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THE DEVELOPMENT OF HABITUATION AND ITS RELATION TO
SELECTIVE ATTENTION IN ELEMENTARY SCHOOL CHILDREN

by

Robert William Flewelling

Thesis presented to the Faculty of Graduate Studies
and Research of Carleton University in partial
fulfillment of the requirements for the degree of
Doctor of Philosophy

DEPARTMENT OF PSYCHOLOGY

CARLETON UNIVERSITY

Ottawa, July, 1976

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The undersigned recommend to the Faculty
of Graduate Studies and Research acceptance of the thesis
"The Development of Habituation and Its Relation
To Selective Attention in Elementary School Children"
submitted by

Robert William Flewelling

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August, 1976

THE DEVELOPMENT OF HABITUATION AND ITS RELATION TO
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ABSTRACT

A series of experiments investigated rate of habituation, and a proposed relation between rate of habituation and selective attention performance in elementary-school children. Results of the initial study indicated that the rate of habituation of a visual fixation response decreased across Grades one to five. This reversal of the expected direct relationship between age and habituation rate was interpreted on the basis of a post-experimental questionnaire which revealed that a majority of the subject's perceived the task as requiring sustained attention. A second study, combining habituation of the visual fixation response and an incidental learning measure of selective attention, provided no direct evidence of a relation between habituation and selective attention. A final experiment measuring habituation of the suppression of a finger-tapping response showed neither age-related change in habituation rate nor direct evidence of a relation between habituation and selective attention. Correlational analyses revealed expected relationships between measures of selective attention (incidental learning) and sustained attention (Continuous Performance Test). In addition, some initial normative data were obtained for the CPT performance of young children.

The combined evidence of the present studies both underline the need to develop measures of the habituation

process for children in this age-range, and question the validity of the incidental learning task as a measure of selective attention ability. Further research must first solve methodological problems relating to the measurement of habituation rate and selective attention before progressing to an examination of proposed relationships between the two processes.

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This research programme examined developmental changes in rate of habituation, and a proposed relation between habituation and selective attention. Habituation refers to the progressive weakening of a response which occurs as the result of repeated stimulation. Rate of habituation then refers to the speed with which the response decrement occurs. The process of habituation has been the subject of considerable experimental effort and theoretical speculation. This is primarily due to the fact that habituation is one of the most fundamental forms of behavioural adaptability. Habituation has been observed across an extremely wide range of phylogenetic levels (Harris, 1943). Moreover, it has been described frequently as one of the first adaptive mechanisms to appear ontogenetically (e.g. Thompson, 1972). Many of the experimentally demonstrated characteristics of habituation indicate that habituation is a form of learning. Its early appearance coupled with its stimulus-specific nature have made the habituation-dishabituation paradigm a leading behavioural technique for the study of sensory and information-processing abilities of human infants (e.g. Bronson, 1974; Cohen, 1973).

Developmental studies have shown that older children habituate more quickly than do younger children (e.g. Lewis, Goldberg & Campbell, 1969). However, no experimental studies have yet isolated factors which might explain the developmental

change in habituation rate. Nonetheless, there is correlational evidence which shows significant relationships between rate of habituation and various organism status variables usually associated with cognitive capacity. For example, significant positive correlations have been found between habituation rate and chronological age (Lewis et al, 1969), mental age (Siddle & Glenn, 1974), and socio-economic status of the father (Lewis, et al, 1969). In addition negative correlations have been obtained between the presence of brain lesions (Thompson & Spencer, 1966), birth condition (e.g. Eisenberg, Coursin & Rupp, 1966), and habituation rate. Rate of habituation has also been shown to predict children's performance on certain learning and cognitive tasks. For example, Lewis et al (1969) found that fast habituators at 44 months of age made fewer errors in a discrimination learning task than did slow habituators.

Although habituation during infancy and adulthood has been studied frequently, the period of early and middle childhood has been relatively neglected. Also, most of the available studies of young children have not included the necessary control procedures to provide clear demonstrations of habituation. In addition to investigating the development of habituation, the present research examined the relation of habituation and rate of habituation to selective attention. Selective attention refers to the ability to focus on

relevant stimuli and to ignore irrelevant stimuli, simultaneously. The need for this ability is obvious, since the amount of stimulation impinging upon an organism at any moment usually exceeds its information processing capacity. Like many other abilities, selective attention skills become more efficient with increasing age. Basically, two experimental procedures have been used to investigate the development of selective attention. One of them, the selective listening procedure, measures the child's ability to attend to and to report one auditory message when competing messages are presented simultaneously (e.g. Maccoby & Konrad, 1967). The other measure of selective attention is based upon the incidental learning paradigm (e.g. Hagen, 1967). In this procedure certain features of a visual stimulus are designated as relevant, while others are defined as incidental. Selective attention is inferred on the basis of the child's recall of both the relevant, and the incidental information.

There has been increased speculation regarding a possible connection between habituation and selective attention (Gibson, 1969; Jeffrey, 1968, 1969; Weinberger, 1971). Selective attention implies the simultaneous occurrence of two events. One is the focussing of attention on relevant stimuli; the other is the ignoring of the irrelevant stimuli. It is suggested that habituation is the mechanism by which the child learns to ignore regularly

occurring but insignificant stimuli. This suggestion led to the following general predictions regarding children's selective attention performance. First, children who have been habituated to stimuli subsequently used as the irrelevant stimuli in a selective attention task perform better than children who have not been habituated to these stimuli. Second, children classified as "fast-habituators" perform better than "slow-habituators" because they learn to ignore the irrelevant stimuli more quickly. Experimental confirmation of these predictions would provide evidence of a functional relation between habituation and selective attention.

The need for the systematic investigation of selective attention recognizes two divergent sources of input, teachers' experience and scientific investigations. Teachers often attribute their pupils' learning difficulties to "poor attention span", "distractibility", and other related constructs. The perceived importance of attention in learning is reflected by their attempts to minimize distractions, and to make the subject matter more interesting. Since acquiring knowledge about the environment depends so intimately upon how the child distributes his attention, it is important to determine what governs these processes.

CHAPTER I

REVIEW OF THE HABITUATION LITERATURE

1. Nature and Significance of Habituation

The term habituation commonly refers to the occurrence of response decrement as a result of repeated stimulation (e.g. Harris, 1943; Jeffrey, & Cohen, 1971; Thompson, & Spencer, 1966). Defined in such a general manner, however, habituation cannot be distinguished from other decremental events, such as, receptor or effector fatigue, adaptation, and stimulus satiation. J.D. Harris (1943) made a significant contribution to this field of investigation when he presented an extensive review of the literature on habitulatory response decrement observed across a broad range of phyla. In addition, Harris was one of the earliest writers to suggest and to emphasize a distinction between habituation and other similar processes. On the basis of the data reviewed, Harris (1943) described three fundamental characteristics of habituation, namely:

- a) Habituation, plotted as a function of time, occurs rapidly at first and then progressively more slowly.
- b) Habituation can proceed to a below zero level, that is, after the response has disappeared, further stimulation results in slower recovery.
- c) The mechanisms of habituation are similar to those of conventional learning.

The first two characteristics have been supported experimentally (Thompson & Spencer, 1966); however, the third remains

a matter of dispute (Jeffrey & Cohen, 1971). Since Harris' (1943) early formulations concerning habituation, the amount of relevant experimental evidence has increased considerably. Reviewing the literature, Thompson and Spencer (1966) posited nine restrictive qualifications which they felt constituted a critical definition of habituation. Since it is generally recognized as the most precise definition of habituation, it bears repetition.

1. "Given that a particular stimulus elicits a response, repeated applications of the stimulus result in decreased response (habituation). The decrease is usually a negative exponential function of the number of stimulus presentations.
2. If the stimulus is withheld, the response tends to recover over time (spontaneous recovery).
3. If repeated series of habituation training and spontaneous recovery are given, habituation becomes successively more rapid (this might be called potentiation of habituation).
4. Other things being equal, the more rapid the frequency of stimulation, the more rapid or more pronounced is habituation.
5. The weaker the stimulus, the more rapid and/or more pronounced is habituation. Strong stimuli may yield no significant habituation.
6. The effects of habituation training may proceed beyond the zero or asymptotic response level.
7. Habituation of response to a given stimulus exhibits stimulus generalization to other stimuli.
8. Presentation of another (usually stronger) stimulus results in recovery of the habituated response (dishabituation).

9. Upon repeated application of the dishabituation stimulus, the amount of dishabituation produced habituates (this might be called habituation of dishabituation)."

(Thompson & Spencer, 1966; pp. 18-19.)

Most of the characteristics, although descriptive of habituation, do not differentiate habituation response decrement from "fatigue-like" decremental processes. On the other hand, the fact that weaker stimuli result in faster habituation is clearly inconsistent with a fatigue explanation of response decrement. One would expect satiation, or receptor and effector fatigue to occur more quickly to stronger stimuli, however, strong stimuli may yield no significant habituation. If, as proposed by Thompson and Spencer, dishabituation occurred only with the presentation of a stimulus stronger than the habituated one, then item 8 does not imply that habituation is a distinct process. However, some investigations have demonstrated dishabituation using less intense (e.g. Engen & Lipsitt, 1965), or novel (e.g. Pancratz & Cohen, 1970) stimuli. The occurrence of dishabituation to less intense or merely discrepant stimuli represents the most critical criterion for the assumption of habituation. Many experiments which have purported to study habituation (e.g. Cohen, 1969; Keen, Chase, & Graham, 1965; Mackworth & Otto, 1970; Milstein, Stevens, & Sachdev, 1969; Moreau, Birch, & Turkewitz, 1970) either did not attempt, or failed to demonstrate dishabituation; thus, the conclusions of such studies

regarding habituation are not convincing. It is necessary that any experimental investigation of habituation be designed such that, if response decrement is observed, it can be interpreted as a demonstration of habituation rather than some other process.

There are several important reasons for studying the process of habituation. First, habituation is considered to be a basic developmental process which represents probably the most ubiquitous and primitive manifestation of behavioural adaptability (e.g. Harris, 1943; Jeffrey & Cohen, 1971). Second, habituation is significant as a possible mechanism of learning. In addition, habituation has proven to be useful as one of the few techniques for investigating the development of sensory and information-processing capacities of human infants and infrahuman organisms (e.g. Bronstein, Neiman, Wolkoff & Levine, 1974).

As a basic process of development, habituation plays an important role in the models of Bronson (1965) and W.R. Thompson (1968, 1972). According to Bronson, early development consists of the successive emergence of increasingly complex adaptive mechanisms. The development of the adaptive mechanisms reflect gradual increments in the level of sensory and motor differentiation involved, and is governed by the sequential maturation of three levels of the central nervous system (CNS). Levels I (brain stem), II (sub-cortical forebrain), and III (neocortex) mediate habituation and

classical conditioning, instrumental learning, and latent learning respectively. Subsequent levels depend upon and extend the complexity of the preceding levels. Various CNS levels are differentially responsive to various types of input. For example, level I responds only to changes in intensity of stimulation while level II reacts to changes in frequency. Pattern variations require the activity of level III. Sharpless and Jasper (1956) presented habituation data from a series of experiments with cats which indicated such a progression. Bronson's notion of the differential salience of stimulus characteristics closely resembles the following statement by Harris (1943).

"With increase in morphological organization, changes in the possibilities for habituation occur in the direction of a lessened dependence upon stimulus intensity(...) and a progressive freeing from a more or less restricted temporal pattern of stimulation."

In Bronson's model habituation is the first adaptive mechanism to emerge; thus, it is represented at all levels of the CNS hierarchy.

Thompson's (1968, 1972) developmental schema is similar to that of Bronson, particularly with respect to the order of appearance of the various adaptive mechanisms. Rather than explaining the ontogenetic changes only on the basis of the morphological maturation of central nervous system networks, however, Thompson related these changes to the interaction, over time, of three developmental processes;

differentiation, growth, and organization. These processes interact to influence both morphological maturation and behaviour changes. He suggests that differentiation occurs by means of an "inhibiting process or processes which give greater selectivity to both input and output" (1968, p. 152).

Habituation is consistent with the description of the inhibitory process postulated by Thompson in terms of both inhibition and selectivity. Like Bronson, Thompson views habituation as the first adaptive mechanism to emerge in early development while both input and output systems are relatively undifferentiated. Habituation also plays a prominent role in models of perceptual-cognitive development (Gibson, 1969; Jeffrey, 1969; Lewis, et al, 1969).

It has been argued affirmatively for many years (e.g. Harris, 1943; Humphrey, 1933) that habituation represents a type of learning mechanism. Recently, however, it has been suggested (Jeffrey, & Cohen, 1971) that habituation as a form of learning is a matter of dispute. An adequate treatment of the issue requires, first of all, a definition of the term learning. Numerous definitions have been reviewed by Kimble (1961) who stated that there is general agreement that, operationally, "learning refers to a more or less permanent change in behaviour which occurs as a result of practice" (p. 2). In this definition, the independent variable is practice and the dependent variable is a relatively permanent change in behaviour. Learning represents a

mediating variable between the two. Habituation, it is proposed, also represents a mediating variable between repeated stimulation ("practice") and more or less permanent response decrement. Essentially, and operationally, therefore, no differences exist between the definitions of habituation and learning. The operational congruity between the two processes is exemplified by Hunter's definition that "learning is taking place whenever behaviour shows progressive change or trend with repetition of the same stimulating situation and when the change cannot be accounted for on the basis of fatigue or receptor or effector changes" (c.f. Kimble, 1961, p. 2). Habituation, however, does differ from learning defined as either classical or instrumental conditioning. Both classical and instrumental conditioning are paradigms or laboratory procedures which are assumed to reflect the more general learning process. These two procedures are generally recognized as distinct and yet both are considered mechanisms of learning. Viewed in this way, there is no reason why habituation cannot be considered distinct from the other two learning paradigms. Rather than focussing on incremental or positive aspects of learning, habituation is a mechanism by which one learns not to respond to irrelevant stimuli.

The third significant aspect of habituation lies in its utility as one of the few techniques for the experimental investigation of the sensory capacity of human infants and

infra-human organisms (Reese, & Lipsitt, 1970). In fact, the original data on habituation in immature human organisms, came from investigations in which habituation played a secondary role as a tool for examining the auditory capacity of neonates (Bridger, 1961; Bronshtein & Petrova, 1967). An experiment by Moffitt (1971) provides a good example of the application of a habituation-dishabituation paradigm. Using cardiac deceleration to a novel stimulus as a dependent measure, Moffitt examined the consonant cue perception of 24 week-old infants in order to determine whether the infants were capable of discriminating between the speech sounds /b/ and /g/. Briefly, the procedure involved two phases. In the first, the habituation phase, one of the two speech sounds was repeatedly presented. It was expected that, initially, the infant would respond to the stimulus presentation with cardiac deceleration, the magnitude of which would decrease as the stimulus was repeated. Following this phase the second speech sound was presented. It was expected that, if the subject was capable of discriminating the sounds, the magnitude of the dishabituated decelerative response would be higher than that observed on the last trial of the habituation phase. The results of Moffitt's experiment indicated that during the habituation phase the magnitude of response decreased significantly over trials. Secondly, the results indicated that dishabituation occurred for two of his three groups; thus, he concluded that young infants are able to

discriminate between the consonants /b/ and /g/. Similar methodologies have been used to explore visual discrimination abilities and visual information processing (e.g. Wetherford & Cohen, 1973).

The widespread use of the habituation procedure as a tool for studying the sensory capacities of infants points out the need for the understanding of the process and its development. If the techniques used in experimental research are not well standardized, the conclusions based upon the studies using these techniques rest on a weak foundation. For example, most studies of habituation have been designed such that the observed response decrement cannot be unequivocally attributed to habituation rather than to fatigue, satiation or another decremental process. The demonstration of dishabituation is considered to be one of the minimum criteria for accepting a response decrement as habituation. In the subsequent review of the habituation literature the studies will be evaluated on the basis of this criterion. The conclusions of investigations not using a dishabituation paradigm or an equivalent control procedure will be considered questionable in so far as they pertain to the process of habituation.

2. Theories of Habituation

The process of habituation has been the focus of much theoretical speculation. All of the theories, with one exception (Stein, 1966), have been stated in neurophysiological

terms. Although this research programme does not propose to investigate the neural substrates of habituation, knowledge of the neurophysiology of the process is essential if it is to be fully understood. Thus, an overview of the various models is undertaken here. More detailed reviews have been presented by Lynn (1966), Groves and Thompson (1970), and Peeke and Herz (1973a, b). Lynn's review provided a particularly significant contribution because of its comprehensiveness, and for its coverage of the Russian literature which previously had been inaccessible.

One and two-stage Theories

Lynn (1966) divided the neural theories into one-stage and two-stage models. One-stage models are those which assume that repeated stimulation generates an inhibitory process in a particular body of neurons, such that the response threshold of those neurons is eventually raised sufficiently high to eliminate the response. Two-stage models, on the other hand, embody one stage in which there is an analysing mechanism to determine whether the stimulus necessitates an orientation reaction, and a second stage in which an excitatory or inhibitory mechanism is innervated to evoke or suppress the reaction. Although Lynn (1966) focussed on habituation of the orientation reaction, most of the models are stated in a sufficiently general fashion so as to be applicable to a broader range of responses.

The theories of Pavlov, Sharpless and Jasper, Gastaut, and Roitbak (cf. Lynn, 1966), and Horn (1967) are examples of one-stage models. Although all one-stage theories share the assumption that the build up of internal inhibition causes habituation, they differ with regard to the specific anatomical sites responsible. Since an adequate theory of habituation must account for all the behavioural characteristics of habituation as well as be consistent with neurophysiological evidence, none of the one-stage theories can be considered completely adequate. Particularly embarrassing for the one-stage models are the observations of the occurrence of dishabituation to less intense (e.g. Engen and Lipsitt, 1965) or novel (e.g. Pancratz and Cohen, 1970) stimuli. Because of this, and similar results, Lynn (1966) rejected the one-stage models as untenable, and supported instead the two-stage models. Since Sokolov's theory is the one most fully worked out, and is the one to which most research is compared, it is the only model described here in detail. Figure 1, reproduced from Lynn (1966) provides a schematic outline of Sokolov's (1960, 1963) model.

Following from the model presented in Figure 1, afferent stimulation is registered in the cortex. The registration or memory trace consists of a chain of neural cells which preserve information about the intensity, quality, duration, and order of presentation of the stimuli.

Figure 1. Sokolov's Model for the Orientation Reaction

- 1: specific pathway from sense organs to cortical level of modelling system.
- 2: collateral to reticular formation (represented here as amplifying device).
- 3: negative feedback from modelling system to synaptic connections between collaterals from specific pathway and reticular formation (RF) to block input, in the case of habituated stimuli.
- 4: ascending activating influences from the RF to the modelling system (cortex).
- 5: pathway from the modelling system to amplifying system (this is the pathway through which the impulses signifying non-concordance between input and existing neuronal models are transmitted from the cortex to the RF reticular formation).
- 6: to specific responses caused by coincidence between the external and neuronal model (habitual responses).
- 7: to the vegetative and somatic components arising from the stimulation of the RF (p. 14).

