$, $p < .01$) and more runs (M_{rt} = 1.17, M_{rnc} = 0.73; $F = 9.521$, $df = 1/28$, $p < .01$) on the NTE. These results are similar to those obtained from exploratory analyses of Task I and II EM data, but are not in agreement with those reported during Task II for N-T Ss who tended to show an increase in perceptual activity on the TE.