The information which is conveyed by the sensory tracts is analysed and compared with the stored neuronal models of past stimulation. The analysis and comparison processes result in one of two outcomes. In the first case, if the stimulus does not match an existing model, the orientation reaction occurs; that is, impulses are sent from the cortex to the reticular formation and sensory impulses are permitted to reach the reticular formation via the afferent collaterals, initiating the orientation reaction. This is the same operation by which dishabituation occurs. Secondly, if the stimulus matches an existing model, the orientation reaction is blocked. This blocking results from the failure of the reticular formation to receive impulses from both the cortex and the afferent collaterals. Thus, impulses from the cortex to the afferent collaterals block or inhibit the conduction of the non-specific effects of sensory stimulation to the reticular formation.

Whereas Sokolov (1963) assumed the inhibitory block to take place at the afferent collaterals, the other two-stage theorists postulated additional mechanisms, variously located in the pons (Moruzzi, 1960), hippocampus (Grastyan, 1959), and neocortex (Jouvet, 1961), which were assumed to inhibit the reticular formation (all cf. Lynn, 1966).

Although the two-stage models agree that the cortex contains analyzing mechanisms which are instrumental in generating downward inhibitory impulses, they differ with respect to the precise mechanisms of inhibition.

Horn (1967) described Sokolov's schema as an unsatisfactory general theory, because response decrement can occur in the absence of the cerebral cortex. Horn, however, did not distinguish habituated response decrement from that of fatigue; thus his argument is not convincing. It is quite likely, that Horn (1967) and Sokolov (1963) are theorizing about different processes or, at least, different aspects of the same general process, i.e., response decrement.

Afferent Neuronal Habituation

The models thus far mentioned have assumed cortical participation in habituated response decrement, however, Hernandez-Peon (1960) presented a theory of afferent neuronal inhibition in which the cortex was considered unnecessary for the occurrence of habituation. Afferent neuronal habituation refers to response decrement which takes place in those afferent pathways which carry sensory impulses of a single modality from the receptors up to the cortical receiving area. Using an evoked potential technique Hernandez-Peon reported habituation at the cochlear nucleus, at the retina, the olfactory bulb, and at the fifth spinal sensory nucleus which he accounted for by "centrifugal plastic inhibition" acting at those peripheral sensory synapses (Hernandez-Peon, 1960). Worden (1966) after six years of experimentation directed towards replicating Hernandez-Peon's work, finally rejected the hypothesis of afferent inhibition. Worden

attributed Hernandez-Peon's results, particularly regarding the cochlear nucleus, to inadequacies of methodology, notably a lack of control over acoustic input and neglect of ear-muscle activity. Worden's investigations are very embarrassing for Hernandez-Peon's theory. Thus, the reader is referred to Worden's (1966) detailed description. Groves and Thompson (1970) described a study by Weinberger, Goodman and Kitzes (1969) which failed to support the notion that behavioural habituation is a function of peripheral auditory system blockade. They found no relationship between habituation of eye movement to repeated auditory stimulation, and ascending auditory evoked potentials. The hypothesis of afferent neuronal habituation, although it has demonstrated great heuristic value, appears unable to explain much of the recent habituation data.

A Psychological Theory

Stein (1966) presented a theory which consists of elements from both one- and two-stage models. It is interesting for its use of psychological rather than neurophysiological terminology. The theory was outlined by Stein as follows:

"A theory is described which assumes that: (a) the arousal reaction is controlled by antagonistic excitatory and inhibitory brain mechanisms; (b) a novel stimulus activates the excitatory mechanism which in turn activates the inhibitory mechanism; and (c) the inhibitory mechanism becomes conditioned (by Pavlovian conditioning) to

the onset of the stimulus itself after repeated presentations. Habituation of arousal is said to occur when the anticipatory, conditioned activation of the inhibitory mechanism overrides the direct activation of the excitatory mechanism. Reactivation of the arousal reaction when the habituated stimulus is changed is explained by a reduction in conditioned inhibitory activity due to stimulus generalization decrement."

(1966; p. 352)

One of the characteristics of habituation is that low intensity, less intense stimuli lead to faster habituation.. In order to handle this effect Stein's classical conditioning model would have to state that weaker stimuli result in faster conditioning of the inhibitory mechanism. As Groves and Thompson (1970) point out, however, the evidence (e.g. Brogden, 1951; Kamin, 1965; Razran, 1949) suggests that a decrease in CS intensity produces a decrease in the speed of acquisition of a conditioned response. Despite this weakness, Stein's theory handles some of the habituation phenomena very well, particularly dishabituation and generalization. It is not obvious to what extent Stein's model is distinct from other models. However, it affords many psychologists the opportunity to discuss habituation in more familiar terms.

Dual-process Theory

The "dual-process" theory of habituation has been summarized by Groves and Thompson (1973) and Thompson,

Groves, Teyler and Roemer (1973). Basically the theory postulates that behavioural habituation is the product of two inferred processes, habituation and sensitization. Groves and Thompson assume that any effective stimulus has two properties. First, it elicits an inferred response in the S-R pathway which is the most direct route through the central nervous system from the stimulus to the response. Secondly it induces an inferred change in state which is defined as a collection of pathways, systems, and regions that determine the organism's general level of responsiveness. The theory further postulates that the repetition of an effective stimulus results in an inferred decremental process in the S-R pathway which results in "behavioural habituation". Stimulus repetition also causes an inferred increment in the organism's tendency to respond which results in "behavioural sensitization". Although the inferred processes of habituation and sensitization are independent, they interact to yield the final outcome.

Habituation is considered to be primarily phasic in its action on response while sensitization is primarily tonic. The term sensitization seems to be somewhat analogous to the term dishabituation which is used by other theories. However, sensitization is a more general process than is dishabituation since the dishabituation occurs to a change in an habituated stimulus while sensitization represents a more

generalized increase in responsiveness to any effective stimulus.

Summary

The phylogenetic ubiquity of habituation and its occurrence under widely varied experimental conditions, led Harris (1943) to state that "any single explanatory principle (of habituation) would be too general to be satisfactory" (p. 388). He remarked on the dearth of knowledge pertaining to the neurophysiological mechanisms of habituation, and recommended that the primary goal of researchers should be to elucidate the exact conditions under which habituation occurs. An impressive amount of behavioural and neurophysiological evidence in both intact organisms and more simplified preparations has been collected since. The development and use of electroencephalographic recording (e.g. Sharpless & Jasper, 1956; Milstein, et al., 1969), sensory evoked potential techniques (e.g. Worden, 1966), and lesioning procedures (e.g. Thompson & Spencer, 1966) have contributed significantly to increased understanding of the neurophysiological aspects of habituation. In fact, all of the theoretical schemas, with one exception (Stein, 1966), have described habituation in neurophysiological terms. One of the shortcomings associated with the emphasis on the neural substrates of habituation, however, has been the evolution of the popular view that habituation reflects

solely the operation of wired-in neural networks. Consequently, investigation of the ontogenetic development of the process has often been based on the implicit premise that age-performance functions are fixed and final, and need merely to be discovered. Consider Weinberger's (1971) statement about attention that "identification of the neural bases of stimulus selection will constitute an explanation itself" (p. 156). Adherents of this view consider, therefore, that changes in age-performance functions reflect maturational unfolding of the appropriate neural networks. Such an approach is antagonistic to the view adopted in this research programme in that the development of any network, mechanism, process, or behaviour is considered to be the product of the continuous interaction over time of both hereditary and environmental factors. Some investigations have demonstrated that appropriate environmental manipulation can alter age-performance functions (e.g. Snedden, Spevack and Thompson, 1971). Thus, although most models concentrate on the neural substrates of habituation, one should recognize that identification of neuronal mechanisms while necessary are not sufficient for the understanding of the development of the habituation process.

3. Ontogeny of Behavioural Habituation

The history of systematic investigations devoted to the development of habituation in immature organisms is

relatively brief. Jeffrey and Cohen (1971) stated that "A chapter on habituation in infants could not have been written a decade ago. There was too little evidence available" (p. 92). Although recent years have witnessed a considerable expansion in the amount of research conducted with infant subjects, studies of young children remain scarce. According to Reese and Lipsitt (1970), "the period of infancy has received attention disproportionate to the amount of time it encompasses, partly because this period is believed to be more important than most for the understanding or predicting of later gross development" (p. 33). In addition, the problem of the sensory capacity of infants has been of perennial interest. Since the habituation paradigm is one of the very few techniques available for the study of infant perceptual development, the age bias in habituation studies is not surprising. Reese and Lipsitt (1970) reviewed those studies which have utilized the habituation paradigm. Because of the secondary role assigned to habituation, studies of this nature provide little insight into the development of habituation except as demonstrations that habituated response decrement occurs at various ontogenetic levels. Most investigations have focussed on the demonstration of habituation per se, or the elucidation of relevant stimulus and training variables. Very few have been of a comparative, developmental nature.

Infants and Infra-human Research

Jeffrey and Cohen (1971) presented a comprehensive review of habituation in the human infant, which is summarized here. Although habituation is not readily obtained in the neonate, Jeffrey and Cohen found that by two months of age habituation is clearly observable to a variety of stimulus modalities. While no experiments have as yet used gustatory stimuli, habituation has been observed to auditory (e.g. Bartoshuk, 1962(a)(b); Bridger, 1961; Bronshtein & Petrova, 1967; Campos & Brackbill, 1973; Graham, Clifton & Hatton, 1968; Hatton & Graham, 1969; Keen, Chase & Graham, 1965; Lewis, 1971), visual (e.g. Brown, 1974; Caron & Caron, 1968; Cohen, 1969; Cornell & Strauss, 1973; Kagan & Lewis, 1965; Meyers & Cantor, 1967; Saayman, Ames & Moffett, 1964; Weizman, Cohen & Pratt, 1971), olfactory (Engen & Lipsitt, 1965; Engen, Lipsitt & Kaye, 1963), and tactile (Lewis, Bartels & Goldberg, 1967; Moreau, Birch & Turkewitz, 1970) stimuli. Enough data were available to allow Jeffrey and Cohen to evaluate the extent to which Thompson and Spencer's (1966) restrictive qualifications applied to habituation observed in infants.

Although all of the characteristics reported by Thompson and Spencer are descriptive of habituation, dishabituation most clearly distinguishes habituation from other types of response decrement to repeated stimulation,

e.g. fatigue. According to Thompson and Spencer dishabituation refers to the recovery of an habituated response to the original stimulus following the presentation of another, usually stronger, stimulus. Recently, dishabituation typically refers to elicitation of a response to a novel stimulus (S2) which is discrepant from the stimulus (S1) to which the subject has been habituated. One must insure, however, that S2 is not always more effective in eliciting the response than S1. In this review of the habituation literature all experiments are evaluated on the basis of whether they have demonstrated dishabituation which is considered here to be the minimal criterion for the assumption of habituation. Dishabituation has been observed for auditory (e.g. Bridger, 1961; Bartoshuk, 1962a,b; Clifton & Meyers, 1969; Moffit, 1971), visual (e.g. Caron & Caron, 1968, 1969; McCall, 1973; McCall, Hogarty, Hamilton, & Vincent, 1973; Pancratz & Cohen, 1970), and olfactory stimuli (e.g. Engen & Lipsitt, 1965; Engen, Lipsitt & Kaye, 1963). Including a demonstration of dishabituation allowed these investigators to eliminate state-change and effector fatigue explanations of observed response decrements.

One of the characteristics of habituation, the spontaneous recovery of an habituated response, has received little experimental investigation. Bronshtein and Petrova (1967) examined the habituation of the suppression of a non-nutritive sucking response to a repeated auditory stimulus

in infants between the ages of 2 hours to 8 days. They reported that when the auditory stimulus was withheld the habituated response recovered. However, the data on which Bronshtein and Petrova's conclusion was based, were presented so sketchily that its adequacy cannot be evaluated. In a more recent study, Pancratz and Cohen (1970) presented 4-month-old infants with a repeated visual stimulus and measured habituation, dishabituation and spontaneous recovery of a visual fixation response. They found that male subjects but not females habituated over trials. In addition, the males dishabituated to a novel stimulus but spontaneous recovery did not occur after a five minute interval. They felt that the failure to obtain spontaneous recovery was due to the possible effects of situational fatigue. On the basis of the available data, it can be concluded that spontaneous recovery of an habituated response has not been convincingly demonstrated with infant subjects.

According to Thompson and Spencer (1966) the more rapid the frequency of stimulus presentation, the more rapid is habituation. Bridger (1961) examined newborn infants' ability to habituate their startle response to auditory stimuli, and used a dishabituation procedure to determine whether newborns could discriminate the pitch of auditory stimuli. He found that habituation was more likely to occur, and to occur more quickly to stimuli of long duration with a brief interstimulus interval (ISI) than to stimuli of shorter

duration with longer ISI's. Since Bridger's subjects dishabituated to changes in pitch, his data can be considered to be a clear demonstration of the effect of frequency of stimulation on the speed of habituation. Bartoshuk (1962a,b) conducted similar experiments with newborns, and obtained no differences in habituation to repeated auditory stimulation using 15, 30 and 60 second ISI's. Bridger, however, used ISI's of $\frac{1}{2}$ or 3 seconds, thus, it may have been that the newborn's memory storage cannot retain information with ISI intervals of the length used by Bartoshuk. Lewis, et al, (1969) measured the habituation of a visual fixation response of 12 week olds to stimuli presented at three intertrial intervals: 0, 5 and 15 seconds. The results indicated that both the 0- and 5-second groups showed response decrement whereas the 15-second group failed to habituate. Since the study by Lewis et al (1969) was not designed to demonstrate dishabituation, and since the stimulus modality differed from that of the preceding studies, it does not provide clear confirmation of the memory storage explanation of the intertrial interval effect. Nonetheless the results are at least consistent with the expectation. On the basis of these studies it appears that with infant subjects habituation is more rapid to higher frequencies of stimulus presentation as long as the intertrial interval is less than 15 seconds.

According to Thompson and Spencer, the weaker the

stimulus the more rapid is habituation. No studies of immature organisms have directly investigated this characteristic as yet. If, as Jeffrey and Cohen (1971) have suggested, the definition of strength includes the complexity of stimulation as well as intensity, then a substantial amount of evidence is available. In an initial study Caron and Caron (1968) examined the effect of two levels of complexity of a visual stimulus on the rate of habituation of a visual fixation response in 3½ month old infants. They found that the more complex stimulus resulted in significantly slower habituation than was found for the simple stimulus. In a later study, Caron and Caron (1969) replicated these results using three levels of complexity. The relationship between rate of habituation and degree of complexity was inverse and monotonic. Supportive evidence for this relationship has been reported by Cohen (1969) and by Greenberg, O'Donnell and Crawford (1973). A recent experiment by Brown (1974), using three levels of complexity of visual stimuli with 8 week olds, obtained results which did not support the notion that degree of habituation is linearly related to complexity. Less habituation was observed to moderately complex stimuli than to either the more simple or the more complex stimuli which did not differ from each other in terms of degree of habituation. On the basis of the available evidence it appears that more complex stimuli result in slower habituation although the relationship is not necessarily linear.

The characteristic of generalization of habituation has also been examined. Saayman, Ames and Moffett (1964), exposing 3-month old infants to simple geometric patterns differing in either form, colour, or both form and colour, found that habituation of the visual fixation response generalized so long as one of the two dimensions remained the same. Using more complex three-dimensional objects, McCall and Kagan (1970) found generalization to occur; however, habituation was observed in only one-third of the 4-month old subjects. Thus, the conclusions are not convincing. A study by Cohen, Gelber and Lazar (1971) found generalization of habituation to obtain in 3-month old infants with less recovery to patterns changing on one dimension than those on which both possible dimensions were varied. Additional supportive evidence for the generalization of habituation in infants was presented recently by Cornell and Strauss (1973) who used compounds of habituated visual stimuli.

Three of the parametric characteristics of habituation (Thompson & Spencer, 1966) have not been investigated in human infants. They are below-zero habituation, potentiation of habituation, and habituation of dishabituation.

Apart from those studies which have examined the extent to which Thompson and Spencer's characteristics apply to habituation observed in infants, some studies have investigated developmental changes in habituation during infancy.

Lewis (1971) examined the habituation of the cardiac decelerative response to the onset and offset of repeated auditory stimulation in infants 3, 6, and 12 months old. All subjects habituated to both the onset and offset of stimulation with dishabituation occurring to a change in the repeated stimulus. An age-associated change in habituation to onset was observed, with 3-month olds showing the least amount of habituation and 12-month olds the most. The pattern for offset was different with the 3- and 6-month olds showing significantly more habituation than 12-month olds. The data for habituation to onset were consistent with a study by Lewis, et al (1969) which measured cardiac deceleration habituation to visual stimuli. Similar developmental results have been obtained in studies which have measured visual fixation responses to repeated visual stimuli in newborns (Friedman, Nagy & Carpenter, 1970) and 3- to 18-month olds (Lewis et al, 1969; McCall, 1973; Wetherford & Cohen, 1973). On the basis of the data reviewed, it appears that rate of habituation is an increasing function of changes in age during the period of infancy.

Studies of developmental changes in habituation have also been conducted with immature infrahuman subjects. Lynn in a discussion on the development of the orientation reaction, cited a few experiments pertaining to the ontogeny of habituation in young animals. Nikitina (1953, cf. Lynn, 1966), for example, found that young puppies aged 3-14 days,

required approximately 200 trials to habituate to a sound; whereas, puppies aged 40-60 days required only 15-20 trials. In a subsequent study Nikitina and Novikova (1958; cf. Lynn, 1966) indicated that, in puppies, the morphological maturity of the cortex and the adult habituation rate had occurred at approximately the same time, namely, 6-8 weeks. Snedden, et al (1971) examined age differences in rats using a conditioned emotional response paradigm. The study was designed such that an independent assessment of age differences in habituation could be obtained. With groups of rats treated at 15, 22, 35, and 70 days of age, Snedden et al (1971) observed that an unconditioned suppression response habituated more quickly in older than in younger subjects. Age-related increments in rate of habituation have also been observed for an investigatory head poking response in rats from 15 days old to adulthood (Feigley, Parsons, Hamilton & Spear, 1972; Parsons, & Fagan, 1973). More recently, Bronstein, Neiman, Wolkoff, and Levine (1974) found no habituation of open-field activity in 15-day old rats, but 21 day-old rats did habituate. File and Plotkin (1974) found that habituation of a head-raising and turning response elicited by a puff of air occurred reliably by the time infant rats reached 3 days of age. Contrary to the previous studies with older rats the number of trials to habituate the response increased with age. None of the infrahuman studies included a habituation procedure in their design, and, therefore, none differentiated

habituation from fatigue or state-change response decrement. Hence, the observed developmental changes in response decrement cannot be interpreted unequivocally as age-related changes in rate or amount of habituation. This problem is particularly critical for File and Plotkin's (1974) experiment because some of their subjects were observed during the neonatal period when state-changes play a greater role in behaviour.

Although the studies using infrahuman subjects do not definitively support the age-related increase in rate of habituation that has been observed in human infants, the general finding is supported by indirect evidence from an alternative line of enquiry. Lynn (1966) cited comparative investigations which showed that animals higher on the phylogenetic scale habituate more rapidly than do lower animals (e.g. Vedyayev and Karmanova, 1958; Guselnikov, 1958; Zagorylko, and Sollertinskaya, 1958; all cf. Lynn, 1966).

Thus to the extent that ontogeny and phylogeny are parallel, the data pertaining to phylogenetic development of habituation appear to be consistent with that obtained for its ontogenetic development. However, it should be pointed out that these studies are available only in a secondary source (Lynn, 1966) without sufficient detail to enable critical evaluation.

Ontogeny of Habituation in Young Children

Developmental studies of habituation in children are relatively rare. Lynn (1966) briefly described an experiment in which he compared the habituation rates of girls (4-6 years) and young women (18-21 years). For the women habituation of the PGR to a discrete auditory tone required a mean of 23 trials, while the children failed to habituate after 60 trials. Although the difference between the groups was reported to be highly significant, Lynn did not present sufficient detail of the experimental procedure to allow a clear interpretation of the results.

The failure of Lynn's (1966) 4-6 year old subjects to habituate is surprising when one considers the number of experiments which have clearly demonstrated that infants can habituate to a variety of stimuli. A series of experiments with 44-month old children by Lewis and his associates (Dodd & Lewis, 1969; Lewis & Baumel, 1970; Lewis & Goldberg, 1969; Lewis, Goldberg & Rausch, 1967) have demonstrated habituation and dishabituation of visual orienting responses to a variety of stimuli. Despite Lynn's puzzling results, the weight of evidence supports the general conclusion that children's responses to a variety of stimuli may be habituated.

The most ambitious developmental study of response decrement was presented by Lewis, Goldberg and Campbell (1969) who conducted a series of experiments with infants

and children ranging in age from 3-44 months. In the first two experiments they measured rate of response decrement of a visual fixation response to four presentations of a blinking light located within a light matrix. Rate was defined primarily by subtracting the fixation score for the last trial from that of the first trial and dividing by the first trial score $(1-N/1)$ to control for initial level of response. Regression analysis of the data from the four trials was a second measure of rate of response decrement. Response decrement was indicated by a best fit line of negative slope with higher values indicating more rapid response decrement. The results of these experiments indicated that rate of response decrement was directly related to chronological age across an age range of 3-, 6-, 9-, 13-, and 18-months.

In the third experiment the same procedure was followed except that the blinking light moved across the light matrix forming a helix pattern. In general, movement of the blinking light resulted in higher initial fixation scores and yielded greater decrement scores. The data from the third experiment were not entirely consistent with the data from the first two experiments. Although the rate of decrement increased regularly with the 3-, 6-, and 9-month olds, the 13-month olds decrement score was placed between the 3- and 6-month olds. This inconsistent result was not explained by Lewis et al.

In the fourth experiment a stationary blinking light was the stimulus. The procedure was the same as that previously described except that nine trials were presented. The results replicated those of the first two experiments in that a direct relationship between age and rate of response decrement was obtained across the 3- to 18-month age-range. In a second episode the subjects were presented with six presentations of a curved line stimulus, and the results were compared with a group of 3½ year old children who had been tested previously. The same age by rate of decrement effect obtained with the 3½ year olds showing the greatest decrement.

On the basis of the data presented by Lewis et al (1969) it appears reasonable to conclude rate of response decrement is directly related to increasing chronological age. The nature of the response decrement is not clear, however. Lewis et al did not include dishabituation trials in order to rule out state- and/or fatigue-based response decrement.

Milstein, Stevens and Sachdev (1969) investigated the habituation of a neurophysiological component of the orienting reaction (alpha blocking) to the repeated presentation of brief light flashes. They compared the habituation curves for normal children (8-16 years) and adults with age-equivalent subjects representing various psychiatric populations. The results indicated that the oldest children

(14 years) habituated significantly faster than the youngest children (8 years), and that the habituation curves of the oldest children were more similar to those of adults than to those of the youngest children. Unfortunately, Milstein et al did not use a dishabituation paradigm, therefore, their results cannot be considered a definitive demonstration of habituation.

Thus far, all the studies reviewed have suggested that habituation rate is directly related to chronological age. However, a recent investigation measuring habituation of the visual orienting response in children aged 2-3, 4-5, and 6-7 years (Mackworth & Otto, 1970), revealed no age-related effects. The visual array used by Mackworth and Otto (1970) was a 4 x 4 matrix of 16 white geometric shapes. When a circle suddenly changed to red, the children immediately looked at it for two-thirds of the presentation time, a reading which was 16 times the initial level before the novel colour was introduced. With repeated presentation fewer fixations fell upon the red circle, however, after 20 trials habituation remained incomplete in that the novel stimulus was still drawing six times the initial amount of looking. No age differences were observed in either the number of fixations to the novel stimulus, or in the rate at which habituation occurred. On the twenty-first trial the red circle was changed back to white in order to test for

dishabituation. Overall the results indicated that this alteration in the stimulus did not result in dishabituation. However, when only the two younger groups were analyzed Mackworth and Otto found a significant sex by condition interaction which indicated that the boys dishabituated while the girls did not. Mackworth and Otto's results contradict those of other studies which have examined the development of habituation in young children.

Although the developmental studies using infant and infrahuman subjects have clearly demonstrated a direct monotonic relationship between rate of habituation and chronological age, similar studies of young children have not yielded such definitive results. The research which has been done with young children has not covered a wide age-range, and clear interpretation of most studies is made impossible by their failure to include a dishabituation control. Only one of the developmental studies with young children (Mackworth & Otto, 1970) included a dishabituation procedure to control for the effects of state and fatigue, and that study failed to show age-related increments in habituation rate. Moreover, dishabituation was obtained with only a small segment of their subjects, i.e., younger males. Therefore, more research is needed to test adequately the suggestion that rate of habituation increases with age in young children.

Ontogeny of Habituation Rate: Possible Explanations

Even though the experimental data have not definitely established that habituation rate always increases with age, it is useful to examine how the various theoretical approaches to habituation might explain this tentative relationship. Three theories appear to be particularly relevant. According to Sokolov (1960, 1963) habituation is mediated by cortical neuronal models which store information about the intensity, quality, duration, and order of presentation of stimuli. Since the neuronal models are built up as a function of experience, it follows that younger (more naive) organisms possess fewer models with which to mediate their responsivity to environmental events. Conversely, the greater the number of models available, the more probable it becomes that for any environmental event, the organism will have created a model of at least some aspect of the stimulation, hence, it will habituate more quickly. Although differing in its approach from that of Sokolov's, Stein's (1966) theory would make the same predictions regarding the effect of experience on habituation rate. According to Stein, repeated stimulation results in the classical conditioning of an inhibitory response to stimulus onset. Thus, as the organism matures, experience is stored as classically conditioned associations which weaken the organism's responses to subsequent repetitive stimulation. Scott (1969) in a discussion of the role

of early experience in development stated that "a young child or any other young mammal is a non-habituated animal and is much more responsive to environmental stimuli than it is in later life" (p. 134).

A third theory, Groves' and Thompson's dual-process theory (1970, 1973; Thompson, et al, 1973) would predict that only maturation of S-R pathways would be required for increments in rate of habituation, while development of the "state" systems would be required for sensitization, or dishabituation. Maturation of both the S-R pathway and the "state" system would interact to mediate the development of habituation, although precise predictions regarding the effects on habituation cannot be made at this time.

Many other explanations of the developmental increase in habituation rate have implicitly viewed its occurrence as maturational (i.e. as a function of chronological age), or explicitly as a function of morphological development (Lynn, & Compton, 1966). It has been argued that the maturational-morphological viewpoint is not completely adequate as an explanatory construct (e.g. Baltes & Goulet, 1971; Wohwill, 1970). Recent experimental evidence has added substantial weight to this criticism. Snedden, et al (1971), investigating the ontogeny of habituation in rates, obtained the usual age-habituation relationship. More importantly however, by manipulating the auditory experience on the subjects, Snedden

et al (1971) were able to demonstrate that special training led to increases in habituation rate which superceded normal age differences. As a result of his findings Snedden suggested that "age-related" increase in habituation rate might be more appropriately termed "experience-related".

CHAPTER II

SELECTIVE ATTENTION: AN INCIDENTAL LEARNING APPROACH

Selective attention refers to the fact that organisms focus their sensory and perceptual-cognitive processes on only a portion of the stimuli concurrently available in the environment, while the remainder are ignored. Starting with Broadbent (1958) a number of theories have been developed in an attempt to understand selective attention. Since this research does not propose to examine any particular theoretical position, the reader is referred to the detailed reviews which have been presented by Moray (1969), Mostofsky (1970), Swets and Kristofferson (1970) and many others.

Basically two procedures have been used to investigate selective attention in young children; selective listening and incidental learning. Selective listening procedures measure the subject's ability to select and to report one auditory message when competing messages are presented simultaneously. Typically, the subjects are required to listen to two voices simultaneously, and to report what one of the voices has said. Developmental studies using this method have been summarized by Maccoby (1969). In the incidental learning procedure certain features of the stimulus are designated as relevant for task performance and others are designated as incidental. Two measures, performance on the

central task and recall of the incidental stimuli, provide the basis for inferring selective attention. High central task performance with a low incidental recall score would indicate selectivity of attention (Hagen and Hale, 1973).

The present research used an incidental learning paradigm. The overall purpose of this research was to study developmental changes in rate of habituation and a possible relationship between rate of habituation and selective attention performance. The visual fixation response and the visual incidental learning procedure were selected as the most appropriate combination of dependent variables for investigations with children in this age range.

1. Ontogeny of Incidental Learning

The initial developmental study of incidental learning was presented by Maccoby and Hagen (1965) who examined the effect of distraction on the central-incidental learning of children from four grades (first, third, fifth and seventh). Subjects were shown 14 arrays of four to six picture cards, each with a distinctively coloured background. For the central task, which followed a five second exposure period, the set of cards was turned over and the subject was asked to point to the card whose background colour matched a colour chip held by the experimenter. After the presentation of the fourteen sets, the incidental task was performed.

This task required the subject to identify which picture had appeared upon each background colour. In the distraction condition, the subject was required to tap to a low note that was imbedded in piano music which was played during the central task.

The results indicated that the amount of central recall increased monotonically with age. Incidental recall remained the same through the first-to-fifth grade range, then declined between the fifth and seventh grade. Distraction lowered the central recall performance equally throughout the age range, but had no effect on incidental recall. Correlation coefficients calculated between central and incidental recall scores were non-significant, suggesting that efficient central task performance was independent of incidental performance.

In a second experiment Hagen (1967) added a second picture to the cards in order to counterbalance the central and incidental features of the stimulus cards. A control condition used a second set of cards with only one picture per card. Apart from changes necessitated by alterations in the stimulus cards, the procedure was identical to that of the previous study. The results indicated that central performance increased regularly with age, while incidental recall showed no change. The one-picture-per-card condition was significantly easier overall.

Distraction depressed the central scores but equally so for all ages. Under distraction conditions incidental performance was impaired only at the oldest age level.

Correlations between central and incidental scores were different for the younger and older children. The correlations were positive at the youngest age levels and negative at oldest age levels. The correlations were significant only for scores obtained with the cards containing two pictures. Similar relationships have been reported also by Druker and Hagen (1969) and Hagen, Meacham, and Mesibov (1970).

On the basis of the results from the first two studies, Hagen concluded that the improvement in central recall with age without improvement in incidental recall indicated a developmental increase in selective attention. Moreover, the decrease in incidental learning at the oldest age level in the initial study, coupled with the negative correlations between central and incidental recall in the second study, suggested that older children give up incidental information in order to maintain central performance. The failure to obtain a similar negative correlation in the initial study seems to have been due to differences in the difficulty of the two tasks. Since the first study used cards with only one picture it may have been easier for the older children to perform the central task without giving up

incidental information. In the second study the correlations were significant in the two-pictures-per-card condition.

The congruence of the data from the first two studies suggests that the age-related improvement in central task performance is a reliable effect. Further support was presented by Hagen and Huntsman (1971) who used the standard incidental learning procedure to compare the selective attention of retardates and normals at four equivalent Mental Age (MA) levels. They found no differences in performance between the two groups, although central recall scores improved significantly across MA levels while incidental learning remained the same. Having demonstrated the replicability of the developmental improvement in selective attention, subsequent research by Hagen and his associates focussed on various factors which might account for the improvement.

Stimulus Factors

Druker and Hagen (1969) examined the role of perceptual discrimination in the development of selective attention. They did so by varying, in two ways, the discriminability between the central and incidental stimuli on the standard picture cards. First, the two stimuli which were normally contiguous were spatially separated. Second, the relevant picture always appeared at the top or bottom of the card rather than in an alternating position as in

previous studies. It was predicted that these manipulations would facilitate central-incidental performance, particularly at the younger age levels. Overall the results were similar to those previously obtained. Central learning increased with age while incidental learning remained the same. Separating the stimuli decreased incidental learning at all ages but did not affect central learning. This result was replicated in a recent study by Wheeler and Dusek (1973).

Alternating the position of the stimuli had no effect. The basic developmental function, therefore, was not altered by these manipulations of the stimulus features.

Subsequent experiments altering the discriminability of the central and incidental features in different ways also have failed to alter the developmental function. Sabo and Hagen (1973) presented the central and incidental stimuli in different colours. They found that the presence of colour improved central task performance but had no effect on incidental recall. There were no age by colour interactions. Hale and Piper (1974) attempted to increase the integration of the stimuli by combining central and irrelevant attributes into a single stimulus unit, but they found no change in either central or incidental performance.

Although the developmental results are quite consistent despite variations in the nature of the stimuli, one type of stimulus has produced discrepant results. Hale and

Piper (1973) used the standard task with coloured geometric figures in addition to the typical line drawings of animals and household objects. With the standard stimuli they found the usual increase in central performance while incidental learning remained constant. However, with the geometric figures in which the shape of the stimulus was the central feature and colour the incidental feature, incidental learning increased significantly across ages. In a second experiment, this effect was replicated. Thus, Hale and Piper concluded that stimuli whose components are contained within a single unit (e.g. coloured shapes) are functionally different from stimuli with spatially separated components (e.g. line drawings of different objects).

Hagen and Hale (1973) have suggested that incidental learning is determined by a two-stage sequence of information processing similar to that proposed by Neisser (1967). The first stage involves making the initial discrimination between the central and incidental features of the stimulus. The second stage involves the selection, memory storage, and further processing of that information which is designated as relevant by the subject. Thus, the younger child's relatively inefficient selective attention may be due to difficulty in discriminating between the stimuli or to difficulty at the second level of processing. Since the studies which have varied discriminability of the stimuli

have not altered the typical developmental function, Hagen and Hale concluded that the developmental differences in efficiency of selective attention are due to age differences in the second stage of information processing.

Degree of Training

Hagen and Hale (1973) describe an unpublished study by Baker (1970) who examined whether older subjects exercise more efficient selective attention from the outset of a task, or if they learn to do so because their initial experience with the task indicates that a selective approach is more efficient. Baker tested this notion by comparing the central-incidental performance of children 8, 10, and 12 years of age on an eight- or a sixteen-trial task. She found that the incidental learning scores of the younger children were significantly higher after 16 trials than after 8 trials, but she found no difference for the 12-year-olds. The results indicated that the older children do not acquire significantly more incidental information after 8 trials, while the younger children continue to acquire incidental information. Unfortunately no attempts to replicate this finding have been reported since Baker's study. However, studies of other types of learning (e.g. Houston, 1967; Hale and Morgan, 1973; Hale and Taweel, 1974) have shown that selectivity of attention changes during the mastery of a task. It would appear that more studies comparing

central-incidenta! recall at different stages of task performance are required.

Summary of Incidental Learning Literature

The data from the incidental learning literature indicate a reliable developmental increase in central learning while incidental performance remains the same or decreases between 12 and 14 years of age. Correlational evidence shows positive relationships between central and incidental scores in young children and negative relationships in older children suggesting that older children actively give up irrelevant information in order to focus on relevant information. These results obtain across the age range of five to fourteen years. If a pair of stimuli is used in the task, increasing or decreasing the discriminability between the central and incidental stimuli has no effect on the developmental function. A study which measured the effect of degree of training on incidental learning showed older children can adopt a selective strategy more quickly than young children, i.e., older children seem better able to determine which information is irrelevant and to ignore it more quickly. Although most of these findings have been replicated with a high degree of consistency, the conclusions regarding the development of incidental learning need to be qualified for two reasons.

The increase in central learning across age has been attributed to the older subjects' greater ability to "give

up" incidental information (Hagen and Hale, 1973). This explanation does not appear to be completely adequate because the central learning scores increase regularly from the earliest ages (five years) while the incidental scores do not decrease until 12 years of age. Although Hagen argues that the ability to actively ignore incidental stimuli plays a definite role in the ability to focus on central stimuli it is not clear to what extent this is true at younger age levels.

The second reason focusses on the possibility that the developmental results are an artifact of an age by task difficulty confound. With one exception (Hagen & Sabo, 1967) all studies of incidental learning have used only the child's recall of the sequential position of the stimuli as the central task. Similarly, the incidental task always required the subjects to recall which stimuli had been paired on the picture cards. No work has been done to determine difficulty of the two tasks across different ages so that subsequent investigations could equate task difficulty across age. However, Hagen and Sabo (1967) designed an experiment to compare the developmental curves for incidental learning as a function of instructional set. The subjects were children in grades three, five, seven, and nine. One group (I) was instructed to learn the exact pairing of each animal with a household object on each of the seven cards used. No

mention was made about the position of the stimuli within the array. A second group (II) was instructed to learn the exact order of the cards, but were told nothing about the pairs of stimuli on each card. This set was identical to the one used exclusively in the incidental learning studies reviewed. The third group (III) was instructed to learn both these things.

The results for group I and II combined indicated that central recall scores increased with age while incidental recall scores stayed the same. Contrary to the other studies reviewed there was a significant grade level by instructional set interaction which indicated no differences in central-incidental scores for the two youngest groups of children, while central scores were significantly higher than the incidental scores for older children. In the previous studies central recall was higher than incidental recall at all age levels. This discrepancy was due to large differences in performance as a function of instructional set. In the group set for "position", age had no effect on either central or incidental scores. However, there was a significant age by task interaction in which the youngest children had higher incidental than central recall scores. There were no differences between incidental and central learning for any other age level. These results for Group II are discrepant with the rest of the incidental learning literature.

For the group set for "pairs" both central and

incidental learning increased regularly with age. Central learning was significantly greater than incidental learning and there were no significant interactions. Overall, Hagen and Sabo's results indicate that the nature of the task has a substantial effect on the developmental function. Furthermore, these results can be interpreted to suggest that the incidental learning literature may involve a methodological problem since task difficulty has been confounded consistently with age of the subjects. Studies looking independently at each of the central and incidental tasks appear to be required. Only when difficulty has been equated across age can a valid developmental function of selective attention be derived, using an incidental learning procedure.

2. A Proposed Relation Between Habituation Rate of Habituation and Selective Attention

At the simplest level of analysis habituation has been viewed as the converse of attention. For example, Gibson stated that "habituation is in a sense the other side of the coin from attention" (1969, p. 327). The elementary nature of Gibson's assertion merits criticism. Not only does the statement not contribute to an understanding of either process or of the relationship between them, it creates by implication, the erroneous impression that habituation and selective attention are well-defined constructs which exist in a simple relationship. A more precise

statement was offered by Weinberger who considered "all examples of 'bona fide' habituation of behaviour to be demonstrations of stimulus selective non-responding, that is, of attention" (1971, p. 152). Weinberger's assertion implies a greater awareness of the complexities of the mechanisms involved than did Gibson's. Unfortunately, neither author developed further the implications of their statements. Moreover, the proposed relation has not been tested empirically as yet.

There appear to be three general classes of data which support the present hypothesis that the process of habituation plays a role in selective attention and its development. The first includes those studies which have investigated the nature of each of the processes separately. The second class consists of those studies which have demonstrated relations between rate of habituation and various organismic indices associated with cognitive capacity. The third class refers to studies which have demonstrated relations between habituation rate and performance on other learning and cognitive tasks.

Habituation refers to the relatively permanent decrement in the strength of a response to repeated stimulation. Studies which have used a dishabituation paradigm indicate that habituation is stimulus-specific but that it does generalize to other similar stimuli, i.e., the more novel

the dishabituating stimulus, the more marked the dishabituation response. Habituation occurs to repetitive insignificant stimuli but can be disrupted if the stimulus is designated as "important". In the incidental learning procedure certain features of the stimulus are designated as relevant while others are defined as irrelevant. The results indicate that children at all grade-levels are able to attend selectively to the relevant stimuli while ignoring the incidental stimuli, and that the ability to do so improves with age. A study by Baker (1970; cf. Hagen and Hale, 1973) indicated that selectivity of attention increased across trials, i.e., the older subjects were better able to ignore the irrelevant stimuli after 16 trials than after 8 trials. It seems reasonable to postulate that these subjects had habituated as a function of the repeated presentation of the incidental material. A number of studies have indicated that habituation rate increases with age, therefore it is not unexpected that the older children would habituate more quickly than the younger children. According to Hagen and Hale (1973) the reliable age-improvement in selective attention is due at least partially to the greater ability of the older children to ignore the irrelevant information. The frequently observed negative correlations between attention to relevant information and incidental information in older children supports this conclusion. It is proposed here that this improved

ability to ignore irrelevant information reflects developmental differences in rate of habituation of younger and older children.

The second line of inquiry consists of studies relating rate of habituation to "organism status variables usually associated with cognitive capacity" (Lewis, et al, 1969; p. 34). Significant positive correlations have been found between chronological age (e.g. Lewis et al, 1969), mental age and intelligence (Lewis, 1967; Siddle and Glenn, 1974) socio-economic status of the father (Lewis, 1967), educational attainment of parents (McCall, 1973) and the quality and quantity of mother-infant interaction (Lewis and Goldberg, 1969) and rate of habituation. In addition negative correlations have been observed between the presence of brain lesions (Thompson and Spencer, 1966), birth condition (Eisenberg, Coursin, and Rupp, 1966) and habituation rate. If, as Lewis, et al (1969) suggested, habituation rate is predictive of "cognitive capacity", it would seem to follow that habituation rate may predict a subject's performance on tasks which would reflect differences in "cognitive capacity".

Lewis, et al (1969) designed two correlational experiments to test whether one could predict performance on cognitive tasks using rate of habituation as an organismic variable. In the first experiment, they measured the habituation rates of twenty 44-month-old children to six repetitions of a curved-line stimulus. Rate of habituation was determined

by subtracting the visual fixation score on the sixth trial from that observed on the first trial, and dividing the difference by the first trial score. When rate of habituation was compared with the number of errors on a concept formation task, it was found that subjects who showed greater response decrement also made fewer errors. Using the same habituation measure, Lewis et al (1969) compared rate of habituation with performance on a two-choice visual discrimination task.

Unfortunately, the task was so difficult that only 14 of 32 subjects reached the criterion level of performance. However, comparing the solvers to the non-solvers, Lewis et al found that the subjects who solved the problem showed significantly greater habituation than those who did not. In addition a significant negative correlation was obtained between number of errors on the discrimination task and rate of habituation. Lewis et al (1969) concluded that rate of habituation can be predictive of level of "cognitive" functioning. It should be pointed out that habituation rate as an organismic variable cannot be varied, replicated, and arbitrarily assigned as one would expect of an experimental variable, therefore, it can contribute only indirectly to an explanation of the role of habituation in other processes. Nonetheless, the Lewis' et al (1969) experiments support the investigation of the proposed relation between habituation rate and incidental learning.

Summary of Issues and Outline of Present Research Programme

In the preceding review of research and theory related to processes of habituation and selective attention two basic issues emerged which are the focus of the present research programme. Although the research both on the characteristics of habituation in adult organisms and its development during infancy is extensive, it is apparent that there has been relatively little research during the period of childhood. Thus, one of the aims of this project was to examine the development of habituation in young children. Second, research on the development of selective attention was reviewed, and a possible relation between habituation and selective attention was proposed. It was suggested that habituation operates as the mechanism by which children come to ignore irrelevant stimuli in order to focus more efficiently on relevant information.

The first step in the present research programme was a pilot study to develop a procedure and a response measure appropriate for the measurement of behavioural habituation of elementary-school age children. It was felt that none of the procedures reported in the research with young children provided an adequate measure of the habituation process. Using the habituation procedure developed from the pilot research, an experiment was conducted to investigate the development of habituation in children from Grades one through five. A second experiment examined the proposed

relation between habituation and selective attention. This was accomplished by examining the effect of prior habituation to irrelevant stimuli on subsequent performance on the incidental learning task which was used as the measure of selective attention. In addition, the second experiment assessed whether subjects classified as "fast" habituators performed better than subjects classified as "slow" habituators on the basis of their previously measured habituation rates. A third experiment reexamined the proposed relation using an alternative measure of behavioural habituation as well as an GSR measure of autonomic nervous system habituation.

CHAPTER III

PILOT STUDY

The purpose of this pilot study was to determine a suitable procedure for measuring visual fixation habituation rate in children eight years of age. A common method has been to present the subject with a series of visual patterns for several trials of fixed duration with a constant inter-trial interval. This procedure, referred to as the fixed-trial method, yields several measures of visual fixation which include: latency to first fixation, duration of first fixation, total fixation time, number of fixations, and duration of the longest fixation (Lewis, Goldberg, and Campbell, 1969). In two recent papers Cohen (1972; 1973) cited three problems which are frequently associated with visual fixation studies using the fixed-trial procedure. First, few studies have controlled for pre-trial looking behaviour. For example, a child whose direction of gaze is towards the stimulus has a greater chance for viewing it than one whose is in a direction away from the stimulus. This factor could render ambiguous the data from each of the fixation measures, but it can be avoided by commencing a trial only when the child is looking in the direction of the stimulus. A second solution to the problem would be to provide an experimental manipulation which would ensure that the subject's gaze at stimulus onset would be in a direction away from the stimulus.

A second problem of the fixed-trial procedure involves what the child is doing at the end of a trial. For example, if a child is fixating the stimulus at the end of a trial, he may have continued to do so but for the termination of the stimulus. In this event the resulting visual fixation measure would be inaccurate. Also Cohen (1972) pointed out that, when subjects fixate the stimulus for the entire or almost entire duration, a ceiling effect is introduced which further obscures the data. This problem can be overcome by terminating the trial only when the subject turns away, or by having the subject himself terminate the trial when he discontinues looking.

A third problem cited by Cohen relates to the use of total fixation time as the sole dependent measure. For example, two children could obtain the same total fixation score but on the basis of totally different looking behaviour. One child may have made several brief glances while the other may have made one continuous look of an equal total duration. Interpretative problems would inevitably result since one could not assume that the same underlying attentional mechanism accounted for both types of looking behaviour.

In response to the difficulties associated with the fixed-trial procedure, Cohen (1973) developed an alternative method which does not use trials of a fixed duration. This procedure controls for pre-trial looking behaviour by means,

of a blinking light located in a direction away from the visual pattern. While the light is blinking and the child is gazing at it, the visual stimulus is presented and simultaneously the light ceases blinking. Then the subject is allowed to fixate the stimulus for as long as he wishes. Thus, two visual fixation scores are obtained, latency to fixation and duration of fixation. According to Cohen the two scores represent two distinct processes which he refers to as attention-getting, and attention-holding processes.

The purpose of this pilot study was to determine which of the standard methods, fixed- or variable-trial, would be most suitable for the measurement of visual fixation habituation rate in eight year olds. Up to this point no studies have examined subjects older than four years of age. The procedure derived from the present study was expected to combine the best features of the two existing procedures. In addition to the two procedures, two different series of visual stimuli were used in order to examine different methods of demonstrating dishabituation which was accepted as the definitive characteristic of the process of habituation.

1. Subjects

Twenty subjects whose mean chronological age was 8 years-4-months were selected. Subjects were volunteers,

attending a summer school in Manotick, Ontario. Chronological age was the only criterion for subject selection.

2. Stimuli

Two series of stimuli were used. Series I consisted of four sets (A, B, C and D) of eight slides. The content of the slides is shown in Figure 2. Each set of slides consisted of seven identical slides (S_1) and one slide which was an altered form of the repeated slide (S_2). In Set A, S_1 was a coloured picture photographed from a Grade two reader, while S_2 was a black and white reproduction of the same slide. In Set B, S_1 consisted of a collection of curved black lines on a blue background, while S_2 contained straight lines which corresponded to the curves. In Set C, S_1 was an orange drawing of a four-legged creature taken from a Grade two reader, while S_2 was the same drawing but coloured yellow. In Set D, S_1 consisted of four green circles plus a red triangle, and S_2 consisted of four green triangles plus a red circle. Series II consisted of 32 slides, 24 which were different and 8 which were identical. The content of the slides in Series II was similar to that of Series I, a mixture of familiar objects, geometric shapes and lines.

3. Procedure

Twenty subjects were assigned randomly to one of four groups which differed in the procedure and slide series

Figure 2. Series I Stimuli Used for the Measurement of
Visual Fixation in the Pilot Study, Experiments
I and II.

used. All stimuli were rear-projected by a Kodak Carousel projector at eye level onto an opaque screen located approximately 1 metre in front of the subject. An orange light, programmed to flash for three seconds prior to slide presentation was located on the table to the left of the screen. Subjects were instructed to watch the flashing light until a stimulus appeared on the screen (see Appendix 1). Subjects assigned to Group 1 were shown the Series I stimuli using a fixed-trial procedure. The order of presentation of slides and sets of slides (i.e. A - D) was constant for all subjects. Within each set S_1 was shown six times followed by S_2 then S_1 again. This procedure was repeated for each of the four sets of Series I stimuli, a total of 32 slides. For subjects in Group 1 each slide was shown for 30 seconds with an interstimulus interval of 3 seconds, during which the orange light flashed twice per second. For the first subject tested in Group 1 the interstimulus interval had been 30 seconds, but this child was unable to complete the task due to its excessive length, hence, the reduction of the interstimulus interval to 3 seconds.

Subjects in Group 2 were shown the Series I stimuli, however, they were tested with a variable trial procedure (see Appendix 1 for Instructions.) Although the stimuli were shown in the same order as described above, the length of each trial varied according to the length of child's first

fixation to the slide. Each slide was presented three seconds after the orange light began to flash, and remained on as long as the subject fixated it. When the child turned his gaze away from the slide for at least one second, the experimenter terminated the trial which automatically activated the light for a three-second intertrial interval. A total of 32 trials were presented in this manner.

The subjects in Groups 3 and 4 were tested with the fixed-trial and the variable-trial procedure, respectively, except that the Series II slides were used instead of the Series I slides. Series II consisted of a total of 32 slides, 24 which differed from each other and eight that were identical. The identical slides appeared once in each successive block of four trials with the constraint that it appear twice at all four positions in the 32 trials.

Measurement of Visual Fixation

The visual fixation response was defined as a turn of the subject's head and eyes toward the stimulus on the screen for at least one second. Momentary glances toward or away from the stimulus were ignored. During the slide presentation one observer, located behind and to the side of the screen, watched the subject's head and eye movements. When the observer judged the subject to be looking at the visual pattern he pressed a hand-held switch which was connected to an event recorder. When the subject looked

away from the stimulus, the switch was released. The event recorder was also connected to the slide projector in order to record stimulus onset and offset. By means of the event recorder the subject's pattern of looking behaviour was obtained. In the fixed-trial procedure duration of first fixation, number of fixations, and total fixation time were scored. In the variable-trial procedure, since the trial was terminated when the subject first looked away, only one score could be obtained, duration of fixation.

In order to evaluate the reliability of the measurement procedures, a second observer was used to record the looking behaviour of half of the subjects. The reliability data included at least two subjects from each group. Initially it was noted that the click associated with the pen deflection was audible, hence the observers could not be considered to be independent. To occlude the sound of the pens and to obtain independent measurements, the observers inserted cotton wadding in their ears and wore earphones.

Measurement of Habituation Rate and Dishabituation

Habituation rate refers to the rate of response decrement with repeated stimulus presentations and was determined in the following manner. For Series I stimuli the mean first and total fixation responses and mean number of fixations for each trial across sets A through D was obtained. Following the Dodd and Lewis' (1969) procedure, a least squares best-fit

regression line was determined for the mean visual fixation response across Trials 1 through 6 for each subject. The slope of this best-fit line was used to determine whether habituation had occurred. A slope of negative value indicated that response decrement had occurred across trials. Rate of response decrement was indicated by the magnitude of the slope score. Using the regression equation for the best-fit line ($Y = a + bx$) it was possible to determine the expected size of the visual fixation response on Trial 7 had the standard stimulus (S_1) been repeated. Thus, by comparing the magnitude of the observed fixation response which occurred to the novel stimulus (S_2) with the magnitude of the expected response it was possible to determine whether response recovery had occurred on Trial 7. If response recovery occurred it was concluded that the response decrement reflected the habituation process, and the response recovery was considered to be dishabituation. A second dishabituation measure was obtained by comparing the magnitude of observed response to S_1 on Trial 8 with the magnitude of response for Trial 7 predicted by the regression equation. The above procedure was used for the fixation data obtained from both the fixed- and variable-trial procedure. The nature of the variable-trial procedure allowed only the measurement of total fixation per trial.

The measurement of habituation rate and dishabituation was different for Series II stimuli. In this series one

stimulus was repeated eight times within successive blocks of three constantly changing stimuli. Habituation was indexed by determining the magnitude of the difference between the response to the repeated stimulus and that of the mean of the varying stimuli within each block. Thus, difference scores were obtained for the eight blocks. It was assumed that the magnitude of the difference score would increase across trial blocks, since the visual fixation response to the repetitive stimulus would weaken overtime. Using the regression analysis outlined above best-fit lines were determined for the eight difference scores. Thus, a positive regression coefficient, i.e. slope, indicated the occurrence of habituation, while the magnitude of the slope reflected the rate of habituation. If the mean visual fixation response to the varying stimuli did not decrease across trial blocks it could be interpreted that habituation rather than some other decremental process accounted for the weakened response to the repeated stimulus.

4. Results

Using REGRESS, a computer programme from the Carleton University Time-Sharing Library, ordinary least-squares regression equations were determined for the group mean visual fixation responses across trials 1 through 6 for Groups 1 and 2. The results presented in Table 1 indicate that statistically

TABLE 1

Linear Regression Equations for
Mean Visual Fixation Responses

Group	Fixation Response	Linear Equation	t-Statistic for Regression Coefficient
1	First Fixation	$Y = 15.37 + (-1.34)X$	-2.88*
	Total Fixation	$Y = 22.75 + (-1.70)X$	-3.76*
	Number of Fixations	$Y = 2.03 + (-.03)X$	-0.32
2	Total Fixation	$Y = 5.83 + (-.07)X$	-0.17
3	First Fixation	$Y = 5.44 + (-2.09)X$	-0.89
	Total Fixation	$Y = 5.52 + (.99)X$	0.67
	Number of Fixations	$Y = 0.09 + (-.07)X$	0.84
4	Total Fixation	$Y = 20.19 + (4.84)X$	1.44

* $p < .05$

significant regression coefficients were obtained for the mean first fixation and mean total fixation scores for Group 1 only. The regression equations for Groups 3 and 4 were calculated on the mean difference scores across eight trials. The results presented in Table 1 indicate that none of these regression coefficients were statistically significant.

Figures 3 and 4 present the mean first fixation score, mean total fixation score, and the best fit regression line for Group 1 only. Included are the mean visual fixation score for trial 7 (presentation of S_1) and trial 8 (presentation of S_2). Comparison of the visual fixation scores for trials 7 and 8 to trial 6 or that predicted by the regression line at trial 7 indicates the degree of dishabituation. Figures 5 and 6 present the mean fixation scores for individual subjects in Group 1.

Inter-observer reliability was determined by the dividing of the number of seconds of agreement between the observers by the sum of number of seconds agreement and number of seconds of non-agreement. This computation yielded 93% reliability for the fixed trial method and 88% for the variable trial procedure.

6. Discussion

The purpose of the pilot study was to develop an adequate procedure, set of stimuli, and method of data analysis for the measurement of visual fixation habituation

Figure 3. Mean First Fixation Response per Trial (in seconds) for Group I (N:4)

Figure 4. Mean Total Fixation Response per Trial (in seconds) for Group 1 (N:4)

Figure 5. Mean First Fixation Response per Trial (in seconds) for Individual Subjects in Group 1.

Figure 6. Mean Total Fixation Response per Trial for Individual Subjects in Group 1.

rate in young children. The results indicated that only the fixed-trial procedure with Series I stimuli resulted in a significant amount of habituation across trials. Examination of the scores on trials 7 and 8 in Figures 3 and 4 suggest that dishabituation occurred, although it was not evaluated statistically. Inspection of the scores for individual subjects in Figures 5 and 6 indicated a wide range of habituation curves, for example, two of the subjects showed little response decrement while the other two showed rapid and considerable habituation.

On the basis of these pilot results, subsequent studies made use of the fixed-trial procedure with the Series I stimuli. In addition, the larger group sizes in these studies enabled the use of split-plot analysis of variance procedures (Kirk, 1968) with multiple comparisons and trend analysis follow-up. These in combination with the regression analysis permitted adequate assessment of habituation, rate of habituation, and dishabituation.

CHAPTER IV

EXPERIMENT 1

This first experiment examined the development of habituation of a visual fixation response in young children. In particular, rate of habituation was investigated as a function of age in school children from Grades one, three and five. Some developmental research has indicated that habituation rate increases as a function of age. This increment has been observed repeatedly both in human infancy and throughout the life span of infrahuman subjects. During young childhood this developmental increment has not been demonstrated as clearly, although the available evidence is consistent with the typical finding. However, there have been relatively few experiments with young children and they share with much of the animal and infant literature the failure to demonstrate that the response decrements observed were habituation. In this experiment it was predicted that habituation rate would increase as a function of grade-level.

Included in the design of this experiment was a control procedure to investigate the effect of preexposure to the experimental room on the children's visual fixation behaviour. It was expected that a subject's visual fixation performance would be the result of two competing behavioural tendencies; one to look at the stimuli presented, the second to explore the novel environment. Experiments with rats

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(Carlton, 1969) have shown that if animals are preexposed to an experimental chamber, then water deprived and reintroduced to the same chamber, they approach the water bottle more rapidly than do animals who have not been preexposed. The rationale is that preexposure results in the habituation of exploratory behaviour, thus the approach response to the water bottle becomes relatively stronger. Thus, in the present experiment it was expected that preexposure would increase the subject's tendency to fixate the visual stimuli presented by the experimenter. However, it was not possible to predict whether preexposure would affect habituation rate or whether it would interact with performance across grade-levels.

1. Design

A visual fixation response was defined as the turning of the subject's head and eyes toward the stimuli on the screen for a duration of at least one second. This judgment was made by an observer who watched the subject through a one-way mirror. The response was judged to be terminated when the subject looked away from the stimulus for at least one second. Two visual fixation measures were recorded; length of first fixation per trial, and total fixation time per trial. Habituation of both visual fixation responses was defined as a statistically significant decrement in looking

time across the six repetitions of the standard visual stimulus (S_1). Dishabituation referred to either a significant increment in looking time between trial six and trial seven when the novel stimulus (S_2) was presented or an increment in looking time between trial six and trial eight when the standard stimulus was repeated.

Preexposure referred to the length of time the subject was in the experimental room prior to the beginning of the slide presentation. Subjects assigned to the preexposure condition were seated in the experimental room for eight minutes before the task instructions were given. The remaining subjects were instructed immediately upon being seated at the table in front of the screen. Half of the subjects from each of the three grades were assigned randomly to the preexposure condition.

2. Subjects

A total of sixty children were selected randomly for participation in the first experiment, twenty each from grades one, three, and five. The mean chronological ages for subjects in grades one, three and five were 6 years-11 months ($SD = 4$ months), 8 years-11 months ($SD = 5$ months), and 10 years-7 months ($SD = 4$ months), respectively. In order, the mean Lorge-Thorndike IQ's for grades were 110 ($SD = 2.0$), 107 ($SD = 3.4$), and 115 ($SD = 2.7$). The

differences in IQ were not statistically significant. Any child known to have a reading, learning or perceptual disability, or emotional disturbance was excluded from the sample. An equal number of boys and girls were included at each age-group. All subjects were students at Glen Ogilvie Public School in Ottawa, Ontario. The consent of the children's parents was obtained, and the children were given the right to refuse to participate or to terminate the session if desired. No subjects refused to participate, nor did any terminate the session prematurely. Participation was voluntary and no rewards were offered to any subject.

3. Stimuli and Apparatus

The stimuli used in this experiment were identical to the Series I stimuli described in the pilot study. The experiment was conducted in a mobile laboratory provided by the Psychology Department of Carleton University. This laboratory is a heated trailer which is divided into two small rooms. The only apparatus in the subject's room was a 75cm x 45cm opaque screen and a slide projector which was located behind the screen.

A Kodak Carousel projector was used to present the series of slides. The slides were rear-projected at eye level onto the opaque screen located approximately 1 metre in front of the subject. The projector was automatically

programmed to present slides for a 30 second period followed by a six second exposure of a blank slide. The offset of the stimulus slide activated an orange light which flashed twice per second. The light was located to the left of the screen but in view of the subject. The light continued to flash until the next stimulus slide was presented, then it was turned off automatically. A Lehigh Valley Instruments, 6-channel event recorder was used to record stimulus onset and offset as well as the subject's looking behaviour. When the experimenter judged that the subject was looking at the stimulus, he depressed a hand-held switch which deflected a pen on the event recorder which provided a record of the subject's looking behaviour. A second pen was connected to another hand-held switch in order to allow a second observer to record independently the subject's looking behaviour. In addition, an ERC digital stopclock (model no. 2641) recorded a second measure of total fixation time per trial.

4. Procedure

Before any subjects were seen individually, the experimenter was introduced to all the classes from which the subjects were drawn, and gave them a brief talk. The purpose of the talk was to familiarize the subjects with the experimenter since they would be going out alone to the trailer with him. The subjects, assigned randomly to test order, were

escorted by the experimenter from the classroom to the trailer which was located in a quiet area of the schoolyard. The subjects were seated at a 1.3 metre x 2.1 metre table facing the opaque screen. Subjects in the preexposure condition were then told that the experimenter was not yet ready to start. The subjects were asked to sit quietly by themselves while the experimenter went into the adjacent room to complete the necessary preparations. After six minutes the experimenter returned to the subject's room and thanked him for waiting so patiently. The experimenter told the subject that he was not yet ready but would be in two more minutes. The experimenter returned to the observation room until the two minutes had elapsed. When the experimenter returned he thanked the subject for his continued patience, then proceeded to administer the instructions for the habituation procedure (see Appendix 2). Subjects in the non-preexposure conditions were given instructions immediately after they had been seated. Since the duration of the habituation procedure was 16 minutes, eight minutes was considered to be an adequate duration for the preexposure period.

The order of the four sets of slides was randomly determined for each subject. Each slide was presented for 30 seconds with a six-second intertrial interval. The intertrial interval consisted of a two second blank period immediately followed by the flashing of an orange light

located to the left of the subject for a period of four seconds. Offset of the flashing light and onset of the next slide occurred simultaneously. After eight trials, the experimenter returned to the subject's room and rotated the slide tray for the next series of slides. The procedure was repeated four times, i.e., until all 32 slides had been shown.

Following the completion of the habituation procedure, the experimenter returned to the subject's room and informed the subject that the session was finished. The experimenter then asked the subject what he thought of the procedure, were there any slides that the subject liked or disliked, did the subject think it was important to look at the pictures, and why?. The subject was then thanked for his participation and accompanied back to his classroom. The grade three children were told that the experimenter would see them again in about two weeks, and at that time the subject would do something different.

Method of Observation

The experimenter observed the subject's looking behaviour through a 1 metre x 1.6 metre one-way observation mirror which was located in the wall which separated the two rooms of the trailer. The responses observed and recorded by means of a hand-held switch connected to an event recorder, were the subject's visual fixations to the slides. The

experimenter released the switch only when the subject looked away for more than one second; therefore, brief glances away were ignored. The printout of the event recorder provided the experimenter with a record of the child's pattern of looking for each trial. An ERC digital stopclock also provided a measure of total looking time per trial. The experimenter recorded the visual fixation time from the digital stopclock during the intertrial interval. Two scores were obtained, length of first fixation for each trial and total fixation time per trial.

Interobserver Reliability

A second hand-held switch was connected to the event recorder and was used by a second observer in order to obtain an independent recording of the looking behaviour of randomly selected subjects. The second observer was instructed in the method of recording and given the definition of the visual fixation used by the experimenter. The second observer was naive regarding the design and the purpose of the experiment. Since the reliability of the scoring procedure had been evaluated in a pilot study, only 10 per cent of the subjects were observed by the two observers in the present study. The reliability measure was determined by dividing the number of seconds of agreement by the number of seconds of agreement plus non-agreement per trial.

5. Results

Both the first and total fixation scores were transformed by assigning a value of 100 to the Trial 1 score and changing the remaining scores to a percentage of the response on the first trial. The analysis of variance of first fixation scores, presented in Table 2, revealed a significant main effect only for trials. The change in the magnitude of the transformed first fixation scores averaged across grade levels can be seen in Figure 7. The absence of a significant main effect for Grade level, and the failure to obtain a significant Grade x Trials interaction suggests that there was no developmental change in the decrement of the first fixation response across trials.

Newman-Keuls a posteriori multiple comparisons were carried out on the first fixation trial means. These comparisons, summarized in Appendix 3, indicated that the mean first fixation response on Trial 1 was significantly higher than the means for Trials 3-6. The mean for Trial 7 was higher than the means for all other trials. The means for Trials 2 and 8 were significantly higher than those for Trials 4 and 5. There were no other significant differences.

The analysis of variance for the mean transformed total fixation scores per trial is presented in Table 3. In contrast to first fixation scores, this analysis revealed significant main effects for Grade level, Trials, and a

TABLE 2

Analysis of Variance for Effects of Preexposure,
Grade-level, and Trials on Mean First Fixations in
Experiment 1 (N:60)

Source		df	SS	F
Grade		2	64599.0	2.84
Preexposure		1	18.0	.00
Grade x Preexposure		2	27191.0	1.19
Error		54	615190.0	
Trials		7	208,380.0	14.61 ***
Grade x Trials		14	32374.0	1.13
Preexposure x Trials		7	14495.0	1.02
Grade x Preexposure x Trials		14	23272.0	.82
Error		378	770,440.0	
Total		479	1,756,000.0	

*** $p < .001$

Figure 7. Mean First Fixation Response per Trial Expressed
as a Percentage of First Trial Response in
Experiment I (N:60)

MEAN PERCENT OF FIRST TRIAL
FIXATION TIME

significant Grade x Trials interaction. Once again, the main effect on preexposure was not statistically significant. The significant main effect for Grade is compatible with a developmental change in the overall magnitude of the Total Fixation response. Newman-Keuls comparisons of the Total Fixation means (Appendix 4) indicated that the Grade I children looked at the slides significantly less than either the Grade III or the Grade V children.

The main effect for Trials indicates that the Total Fixation time varied as a function of trials. Inspection of Figure 8 reveals that the mean overall Total Fixation response decreased across trials 1-6, recovered on Trial 7 and dropped again on Trial 8. Newman-Keuls comparisons (Appendix 5) of the overall Trial means indicated that the mean Total Fixation on Trials 1 and 7 differed from all other Trial means. These comparisons are compatible with the occurrence of habituation and dishabituation. However, the significant Grade x Trials interaction indicated the presence of Grade-level differences in the change in response over trials (see Figure 9).

The results of a simple main effects analysis of the Grade x Trials interaction (Table 4) revealed that there was no change in mean Total Fixation response across trials for the Grade V children. Newman-Keuls comparisons of the Total Fixation means across Trials within Grades I and III (Appendix 6) indicated that the mean Total Fixation

TABLE 3

Analysis of Variance for Effects of Preexposure,
Grade-level and Trials on Mean Total Fixation Scores
in Experiment 1 (N:60)

Source	df	SS	F
Grade	2	54,784.0	4.10 **
Preexposure	1	1,216.0	.18
Grade x Preexposure	2	1,480.9	.11
Error	54	361,000.0	
Trials	7	159,690.0	20.23 ***
Grade x Trials	14	40,982.0	2.60 ***
Preexposure x Trials	7	6,289.8	.80
Grade x Preexposure x Trials	14	20,950.0	1.33
Error	378	426,160.0	
Total	479	1,072,600.0	

** $p < .02$

*** $p < .001$

responses on Trials land 7 were significantly higher than the means on all other trials. These findings are compatible with the occurrence of habituation and dishabituation for both Grade I and Grade III children.

Simple main effects analysis of Grade-level at each trial indicated that differences between groups emerged over trials. Specifically, the groups differed on Trials 3, 4, 6 and 7. These effects are compatible with the analysis of Trials at Grades which indicated that Grades I and III changed across trials but Grade V did not. Newman-Keuls comparisons (Appendix 7) revealed that the Total Fixation scores of Grade I children at trial 3 were lower than those of the Grade III and Grade V children. At trials 4 and 6, the Grade I children had significantly lower mean scores than the Grade V but not the Grade III children. At trial 7, the Grade III subjects had significantly higher scores than either the Grade I or Grade V children.

Interobserver Reliability of Visual Fixation Measures

A measure of interobserver reliability was determined for both first fixation and total fixation scores by dividing the number of seconds agreement between observers by the number of seconds of agreement plus non-agreement per trial expressed as a percentage. Based on the data from six randomly selected subjects the percentages were 81.7% and 93.7% for first fixation scores and total fixation scores, respectively.

Figure 8. Mean Total Fixation Time per Trial Expressed as
Percentage on First Trial Response in Experiment 1
(N:60)

MEAN PERCENT OF FIRST TRIAL RESPONSE

TABLE 4

Analysis of Variance of Simple Main Effects for
Grade-Level and Trials on Total Fixation Scores
in Experiment 1 (N:60)

Source	SS	df	MS	F
Grade	54,784.00			
Grade at Trial 1	0.00	2	0.00	0.00
Grade at Trial 2	8,312.14	2	4156.07	2.28
Grade at Trial 3	14,214.04	2	7107.02	3.90 *
Grade at Trial 4	11,323.90	2	5661.95	3.11 *
Grade at Trial 5	10,072.04	2	5036.02	2.76
Grade at Trial 6	15,344.14	2	7672.07	4.21 *
Grade at Trial 7	26,958.54	2	13479.27	7.40 **
Grade at Trial 8	9,568.14	2	4784.07	2.63
Within Cell	787,160.00	432	1822.13	
Trials	159,690.00			
Trials at Grade I	76,818.55	7	10974.08	9.85 **
Trials at Grade III	112,463.70	7	16066.24	14.42 **
Trials at Grade V	11,363.30	7	1623.33	1.46
	426,160.00	378	1114.18	

* $p < .05$

** $p < .01$

Figure 9. Mean Total Fixation Time per Trial Expressed as Percentage of First Trial Response Across Grade-levels in Experiment I (N:20 per Grade-level)

MEAN PERCENT OF FIRST TRIAL RESPONSE

150
140
130
120
110
100
90
80
70
60
50
40

—●— GRADE 1
—●— GRADE 3
—○— GRADE 5

6. Discussion

Although both first fixation and total fixation responses had been recorded and analysed, only the analysis of the total fixation response is discussed in detail. Interobserver reliability measures indicated that the recording of the first fixation response had been less accurate than that of the total fixation response, and analysis of variance results revealed that first fixation was not as sensitive an index of group differences as total fixation.

The analysis of variance of the total fixation response indicated a change in the response as a function of trials. A significant Grade x Trials interaction indicated that the change differed with grade-level. An analysis of simple main effects indicated that the change in total fixation behaviour across trials was limited to the Grade I and Grade III children. Multiple comparisons of the trial means indicated that the total fixation response decreased significantly across Trials 1-6, and recovered on Trial 7. The nature of these results is compatible with the occurrence of habituation and dishabituation of the total fixation response. Inspection of Figure 9 and Newman-Keuls multiple comparisons of the total fixation scores between Grades at Trials indicated that the Grade I children habituated more quickly than the Grade III children, while the Grade V

children failed to habituate. Unfortunately these findings were contrary to the prediction that the rate of habituation increases as a function of age. Although there are several exceptions, the majority of developmental studies have reported an increase in habituation rate as a function of age. None has obtained a developmental decrease in habituation rate like that found in the present experiment. Since Experiment 2 was designed and executed with the expectation that the more typical developmental finding would obtain in Experiment 1, it is important to attempt an explanation of the reversal.

Relative to neutral stimuli, "important" stimuli habituate much more slowly, if at all (Lynn, 1966). Importance can refer to the survival value or meaningfulness of a stimulus. For example, rabbits do not habituate to "rustling" noises, while humans habituate very slowly to the sound of their name or to verbal warnings such as "look out". Other important stimuli include those which signal reinforcement, or those to which the subject has been instructed to pay attention. For example, in vigilance tasks (Mackworth, 1969) subjects habituate much more slowly to signal stimuli than to non-signal stimuli.

It was assumed in the present study that the stimuli were neutral since the subjects were not instructed to pay attention to them. This assumption was apparently a naive one. A post-experimental questionnaire revealed that 42%

of the subjects thought that it was important to look at the pictures. Thirty-five per cent stated that it was not important, while the remaining 23% stated that they did not know whether it was important or not. Within the three categories of stated importance, all grade levels were equally represented. Although the influence of social desirability prevents a clear interpretation of these verbal reports, it can be assumed that the habituation data were affected to some extent by the unexpected demand characteristics of the stimuli. Of the subjects who thought it was important to look at the pictures, the most frequent comment was that "you might learn something". One subject stated that she didn't think she would be asked to come out to the trailer if it weren't important to look at the pictures. Still another felt that it was probably some kind of attention test and that is why he looked at the pictures the whole time. However, a post hoc analysis of variance indicated that the perceived importance of the stimuli did not affect the subjects' habituation rate.

The simplest explanation of the habituation rate reversal would have been that the "importance" of the stimuli was an increasing function of grade level. The questionnaire data failed to support this explanation. However, for the subjects at each grade level who felt that the stimuli were important, it was assumed that the experimental task became a vigilance task requiring sustained attention to the stimuli. Since developmental studies report age-associated improvements in a variety of operationally defined attentional

abilities, one reasonable assumption is that older children are able to maintain attention to important stimuli better than younger children. In the only study which has investigated directly the relationship between age and vigilance, Semmel (1965) reported significant positive correlations between chronological age and the number of correct detections for both educable mentally retarded children ($N = 42$, $r = .51$; $p = .05$) and for average children ($N = 42$, $r = .35$, $p = .05$). The mean age of the children was 12 years-4 months with a standard deviation of 1 year-9 months.

Although the direct evidence is minimal, there is indirect evidence for a developmental improvement in the ability to sustain attention. Douglas and her associates (Sykes, Douglas & Morgenstern, 1972; Sykes, Douglas, & Morgenstern, 1973; Sykes, Douglas, Weiss, & Minde, 1971) have compared the ability of normal and hyperactive children to sustain attention in the Continuous Performance Test. They have consistently found that hyperactives make significantly fewer correct detections and significantly more errors of commission than normals. One of the characteristics that distinguishes hyperactive from normal children of the same age is their developmental immaturity in a variety of cognitive functions and social behaviours. It is as though hyperactives are functionally younger than their age peers. Therefore, inasmuch as the conception of hyperactivity as a maturational lag is correct, the above studies represent

evidence for a developmental increase in the ability to sustain attention.

While not conclusive, evidence from direct and indirect lines of inquiry suggests that older children are better able to sustain attention than are younger children. Assuming 1) that the children perceived the stimuli as "important" rather than "neutral", 2) that they felt they must maintain attention to them, and 3) that older children are more able to sustain attention than are younger children, the age-reversal of habituation rate can be understood. It is proposed that the decrease in habituation rate of the older children reflects their increased ability to sustain attention to "important" stimuli.

The finding that preexposure did not affect visual fixation behaviour was not unexpected. The preexposure treatment was included in the design of the experiment primarily as a control procedure. It was felt that the novelty of the experimental room might differentially affect the visual fixation performance of the subjects at the three grade levels. Since preexposure did not affect visual fixation, either directly or in interaction with other factors, it is concluded that this manipulation is not necessary for the type of habituation measurement used in this experiment.

The results of this experiment also revealed a

methodological problem in the use of the visual fixation response. While the total fixation data revealed significant main effects for Grade level and Trials, and a significant Grade x Trial interaction, the first fixation data yielded a significant main effect only for the Trials factor. This discrepancy may be explained by the reliability data, which indicated that the first fixation measure was less reliable than the total fixation measure. Since the same observation was made in the pilot study, only the total fixation measure should be used in subsequent experiments.

CHAPTER V

EXPERIMENT II

This experiment investigated a proposed relation between the processes of habituation and selective attention. Despite considerable speculation that habituation and selective attention are related (e.g. Gibson, 1969; Jeffrey, 1968, 1969; Weinberger, 1971), direct experimental evidence has not been reported yet. The present study adopted a process rather than a chronological approach to development.

In addition to the examination of a possible connection between habituation and selective attention, information regarding the development of selective attention was sought. Although the children in the first experiment were selected from three grade levels, developmental research can be conducted without varying chronological age. While the elucidation of age-behaviour relationships is a useful first step in the understanding of developmental change, explanation requires a knowledge of the processes which underlie the change. For example, selective attention skill, no matter how it is operationalized in particular experiments, varies as a function of age. Moreover, as with any other behaviour, process or "organism status variable", the level of this particular skill varies among children within a specific age-level, no matter how strictly delineated the age parameter is.

The same situation obtains for the habituation process. Inspection of the slope scores of only the Grade three children from the pilot study and the first experiment indicates that there is considerable variation in the habituation rates of these children.

An assumption basic to developmental research is that behavioural differences observed between children of different ages reflect different degrees of maturation of the processes underlying the behaviour. Similarly, when one observes behavioural differences in children at the same age-level, these differences also may be interpreted to reflect changes in maturational level. Thus, within the context of this experiment the variation in the children's habituation rate was considered to be a reflection of differences in maturational level. Following this line of reasoning and the possibility that habituation and selective attention are related, this experiment was designed to determine whether changes in habituation rate are related in some way to the improvement of selective attention abilities. In addition this experiment examined the possibility that rate of habituation was causally related to selective attention ability by determining the effect of prior habituation to the irrelevant stimuli in the selective attention task. In this experiment selective attention ability was inferred from the children's performance on an incidental learning task.

1. Experimental Design and Predictions

The habituation of a visual fixation response was measured, using the same procedure described in Experiment I. On the basis of a least-squares regression analysis, best-fit lines were obtained for the mean Total Fixation scores of individual subjects across the first six repetitions of the standard stimulus. The magnitude of the slope of the best-fit line provided an index of the rate of habituation, if slope score was a negative value. Thus, the greater the negative slope, the more rapid was the occurrence of habituation.

The habituation rates were thus determined for sixty Grade three children, including the twenty Grade three children from the first experiment. With the exception of ten subjects who had been assigned to the pre-exposure condition in the first experiment, the remaining 50 subjects were divided at the median slope score and categorized as either "fast" or "slow" habituators for the purposes of this study. The ten "pre-exposure" subjects were similarly categorized as "fast" or "slow" habituators, and included in the appropriate habituation-rate group. Since pre-exposure did not affect habituation performance in the first study, it was not included in this one. Nonetheless, as a necessary control procedure, the ten "pre-exposure" subjects were not considered equivalent to the remainder, and were assigned separately.

C

Within each of the "Habituation-rate" groups, half of the subjects were assigned randomly to an habituation training condition in which they were repeatedly shown slides of the incidental stimuli used in the selective attention task. The remaining subjects were assigned to a control condition in which they were shown slides which did not relate to the selective attention task.

Selective attention was measured with an incidental learning task similar to that developed by Hagen and his associates (Hagen and Hale, 1973). The incidental learning procedure yields two measures, a central score and an incidental score. The central score indicates the child's ability to recall correctly the ordinal position (from left to right) of a stimulus after a simultaneous presentation of six stimuli. The incidental score is derived from a task for which the child had received no prior instruction and it measures the accuracy of the child's matching of the elements on the stimulus cards. High central scores and low incidental scores were interpreted as indicative of good selective attention ability. Central scores were blocked into first six trials versus last six trials to determine whether there was a practice effect which might have interacted with habituation rate or with habituation training. The order of trial blocks, trials 1-6 vs trials 7-12, was counterbalanced within experimental groups. Because of the nature of the

procedure it was not possible to examine the effect of practice on incidental recall scores.

Predictions

Predictions regarding the effect of habituation rate on incidental learning performance were based upon the results obtained in the first experiment rather than on the typical research findings which those results contradicted. Previous research has shown frequently that rate of habituation increases with age, while in Experiment I habituation rate was observed to decrease with age. However, it was also observed in that experiment that a significant number of children at each grade level perceived the stimuli to be "important" and to require their sustained attention. Since sustained attention is the opposite of habituation, children who maintained their attention better, habituated more slowly. In addition, previous research has shown that older children are more capable of sustaining attention than are younger children. Therefore, the decrease in habituation rate with age was interpreted to have represented an age-related increase in the ability to sustain attention. Based on the preceding interpretation of the results of the first experiment, the following predictions were made regarding the effect of habituation rate on incidental learning performance:

1. "Slow" habituators would obtain higher central task scores than "fast" habituators,

2. "Slow" habituators would recall fewer incidental stimuli than will "fast" habituators, assuming that central and incidental performance are complementary as has been asserted by previous researchers,
3. "Slow" habituators would show a greater improvement in central scores across trial blocks than would "fast" habituators.

The predictions regarding the effect of habituation training on incidental learning performance were based on the characteristics of habituation which have been determined by previous research. Habituation training involved the repeated presentation of the incidental stimuli prior to central task performance. It was assumed that the habituation training would result in a weakened orienting response to the incidental stimuli making the incidental stimuli less "salient" when presented with the central stimuli in the incidental learning procedure. Thus, it was predicted that:

1. Children who received habituation training would recall fewer incidental stimuli than children who had received no such training.
2. Children who received habituation training would obtain higher central task scores than those who had not received such training.

2. Subjects

A total of sixty Grade three children were selected randomly for participation in the second experiment. The mean chronological age of the total sample was 8 years-11 months (SD = 4 months). There were no statistically significant age

differences between the groups of subjects in different experimental conditions. The mean Lorge-Thorndike IQ for all subjects was 109.0 ($SD = 13.5$), and the mean IQ of the treatment groups did not differ. Any child known to have a reading, learning, perceptual disability, or emotional disturbance was excluded from the sample. All subjects were students at Glen Ogilvie Public School in Ottawa, Ontario. The consent of the children's parents was obtained, and the children were given the right to refuse to participate or to terminate the session if desired. No subjects refused to participate, nor did any terminate the session prematurely. Participation was voluntary and no rewards were offered to any child.

3. Stimuli and Apparatus

The slides and apparatus used for the measurement of habituation rate in this experiment were identical to those described in Experiment I. An additional set of slides was used for the habituation training condition. This set consisted of five repetitions of the six black and white line drawings of household objects which were the irrelevant stimuli used in the incidental learning task. The set of control slides consisted of 30 unrelated coloured drawings from Grade three readers. All slides were rear-projected onto a 1 metre x 1.6 metre opaque screen, using a Kodak Carousel projector.

The incidental learning task consisted of a display of six cards, which were mounted on a black showcard panel measuring 20 cm x 70 cm . Each card, measuring 8.75 cm x 15.0 cm , contained two black-line drawings, an animal and a household object. The same animal always appeared with the same household object. These stimuli are shown in Figure 10. A total of twelve displays were used, each containing the same stimulus-pairs but in different positions. The twelve displays were blocked into two groups of six in order to examine changes in performance across trial blocks. Within each block the positions of the stimulus-pairs were assigned according to the following constraints:

1. Each stimulus-pair appeared in each of the six possible positions once in each trial block.
2. Each card was probed twice, once in each trial block.
3. Each position was probed twice, once in each trial block.

For every subject the display cards were presented in a different random order. An example of the stimulus ordering for a single subject is presented in Appendix 8.

4. Procedure

All subjects were seen twice. On the first occasion, habituation of a visual fixation response was measured with a procedure identical to that used in Experiment I. Since the

Figure 10. Stimuli Used in the Incidental Learning Procedure
in Experiments II and III

results from the previous experiment indicated that pre-exposure did not affect visual fixation behaviour, no children were pre-exposed to the experimental room in this experiment.

On the second visit approximately two weeks later the subjects, assigned randomly to running order, were picked up at the classroom and escorted to the mobile laboratory.

After they had been seated at the table, the subjects were instructed about the habituation training procedure (Appendix 9). Following the instructions the experimenter went to the observation room and started the slide presentation.

Depending on the treatment condition to which the subject had been assigned, the subject was shown either the six incidental stimuli repeated five times each, or the 30 unrelated control slides. The observer recorded the subject's total fixation time for only Trials 1 and 5 for each of the six incidental stimuli. The experimenter recorded this only for subjects in the habituation training condition to determine whether or not the subjects did habituate to the incidental stimuli. After habituation training had been completed the experimenter returned to the subject's room, removed the screen and chatted briefly with the subject.

After a brief rest period the subject was given the instructions for the Incidental Learning procedure (Appendix 10). A 20 cm. x 70 cm. display board containing six 8.75 cm. x 15 cm. blank white cards was placed in front of the subject.

In front of the experimenter was a stack of 13 displays of six cards each containing black line drawings of an animal and a household object. A practice trial was used to ensure that the subject understood the instructions. The six card display was exposed to the subject for six seconds and then turned over. From an envelope on the back of the display card the experimenter withdrew a 8.75 cm x 15 cm card which contained a black line drawing of an animal identical to one of the animals on the practise display card. The subject was asked to point, on his blank card display, to the location where that animal had just appeared. After the subject made his response the experimenter turned the display over so that the subject could see if his response was correct. The subject's response was recorded on a separate scoring sheet following each trial. Twelve such trials using the stimuli described above constituted the central learning task. Thus, the subject's central learning score was the number of locations correctly recalled per six trial block.

Immediately after the central learning procedure was completed, the incidental task was run. The experimenter turned over the subject's blank display card to reveal six cards each containing a black line drawing of the household objects which had appeared previously on the cards with the animals. Then the subject was given the instructions for the incidental learning test procedure (Appendix 10). Black line

drawings of the six animals had been prepared as individual cutouts and shown to the subject one at a time. The subject was required to point on his display to the household object which had appeared with that animal during the central learning procedure. Thus, the incidental learning score was the number of animal-household object pairs correctly matched; a perfect score was six. Following the incidental learning procedure, the subject was praised on his performance, thanked for his participation, and allowed to return unescorted to his classroom.

5. Results

To determine whether subjects who received habituation training did in fact habituate to the incidental stimuli, an analysis of variance was carried out on the mean total fixation response for trials 1 and 5. The significant main effect for Trials (see Table 5) indicated that habituation had occurred. This analysis also included a between-subjects factor to determine whether "fast" and "slow" habituators differed in amount of habituation to the incidental stimuli. Since neither the main effect for habituation rate nor the interaction between Rate and Trials reached significance, it can be concluded that "fast" and "slow" habituators did not differ in amount of habituation to the incidental stimuli.

TABLE 5

Analysis of Variance for Effects of Habituation
Rate and Trials on Mean Total Fixation Scores in
Experiment II (N: 60)

Source	df	SS	F
Rate	1	117.60	.30
Error	28	11,148.00	
Trials	1	6,657.1	16.72***
Rate x Trials	1	117.60	.30
Error	28	11,148.00	
Total	59	29,189	

*** $p < .001$

An analysis of variance was carried out on the slope scores obtained from a regression analysis of the mean total fixation responses across trials. The results, shown in Table 6, revealed a significant main effect for Habituation Rate indicating that "fast" and "slow" habituators differed in mean slope scores. The mean slope scores (Fast = -10.63, SD = 3.6, Slow = -1.80, SD = 4.13) indicated that subjects classified as "fast" habituators obtained higher mean slope scores than "slow" habituators. The absence of a significant main effect for Habituation Training indicated that children who received habituation training did not differ in mean slope score from those who received no habituation training.

The central learning scores were the mean number of probed positions correctly recalled per 6-trial block. These scores were analysed in a split-plot factorial analysis of variance design (SPF 22.2, Kirk 1968) with Habituation rate and Habituation training as between-subject factors, and Trial blocks as a within-subject factor. The results of this analysis, presented in Table 7, indicate that neither of the main effects nor the interaction were statistically significant. The mean central learning score was 4.6 out of a possible 12, 38% correct detections.

For the incidental learning scores which were the number of animal-household object pairs correctly matched an analysis of variance was carried out with Habituation rate

TABLE 6

Analysis of Variance for Effects of Habituation
Rate and Habituation Training on Slope Scores in
Experiment II (N: 60)

Source	df	SS	F
Rate	1	1,167.4	75.75***
Habituation Training	1	13.690	.89
Rate x Habituation Training	1	1.0758	.73
Within Cells	56	863.08	
Total	59	2,046.3	

*** $p < .001$

TABLE 7

Analysis of Variance for Effects of Habituation
Training, Habituation Rate and Trial Blocks on
Incidental Learning Scores in Experiment II (N: 60)

Source		df	SS	MS	F
Rate		1	3.3333	3.3333	1.17
Training		1	.8333	.8333	0.29
Rate x Training		1	.8333	.8333	0.29
	Error	56	158.20	2.825	
	Trial Blocks	1	3.3333	3.3333	2.65
Rate x Trial Blocks		1	1.2000	1.2000	0.95
Training x Trial Blocks		1	.3000	.3000	0.24
Rate x Training x Trial Blocks		1	.8333	.8333	0.66
	Error	56	70.333	1.2559	
Total		119	239.20		

and Habituation training as between-subject factors. The results of this analysis (Table 8) revealed no significant main effects but a significant Habituation rate x Habituation training interaction. An analysis of simple main effects (Kirk, 1968), shown also in Table 8 indicated that "fast" habituators obtained significantly higher incidental learning scores when they received no habituation training than did "fast" habituators who had received habituation training. This effect is shown in Figure 11.

Correlation coefficients were calculated for habituation rate, i.e., slope scores, Lorge-Thorndike IQ scores, central and incidental learning scores. None of the correlations were statistically significant. Correlation coefficients were also calculated on the central and incidental scores within each of the experimental groups to determine whether the relation between central and incidental scores was influenced by either rate of habituation or habituation training. None of these correlations were statistically significant.

6. Discussion

The central learning task appeared to have been quite difficult. The mean central learning score of 4.6 indicated 36% accuracy in the correct recall of the locations of the probed stimuli. In two previous experiments (Hagen, 1967; Hagen and Huntsman, 1971) using subjects of the same age and

TABLE 8

Analysis of Variance and Simple Main Effects for
Effects of Habituation Training and Habituation Rate
on Incidental Learning Scores in Experiment II (N: 60)

Source	SS	df	MS	F
Rate	.01667	1	.01667	.00
Rate at Training	5.63700	1	5.6370	2.08
Rate At No Training	5.63400	1	5.6340	2.08
Training	6.01670	1	6.0167	2.22
Training at "Fast"	0.53400	1	0.5340	0.19
Training at "Slow"	16.13400	1	16.134	5.96*
Rate x Training	12.15000	1	12.1500	4.49*
Within Cells	151.47000	56	2.7050	
Total	169.650	59		

* $p < .05$

Figure 11. Interaction Between Habituation Training and Habituation Rate on Incidental Learning Scores in Experiment II

a central learning task of apparently equivalent difficulty, the mean central learning scores indicated 54% and 60% accuracy, respectively, which would appear to be significantly higher than those obtained in this experiment. Since the two tasks appear to be of equal difficulty, it is not clear why the present task was so much harder.

The finding that habituation training decreased the amount of incidental recall is consistent with the properties of the habituation process. It was expected that repeated exposure to the incidental stimuli would weaken the subject's visual fixation response to those stimuli, hence, they would pay less attention to them than would subjects who had not been so habituated. It is not clear why this effect obtained only for the "fast" habituators, since an analysis of the effect of habituation speed indicated that both the "fast" and "slow" habituators habituated to the incidental stimuli during pre-exposure.

Although habituation training did influence incidental recall scores, it had no effect on central recall scores. Hagen has suggested that central task performance and incidental learning are complementary, i.e., that subjects "give up" incidental information in order to focus their attention more exclusively on the central information (Hagen and Hale, 1973). If this were the case one would expect that any operation which decreased attention to the incidental information,

e.g. habituation training, would be accompanied by an improvement in central task performance. Thus, the failure to obtain a concomitant increase in central task performance in the present study tends to weaken the notion that central task performance and the recall of incidental information are complementary processes.

Hagen based the notion of complementarity on experiments in which negative correlations had been obtained between central performance and incidental learning scores (Druker and Hagen, 1969; Hagen, 1967). In an initial study Hagen (1967) obtained correlations between the central and incidental measures from children in Grades one, three, five and seven. Positive correlations were obtained for grades one, three and five, however, at the seventh-grade level the correlation was $-.35$ ($p < .05$). These results were partially supported by Druker and Hagen (1969) who investigated children in grades four, six and eight, and found a progression from positive correlations at the lowest grade-level to negative correlations with the eighth-grade children. The results are described as partially supportive because Druker and Hagen used four central-incidental tasks which differed in stimulus characteristics and only two of the four tasks yielded statistically significant correlations. A similar progression from positive to negative correlations across age ($\underline{CA} = 8$ yrs, $r = .14$; $\underline{CA} = 11$ yrs, $r = .10$; $\underline{CA} = 14$ yrs, $r = -.57$) has been

reported in a study by Hale and Piper (1974). Hagen has interpreted these results to indicate that the ability to "give up" incidental information improves developmentally and that this improvement influences the observed improvement in central task performance, and by inference, selective attention skills.

There are other experiments, however, which have failed to support the "complementarity" hypothesis. In the initial incidental-learning experiment conducted by Maccoby and Hagen (1965) correlation coefficients were computed between the central and incidental scores for children in grades three, five and seven. None of the correlations was significant which led Maccoby and Hagen to conclude that "Scores on the central and incidental tasks were independent". Two other incidental learning experiments have failed to obtain significant negative correlations at any grade- or age-level (Hagen and Sabo, 1967; Weiner and Berzonsky, 1975). In fact, Hagen and Sabo found a significant positive correlation between central and incidental scores ($r = .41$, $p < .01$) of ninth-grade children. In the present study, the correlation coefficient calculated on the central-incidental scores was negative but its magnitude was not statistically significant ($r = -.193$). Due to the contradictory nature of the correlational evidence plus the fact that, in the present study, habituation training decreased incidental scores without

increasing central performance, it cannot be concluded that central and incidental learning reflect the operation of complementary processes.

Although the results of the present experiment have provided some evidence which is consistent with the proposed relationship between habituation and incidental learning, the data failed to confirm the predictions that rate of habituation is related to selective attention performance. The reason for the failure to obtain a relationship between rate of habituation and selective attention is not clear. The most parsimonious explanation is that the two processes are not related. However, the research evidence reviewed and the speculation advanced above do support the existence of such a connection. An alternative explanation is that one or both of the operational definitions of habituation rate and selective attention used here did not reflect accurately the inferred processes. The unexpected results of Experiment I raised doubts regarding the use of the visual fixation response as an appropriate index of the habituation process in elementary-school children. On the other hand, if the incidental learning procedure accurately reflects the process of selective attention, one would expect central and incidental learning to be inversely related, particularly, in view of the observed difficulty of the central task. However, the inverse relationship did not obtain in this experiment, despite the

decrease in incidental learning as a function of habituation training in "fast" habituators. The ambiguity of the results of both experiments made necessary further research, using alternative measures of habituation and attention to attempt to resolve these problems.

CHAPTER VI

EXPERIMENT III

The results of the first two experiments did not provide clear evidence regarding the development of habituation nor its relation to selective attention. However, the widely accepted importance of habituation in attention and learning, which was discussed above, merited a second attempt to find a measure which would provide an appropriate index of the habituation process in young children, and to re-examine its relationship to attentional processes. One of the habituation measures chosen for the present experiment has been used frequently in attentional research with infants (e.g. Haith, Kessen and Collins, 1969) and infra-human subjects (e.g. File, 1973; Sneeden, Spevack and Thompson, 1971). This habituation procedure is based upon the observation that the occurrence of a non-signal novel stimulus has a suppressive effect on the ongoing activity of the organism (Lynn, 1966). For example, if a child is performing a response at a fairly high and stable rate and an auditory stimulus is presented, the child's rate of responding decreases momentarily as he orients to the

new stimulus. With repetitions of the stimulus this "response suppression" grows less, i.e., habituates, until it finally disappears. If the characteristics of the stimulus change, the "response suppression" reappears, i.e., dishabituates. In this experiment the response measured was the suppression of finger-tapping rate.

In addition to the behavioural measure of habituation, the galvanic skin response (GSR) to an extraneous visual stimulus was monitored. The GSR is considered to be an indicator of autonomic nervous system (ANS) activation caused by novel stimulation (Lynn, 1966). Numerous experiments have investigated GSR habituation and have shown it to be predictive of the ability to sustain attention (e.g. Crider and Augenbraun, 1975; Siddle, 1972). It was assumed that one of the two habituation measures, response suppression or GSR, would provide an appropriate index of the habituation process, unlike the visual fixation response used in Experiment I which appeared to be sensitive to the task demands perceived by the subject.

As in the previous experiment selective attention ability was inferred from the children's performance on an incidental learning task. A measure of sustained attention was also included in this experiment. It was measured by the Continuous Performance Test (CPT) which has been used frequently to assess the sustained attention abilities of normal and

exceptional children (e.g. Sykes, Douglas and Morgenstern, 1973). The CPT requires the child to watch a random series of letters projected one at a time onto a screen, and to report the occurrence of the letter "X" when it is preceded by an "A". The additional measures of habituation and attention were included in this experiment in an attempt to obtain a clear interpretation of the relation of habituation to attention.

The developmental course of the various measures was examined by selecting randomly three groups of boys from Grades one, three and five. It was predicted that the habituation rate of both the behavioural and ANS measures would increase across grade levels. Regarding the selective attention measure, it was expected that central scores would increase as a function of grade level, while incidental recall scores would decrease. Of CPT performance it was expected that older children would correctly report more signals, and make fewer incorrect reports than would younger children. Within each grade level it was predicted that increased habituation rate would be associated with improved performance on all attention measures.

1. Subjects

A total of sixty boys were selected randomly for participation in this experiment, twenty each from grades one, three and five. The mean chronological ages for subjects in

Grades one, three and five were 6 years-6 months ($SD = 3$ months), 8 years-6 months ($SD = 5$ months), and 10 years-6 months ($SD = 5$ months), respectively. Any child known to have a reading, learning or perceptual disability, or emotional disturbance was excluded from the sample. All subjects were students at Briargreen Public School, Ottawa. The parents were informed by means of a school newsletter that the experiment was being conducted. If they did not contact the principal it was assumed that they had tacitly consented to their son's participation in the experiment. The children were given the opportunity to refuse to participate or to terminate the session if they desired. No subjects refused to participate, nor did any terminate the session prematurely. Participation was voluntary and no rewards were offered to any subject.

2. Stimuli and Apparatus

The incidental learning stimuli used in this experiment were the same as those used in Experiment II except that one of the pictures was dropped from each display. The five remaining pictures were reordered on the display cards according to the same criteria used in Experiment II. The order of stimuli is presented in Appendix 11. The number of pictures was decreased since the results of the previous study indicated that the task was difficult for the grade three children.

Moreover, Grade one children were included in this experiment. With only 5 stimuli, the number of display cards was reduced to ten.

The CPT stimuli consisted of seven slides each containing a single black capital letter which projected an image approximately 3.75 cm x 3.15 cm in size. The order of the letters is presented in Appendix 12. The signal which the subjects had to detect was the letter "X" preceded by the letter "A". Twelve such signals were included in the set at random intervals. A practice set consisting of 14 letters with two "AX" pairings was also used. The letters were rear-projected by a Kodak Carousel 800H modified projector onto a 75 cm x 50 cm opaque screen located approximately 1 metre in front of the subject. The subject held a button which he had been instructed to press only when he detected a signal. This response button was connected to one channel of a Gerbrands six-channel event recorder. The projector was interfaced with a Lafayette photocell reader control, and the Gerbrands event recorder. Presentation of target slides ("X") was recorded on a channel of the event recorder.

For the Finger-tapping test, the subject tapped a high-speed telegraph key which was mounted on a 15 cm x 15 cm square of half-inch plywood. The subject's rate of tapping was recorded on a Lehigh Valley six-pen event recorder. A second pen on the Lehigh Valley event recorder registered the

presentation of the extraneous visual stimulus. This stimulus was described in the Pilot study as S_1 of set C (see Figure 2). In this way the experimenter was able to compare tapping rate before the extraneous stimulus occurred with tapping rate during the four second stimulus presentation. The novel stimulus used on Trial 7 was a slide of a picture taken from a Grade III reader. Both event recorders were driven by an external 28 volt power supply. The projector was interfaced with a four-bank Lafayette interval timer and a Hunter interval timer which controlled slide onset, duration and offset. Each trial was initiated and terminated manually by the experimenter.

A Lafayette four-channel polygraph (Model 76032A) was used to record the subject's GSR activity during the Finger-tapping test. Grass (Type ES5) silver electrodes were attached to the pads of the first and third fingers of the subject's non-dominant hand. Beckman Electrode Paste (NaCl, .5%) was used and maximum extension of the effective electrode area was limited to 1 cm. by placing Beckman electrode collars on the skin. The event recorder on the polygraph was connected to the photocell reader control to record the onset and offset of the extraneous stimulus.

3 Procedure

Prior to the start of the experiment, the experimenter was introduced to all the classes from which the subjects were selected. For the experiment, the experimenter picked up each subject at his classroom area and accompanied him to the experimental room located within the school building. The subject was seated at a table and told that he was going to play three different games which would last for approximately 30 minutes. The experimenter determined which was the child's non-dominant hand, attached the electrodes to the subject, and turned on the polygraph to determine the subject's initial level of skin resistance. A resistance substitution box had been used to calibrate the polygraph identically for all subjects such that a resistance change of one thousand ohms produced a pen deflection of 1.0 cm. Maximum recordable skin resistance change was 6000 ohms. Daily calibration assured a linear relationship between resistance changes and balance settings.

Following electrode placement, the subject was given instructions for the central task of the incidental learning procedure (Appendix 10). The procedure was identical to the one which had been used in the second experiment, except that the reduction of the stimuli from six to five reduced the number of trials from twelve to ten. The exposure time for

each display card remained at six seconds in order to make the task less difficult than it had been in Experiment II.

Immediately following the central task the subject's recall of the incidental stimuli was tested using the same procedure which had been used in the preceding experiment.

For the CPT task the subject was moved to the other end of the table facing an opaque screen. He was then given the instructions for the CPT (Appendix 13). The subject reported the occurrence of a signal ("A" followed by "X") by depressing a hand-held button. A total of 24 signals occurred randomly throughout the 140 letter series. A practice set of letters was repeated until the subject made no errors. Each letter was shown for .27 seconds with a 1.71 second intertrial interval. Following the practice set, the experimenter changed the slide trays, seated himself behind the screen, and initiated the CPT when the subject had indicated that he was ready.

Following the CPT the experimenter changed the slide trays in preparation for the Finger-tapping test, and instructed the child in the operation of the telegraph key (Appendix 14). The subject was given the opportunity to learn the characteristics of the key by tapping it several times. A total of seven trials were given, each for a duration of 15 seconds with 30 second intertrial intervals. During the interval the experimenter monitored the balance reading on

the polygraph since the subjects' GSR activity was recorded throughout the task. Eight seconds into each trial a "distracting" stimulus was rear-projected on the opaque screen for a duration of four seconds. On the seventh trial a novel stimulus appeared. After the seventh trial the child was told that the games were finished. He was praised for his performance, thanked for his participation, and the electrodes were removed. After showing the child how the equipment worked, he was allowed to return unescorted to his classroom.

Treatment of GSR Measurement

Each subject's basal skin resistance was determined prior to the first trial of the Finger-tapping task, approximately 20 minutes after the electrodes had been attached. These resistance scores were converted to skin conductance (Lykken and Venables, 1971) for analysis. To determine the amount of change in electrodermal activity to the presentation of the extraneous stimulus, skin resistance was recorded at the onset of the stimulus, and again during the 4 seconds of stimulus presentation. These resistance measures were converted to conductance (micromhos) and a difference score was obtained by subtracting the first from the second (Edelberg, 1967). These conductance change scores provided the unit of measurement for subsequent analysis.

4. Results

Central learning scores were divided into two 5-trial blocks for analysis. Analysis of variance (Table 9) revealed a significant main effect for Grade. Since the main effect for Trial Blocks was not significant, multiple comparisons were carried out on means calculated on the basis of all ten trials. Newman-Keuls comparisons among the means (Appendix 15) indicate that the Grade five children achieved significantly higher central scores than the Grade one children but were not different from the Grade three children. A one-way analysis of variance of incidental recall scores indicated that the main effect for Grade was not significant ($F_{2, 57} = .32$). The mean central and incidental learning scores across grades are presented in Figure 12.

Separate one-way analyses of variance were carried out on the number of signals correctly detected, and the number of errors of commission on the CPT across grades. Both analyses revealed significant main effects for Grade, $F(2, 57) = 9.71$, $p < .001$, and $F(2, 57) = 14.54$, $p < .001$, respectively. The mean scores shown in Figure 13 indicate that the number of correct detections increased across Grades while the number of commission errors decreased across Grades. Newman-Keuls comparisons of means (Appendix 16) indicated that the Grade five children correctly detected significantly more signals

TABLE 9

Analysis of Variance for Effects of Grade and Trial
Blocks on Central Learning Scores in Experiment III (N: 60)

Source	df	SS	F
Grade	2	14.600	4.04*
Error	57	103.10	
Trial Block	1	.30000	.20
Grade x Trial Block	2	2.6000	.87
Error	57	85.1000	
Total	119	205.70	

* $p < .02$

Figure 12. Mean Central and Incidental Learning Scores in
Experiment III (N: 60)

Figure 13. Mean Correct Detections and Errors of Commission,
on CPT Across Grades in Experiment III (N: 60)

MEAN NUMBER OF CPT CORRECT
REPORTS AND COMMISSION ERRORS

—•— CORRECT REPORTS
—■— COMMISSION ERRORS

than the Grade one children but they did not differ from the Grade three children. Similar comparisons for commission errors indicated that the Grade one children made significantly more errors than the Grade three and the Grade five children who did not differ from each other (Appendix 17).

Suppression of the finger-tapping response to the presentation of the distracting stimulus was measured by a suppression ratio (SR) which was calculated in the following manner (Snedden et al, 1971):

$$\text{SR} = x / x + y$$

where: x = number of responses during stimulus (4 seconds)

and y = number of response during pre-stimulus period (4 seconds)

Therefore, an SR which equals 0.50 indicates that no suppression has occurred, while an SR less than 0.50 indicates that suppression has occurred. The SR's were analysed by means of a split-plot analysis of variance (Table 10) with Grade level as a between-subjects factor and Trials as a within-subjects factor. A significant main effect for Grade, $F(2, 57) = 5.19$, $p < .009$, indicated that the total amount of suppression varied as a function of grade placement. The mean SR's for Grades one, three and five were .474 (SD = .056), .488 (SD = .042), and .487 (SD = .032) respectively. Newman-Keuls comparisons of SR means across Grades indicated that the finger-tapping

TABLE 10

Analysis of Variance for Effects of Grades and Trials
on Mean Suppression Ratios in Experiment III (N: 60)

Source	SS	df	MS	F
Grade	.018172	2	.0090859	5.19*
Error	.099871	57	.0017521	
Trials	.050327	6	.0083878	4.42**
Grade x Trials	.025895	12	.0021579	1.14
Error	.64966	342	.0018996	
Total	.84393	419		

* $p < .01$

** $p < .001$

rate of the Grade one children was suppressed by the distracting stimulus to a greater extent than it was for either the Grade three or the Grade five children who did not differ from each other (Appendix 18). The significant main effect for Trials, $F(6, 342) = 4.42, p < .001$, and an inspection of the trial means presented Figure 14 and Appendix 19, indicate that the amount of suppression decreased across trials. Newman-Keuls comparisons indicated that all subsequent trials showed significantly less suppression than trial 1 and that there were no differences among those trials (Appendix 20).

Using the same procedure described in the pilot study, best-fit lines were determined for the SR scores of each subject over the first six trials. The slope scores of the obtained best-fit lines were then analysed by means of an analysis of variance to determine whether slope scores differed as a function of Grade-level. The absence of a significant effect for Grade, $F(2, 57) = 1.46, p < .24$, indicates that the slope scores did not vary as a function of grade.

Since the slope scores did not vary as a function of grade, the total sample of children was divided at the median slope score into two habituation rate groups, "fast" and "slow", to determine whether habituation rate influenced any of the attention measures. Separate one-way analyses of variance were carried out on each of the attention measures

Figure 14. Mean Suppression Ratios Per Trial for Grades I, III and V in Experiment III (N: 20 per grade)

with two levels of habituation rate as the only between-subjects factor. The results, presented in Table 11 show that only incidental learning score was influenced by habituation rate. Examination of the means (slow = 3.267, SD = 1.437; fast = 2.500, SD = 1.225) indicates that "fast" habituators had lower incidental learning scores than "slow" habituators. There were no significant main effects for rate on any other attention measure.

A one-way analysis of variance of basal conductance scores indicated that there were no Grade differences in the magnitude of basal skin conductance ($F(2, 51) = 1.68, p < .197$). A split-plot analysis of variance of conductance change scores revealed no significant main effects, but a significant Grade $\times$ Trial interaction (Table 12). An analysis of simple effects (Table 12) and inspection of the means (Table 13) revealed no consistent changes in conductance score.

Correlation coefficients were calculated between slope, central learning, incidental learning and CPT scores across all subjects as well as separately within each Grade-level (Table 14). CPT scores showed significant correlations to one another and also provided the only significant correlations among the other variables. The CPT-C and CPT-E scores show a significant negative correlation with one another overall, while within grade levels the inverse relationship was significant at the Grade three and five levels. The CPT-C scores revealed a

TABLE 11

Analyses of Variance for Effects of Habituation Rate on
Central Learning, Incidental Learning, CPT Number of
Correct and CPT Errors, respectively in
Experiment III (N: 60)

	Source	df	Sum of Squares	F
	Rate	1	.0667	.02
Central	Within Cells	58	217.33	
	Total	59	217.40	
	Rate	1	8.8167	4.95*
Incidental	Within Cells	58	103.37	
	Total	59	112.18	
	Rate	1	.4167	.11
CPT Correct	Within Cells	58	217.23	
	Total	59	217.65	
	Rate	1	3.267	.29
CPT Error	Within Cells	58	654.73	
	Total	59	658.00	

* $p < .05$

TABLE 12

Analysis of Variance for Effects of Grade and Trials
on Conductance Change Scores in
Experiment III (N;54)

Source	SS	df	MS	F
Grade	.2710	2	.13550	1.14
Grade at Trial 1	.0523	2	.02615	324.84 **
Grade at Trial 2	.4411	2	.22055	1369.88 **
Grade at Trial 3	.0185	2	.00925	57.45 **
Grade at Trial 4	.0936	2	.04680	290.68 **
Grade at Trial 5	.2404	2	.12020	746.58 **
Grade at Trial 6	.2854	2	.14270	886.34 **
Grade at Trial 7	.2245	2	.11225	697.20 **
Within cell	.0575	357	.000161	
Trials	.2136	6	.03560	.75
Trials at Grade 1	.6373	6	.10622	2.25 **
Trials at Grade 3	.5215	6	.08692	1.84 *
Trials at Grade 5	.1394	6	.02323	.49
Grade x Trials	1.0846	72	.09038	1.91 *
B x Subj. w. groups	14.4780	306	.04731	
Total	22.0920	377		

* $p < .05$

** $p < .01$

TABLE 13

Mean Conductance Change Scores (micromhos)
Across Grades and Trials in Experiment III (N:54)

		Trials						
Grade	1	.1122	.2578	.1494	.2067	.0539	.2633	.1500
	3	.0406	.0650	.1639	.1150	.2172	.0872	.2072
	5	.0989	.0672	.1194	.1222	.1306	.1522	.0511

TABLE 14

Correlation Coefficients Between Slope, Central Learning
Incidental Learning, CPT-C, and CPT-E Scores Within Grades
and Collapsed Across Grades in Experiment III (N:20 per Grade)

I		-.1506	-.1240	-.0424	.4945 *
III	Slope	.3174	-.2642	.1875	-.0314
V		-.0057	-.0524	-.5205 *	-.0289
Total		-.0118	-.1083	-.0956	.3054 *
I		.1338	.1249	-.2207	
III	Central	-.3595	.4991 *	-.4789 *	
V		-.1712	-.0858	.0403	
Total		-.1083	.3402 *	-.3406 *	
I			.0673	-.1010	
III	Incidental		-.4666 *	.4374 *	
V			.3518	-.4485 *	
Total			-.0739	-.0695	
I				-.4032	
III	CPT-C			-.7802 **	
V				-.4023 *	
Total				-.6025 **	

* $p < .05$
 ** $p < .01$

significant positive correlation overall with central learning scores. Examining the relationship by grade levels indicated that only the Grade three group reflected the overall relationship. While the overall correlation coefficients were not significant, CPT-C scores showed a significant inverse relationship with slope scores at the Grade five level and with incidental learning scores at the Grade three level. CPT-E scores had a significant positive correlation with slope overall, however, only the Grade one level reflected this relationship. Central learning scores and CPT-E scores were significantly negatively correlated overall but only the Grade three group manifested this relationship. While no significant overall correlation was obtained between incidental learning and CPT-E scores, the Grade three group showed a significant positive correlation between these two variables, while the Grade five group revealed a significant inverse relation.

5. Discussion

One of the aims of this experiment was to reexamine the development of habituation in children aged 6-10 years using response measures other than visual fixation. The unexpected results of Experiment I suggested that the visual fixation response is sensitive to perceived task demands of elementary school children. It was proposed that the problem of perceived task demands could be overcome by using measures which were more "reflexive" than the visual fixation response.

Hence, the suppression of ongoing activity and the GSR to a non-signal stimulus were selected as the dependent variables in this experiment. The expectation was that one of these two responses would provide an appropriate paradigm to index the habituation process.

The results indicated that the presentation of a visual non-signal stimulus suppressed the finger-tapping rate of the Grade one children to a greater extent than the Grade three or Grade five children. This finding is consistent with the notion that younger children are more "distractible" than older children. The significant decrease in the mean suppression ratio across trials suggested that the suppression of ongoing activity became habituated with repetitions of the visual stimulus. A comparison of the mean suppression ratios on Trials 6 and 7 indicated that dishabituation to the novel stimulus failed to occur. The failure to obtain dishabituation on Trial 7, prohibits one from asserting that the response decrement observed across trials definitely reflected the process of habituation rather than some other decremental process. In any event, the absence of a significant Grade x Trial interaction indicated that the rate of response decrement did not vary as a function of Grade-level. Further evidence against an age-related change in habituation rate was provided by the failure to obtain a change across Grades in the magnitude of regression lines fitted to each subject's

suppression scores.

Since comparisons of the mean suppression ratios indicated that "habituation" occurred primarily within the first two trials, additional "post hoc" analyses were carried out. The SRs were analysed across the first three trials, first two trials, and first trial only. The purpose of analysing the first trial SR was to determine whether there were grade-associated differences in an initial orienting reaction. However, as the number of trials used in the analysis decreased all main effects and interactions decreased in magnitude until the main effects for Grade and Trials became non-significant. Since the differences in suppression ratios across Grades were greatest during the first three trials, grade-level differences in rate, i.e., slope score, might have been more evident using three-trial slope scores than six-trial slope scores. Three-trial slope scores were obtained for each child and analysed. There were no significant effects.

While the analysis of the GSR data revealed a significant Grade x Trial interaction, close examination of this effect showed no consistent pattern of responding to differentiate between the three groups. Perhaps the only conclusion which can be drawn from these data is that children aged 6-8 years show greater variability in the size of their conductance change responses than do 10-year olds.

In addition to the reexamination of the development of habituation rate, a second aim of this experiment was to study the relationship of habituation rate to various attentional behaviours. The total sample of children is divided into two equal-sized groups on the basis of the magnitude of the slope of the best-fit line for their suppression ratios across the six finger-tapping trials. Subsequent analysis revealed that "fast" habituators recalled significantly less incidental information than "slow" habituators. This finding is consistent with the assumption that "fast" habituators compared to "slow" habituators are more efficient at learning to ignore irrelevant information. However, as in Experiment II, the decrement in incidental learning was not accompanied by a corresponding increment in central learning, providing further evidence that central and incidental learning are independent processes. Regarding the proposed relationship between habituation and selective attention, the results of this experiment combined with those of the preceding study suggest that habituation may facilitate the ability to ignore "irrelevant" information. On the other hand, no evidence has been found to suggest the ability to ignore irrelevant information enhances the ability to focus on "relevant" information.

Turning to the process of sustained attention, the results indicated that the "fast" habituators did not differ

from the "slow" habituators in either the number of correct reports or the number of errors made on the CPT. Previous experiments with adult subjects (e.g. Coles and Gale, 1971; Mackworth, 1969; Siddle, 1972) have shown that "fast" habituators have more difficulty sustaining their attention in a vigilance task than do "slow" habituators. Although the CPT and the vigilance task both require sustained attention, there are many differences between the typical vigilance procedure and the CPT which might account for the failure of the present results to concur with those reported previously. Therefore, it is not clear why a relationship between habituation and CPT performance failed to obtain in the present study.

In addition to the information regarding the development of habituation and its relationship to attention processes, the experiment was designed to investigate developmental changes in both selective attention and sustained attention abilities. The data from the incidental learning procedure indicated that central recall scores increased significantly between Grades one and five, while incidental task scores remained essentially unchanged. These developmental findings are similar to those obtained by other researchers (e.g. Hagen, 1967; Hagen and Hale, 1973; Hallahan, Kauffman and Ball, 1974) who have interpreted them to indicate at developmental improvement in selective attention ability.

Although Hagen has asserted that the improvement in central recall depends in part on the improved ability to ignore irrelevant information, the data from this and the preceding experiment have provided no evidence compatible with either an inverse or a direct relationship between central and incidental performance.

Regarding the development of sustained attention, it was found that the Grade five children correctly reported significantly more signals than did the Grade one children. Conversely, the Grade one children made significantly more errors of commission than either the Grade three or Grade five children. The results comparing Grade one to Grade five children are analogous to those comparing learning disabled with normal children (Sykes, Douglas and Morgenstern, 1972, 1973; Sykes, Douglas, Weiss and Minde, 1971). Apart from the original report in which the development of the CPT was described (Rosvold, Mirsky, Sarason, Bransome and Beck, 1956), there appears to be no descriptive data of age-associated changes in CPT performance. All of the experiments appear to be of a comparative nature, focussing on performance differences between normal and exceptional children. Although the direction of the change across grades in CPT performance is consonant with the findings regarding other attentional abilities, there is no direct evidence with which to compare these results.

Correlational Evidence

The results of the correlational analysis provide information regarding the relation of habituation to measures of attention, the relations among the attention measures, and the relation between central and incidental learning. A significant negative correlation between slope score and the number of correctly reported signals in the CPT indicates that "fast" habituators tend to make fewer correct reports than do "slow" habituators; i.e. are less able to sustain their attention to relevant stimulation. This finding is consistent with the "vigilance" research which has shown that among adult subjects "fast" habituators display a greater rate of vigilance decrement than "slow" habituators (e.g. Coles and Gale, 1971; Siddle, 1972). Furthermore a positive correlation was obtained at the Grade one level between slope score and CPT errors of commission. Since magnitude of the slope score was primarily influenced by the amount of suppression on the first trial, higher magnitude slope scores tended to reflect greater first-trial suppression. Suppression of ongoing activity can be considered an index of distractibility, therefore, it is concluded that the positive correlation between slope score and CPT errors of commission is compatible with the interpretation that "distractible" children tend to make more commission errors on the CPT. A substantial negative correlation between CPT number of correct reports and CPT

number of errors indicates that the two measures are not independent of each other. In conclusion, the correlational evidence suggests that "fast" habituators tend to make fewer correct reports and more errors on the CPT than do "slow" habituators. Slope scores were not related to either central or incidental learning scores, providing evidence against a habituation rate-selective attention relationship.

Additional correlation coefficients were calculated to determine whether any relationships existed among the various attention measures. At the Grade three level, central learning scores correlated positively with number of correct reports on the CPT, and negatively with CPT errors of commission. Conversely, incidental learning scores were correlated negatively with the number of correct reports on the CPT, and positively with CPT commission errors. These findings suggest that children who are better able to focus on relevant material in the incidental learning task tend to report correctly more signals on the CPT while making fewer errors of commission. The reverse applies to children who tended to have higher incidental scores. It must be pointed out that these significant correlations were found only for the Grade three children. The failure to obtain significant correlations at the Grade five level may have been due to ceiling effects, since the mean number of correct reports on the CPT was 23.55 out of a possible 24, while the mean number

of commission errors was 1.35. Why no significant correlations were obtained at the Grade one level is not known. In any event, the significant correlations between the various attention measures suggest that the processes of selective and sustained attention are not completely distinct from each other.

The relationship between central and incidental learning has been discussed a great deal. Hagen (1967, Hagen and Hale, 1973) has suggested that the two processes are reciprocal in that older children are able to "give up" incidental information in order to focus on the central information. In this study as in the preceding one, significant correlations between central and incidental recall scores were not obtained at any grade-level. Moreover, it was shown in this series of experiments that incidental performance could be altered without a concurrent change in central recall. Thus, none of the evidence from the present experiments supports the assertion that central and incidental performance are inversely related.

SUMMARY AND CONCLUSIONS

Previous research on the development of habituation in infant and infra-human subjects has demonstrated repeatedly that habituation rate increases ontogenetically. Although this literature is extensive, few experiments have attempted to examine the development of habituation in humans beyond the period of infancy. Those researchers who have attempted to extend to age-range, have provided, with one exception (Mackworth and Otto, 1970), evidence that habituation rate increases through the preschool years (Lewis et al, 1969) to young adulthood (Lynn, 1966; Milstein, Stevens and Sachdev, 1969). However, the data from these studies with older subjects do not provide unequivocal support of the findings with infants, since they have failed to include the control procedures necessary to demonstrate the occurrence of habituation, e.g., a habituation-dishabituation paradigm. Mackworth and Otto (1970) used a habituation-dishabituation procedure but they did not observe age-changes in the habituation rate of their 2 to 7 year old subjects.

In the present research programme, a series of experiments attempted to determine a valid index of the habituation process and to examine its development in children six to ten years of age. Based on the data from a pilot study with eight-year old children, a procedure was developed to

measure the habituation of a visual fixation response. Using a fixed-trial procedure, total fixation time to a visual stimulus decreased with repeated presentations and dishabituated to a novel stimulus. Using this procedure, Experiment I examined the development of habituation in children from Grades one, three and five. The results indicated that the visual fixation response of the Grade one children habituated more quickly than that of the Grade three children while the Grade five children failed to habituate. These findings were directly opposed to predictions, since all previous research reporting age-changes in habituation rate had found habituation rate to increase with age.

A post-experimental questionnaire indicated that a majority of children at all Grade-levels perceived that it was important to look at the stimuli. Therefore, unlike the typical habituation procedure which uses stimuli presumed or demonstrated to have no signal value, Experiment I appeared to have been measuring habituation to "signal" stimuli. Since important stimuli generally require sustained attention, it was interpreted that the results of Experiment I reflected developmental differences in the ability to sustain attention. This interpretation was supported subsequently by data from Experiment III which revealed a developmental improvement in performance on the Continuous Performance Test which measures the ability to sustain attention. Thus, it was concluded that:

the visual fixation response, although useful as a valid measure of habituation with infant subjects (e.g. Cohen and Gelber, 1975), is sensitive to perceived task demands when used with elementary school children.

Since the results of Experiment I did not provide clear evidence regarding the development of habituation, the problem was reexamined in Experiment III using an alternative measure of habituation. One of the responses used was the suppression of finger-tapping speed to a discrete non-signal visual stimulus. It was found that the suppression of ongoing activity decreased with repetitions of the visual stimulus, however there were no reliable Grade-level differences in the rate at which the decrement occurred. Although not significant, the differences were in the same direction as those observed in Experiment I with the younger children showing greater suppression on the first few trials than did the older children. Unfortunately, the suppression response did not recover when a novel visual stimulus was presented. Therefore, it cannot be concluded that the observed response decrement reflected the process of habituation. No consistent changes in skin conductance were observed across trials, either within or between grades. Despite the use of alternative response measures, the data from Experiments I and III failed to provide clear evidence regarding the development of habituation in children of elementary school age. However, these data do

point out that procedures which have been used successfully to measure habituation in infant and infra-human subjects are not appropriate for similar use with young children.

In addition to the examination of the development of habituation rate in Experiments I and III, Experiments II and III explored a proposed relation between habituation and selective attention. Selective attention was measured by the incidental-learning procedure developed by Hagen (1967). This procedure consists of two tasks; a central task which requires the subject to attend to the location of stimuli designated as relevant, and an incidental task which measures the subject's ability to match pairs of stimuli incidental to the central task. Selectivity of attention is reflected in high central performance and low incidental performance. Experiment II investigated two predictions: 1) children who had been habituated to the incidental stimuli prior to the incidental-learning procedure would obtain higher central learning scores and lower incidental learning scores than children who had not been so habituated; and 2) children classified as "fast" habituators would obtain higher central learning scores and lower incidental learning scores than would "slow" habituators. The results of Experiment II provided partial support of the former prediction in that prior habituation training lowered incidental learning scores but only for subjects classified as "fast" habituators. While this finding was consistent with

the properties of the habituation process, it is not clear why the effect obtained only for "fast" habituators. The data did not support the second prediction regarding the effect of habituation rate on selective attention performance.

The problems encountered in the interpretation of the measure of rate of habituation in Experiment I, necessitated further investigation of the relation between habituation rate and selective attention using different responses (suppression of finger-tapping and skin conductance changes) to measure habituation. In this third experiment it was found that "fast" habituators obtained significantly lower incidental learning scores than "slow" habituators. However, habituation rate was not related to central learning performance. Taken together the data from Experiments II and III provided partial support for the proposed relation between the processes of habituation and selective attention. Specifically, the results from Experiment II suggest that prior habituation to the irrelevant stimuli aids "fast" habituators in minimizing attention to those stimuli during performance of the incidental task. Second, the suppression of finger-tapping data from Experiment III suggest that "fast" habituators are more capable of ignoring incidental information than "slow" habituators. Since there were no consistent changes in the skin conductance response, it was not possible to examine the relation of this response to selective attention. Unfortunately, the ambiguous nature of

the habituation data precluded a clear test of the proposed role of habituation in the development of selective attention.

The results from Experiments II and III provided some insight into the nature and development of selective attention. There is a prevailing notion among investigators of selective attention using the incidental procedure that the processes of central and incidental learning are complementary. Specifically, it is proposed by Hagen and Hale (1973):

"that children's ability to exercise selective attention improves with age; increasingly they concentrate on task-relevant stimuli and ignore extraneous information ... The most efficient strategy in the central-incidental task, of course, is to focus upon relevant features at the expense of extraneous information. The correlational data suggest that such a strategy is more characteristic of older than of younger children".

Hagen and Hale (1973) define "older" as 12-13 years of age. When discussing the evidence regarding the age-changes in central-incidental performance, Hagen qualifies the complementarity hypothesis stating that it only obtains at age twelve and older and that the ability to "give up" incidental information is partly responsible for the facilitation of central learning. However, in his formulation of a model of the development of selective attention, the ability to give up irrelevant information appears as a major process underlying the ability to focus on relevant information.

Hagen and Hale (1973) based the concept of complementarity on correlation coefficients calculated between central and incidental learning scores. They concluded that these correlations are positive at the younger age levels (5-6 years), approach zero, and then become negative at the older age levels (12-13 years). Several studies have not obtained this progression in correlational data. In fact, in one experiment (Hagen and Sabo, 1967) a significant positive correlation was obtained between the central and incidental learning scores of ninth-grade children ($r = .41$, $p < .01$). Therefore, it should be noted that previous correlational data are contradictory with regard to the notion of complementarity.

The data from Experiments II and III provided evidence that central and incidental performance are independent rather than complementary. First, none of the correlation coefficients between central and incidental learning were statistically significant for children from Grades I, III and V. Second, in Experiment II it was found that habituation training decreased the incidental learning scores of "fast" habituators, but had no effect on central learning performance. If the two processes were complementary one would expect that any manipulation which decreased incidental performance would result in a corresponding increase in central performance. Similarly, in Experiment III it was found that "fast" habituators obtained significantly lower incidental learning scores than "slow" habituators, while

central learning scores were not affected by habituation rate. These results are contrary to a "complementarity" hypothesis and suggest that this hypothesis needs to be re-evaluated.

Correlational data obtained in Experiment III indicated the presence of an inverse relationship between CPT correct detections and central learning scores. A direct relationship between CPT errors of commission and incidental learning scores was observed as well. Future research is required to isolate the factors which may account for these relationships.

In addition to the data pertaining to the development of selective attention, Experiment III examined the development of sustained attention as indexed by the Continuous Performance Test (CPT). The results revealed that the Grade five and Grade three children correctly detected more signals (CPT-C) and made fewer errors of commission (CPT-E) than the Grade one children. These findings are compatible with a developmental improvement from Grade one through five in the ability to sustain attention. Although the CPT has been used frequently to compare the sustained attention abilities of normal and various types of exceptional children (e.g. Sykes, Douglas and Morgenstern, 1972, 1973), no normative data on the development of CPT performance has been reported. Given the widespread clinical use of the CPT as a diagnostic tool for detecting the presence of brain-damage (Rosvold, Mirsky, Sarason, Bransome and Beck, 1956), and as a measure of attentional deficits in learning-disabled

children (e.g. Tarver and Hallahan, 1975), the absence of normative data is surprising. The data obtained here represent a substantial beginning to the provision of the necessary normative data.

There is a need for further research on the development of habituation during young childhood. Specifically, the most pressing problem is the development of a procedure which will provide a valid index of the habituation process in children at this stage of development. Perhaps the measurement of a GSR response to a repeated non-signal stimulus, independent of any other task demands, might provide a suitable measure. It should be pointed out that whatever method is developed, it must include the necessary control procedures to demonstrate that the response decrement observed reflects habituation rather than some other decremental process.

Despite the present attempts, the proposed relation between habituation and selective attention remains unsubstantiated. However, it is suggested that future research use a measure of selective attention other than the incidental learning procedure. The present data can be interpreted to indicate that the procedure used here did not provide an adequate measure of selectivity of attention, since there was no evidence that central and incidental performance were inversely related. Moreover, as discussed above, the developmental findings reported for the incidental learning

task may be an artifact of an age x task difficulty confound inherent in the tasks.. Further research will be required to equate the difficulty of both central and incidental tasks across ages, and only then may the development of selective attention be examined using this procedure.

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Instructions for Fixed-Trial
Habituation Procedure in Pilot Study

"On the screen in front of you a series of pictures are going to be shown. Before each picture comes on this orange light on your left will start to blink. When it does I want you to stare right at it. While you are staring at the blinking light, a picture will come on the screen in front of you. When the picture comes on I would like you to turn and look at it for as long as you want. You don't have to look at the picture the whole time that it is on, but you may look at it for as long as you like or until it goes off and the screen turns white. After the picture goes off the orange light will start blinking again. When that happens I would like you to stare at it again. Now we'll look at a few pictures just to see if you know what to do."

The experimenter manually presented three pictures interspersed with blank slides and the blinking light. If the subject did not follow the instructions completely, the experimenter reiterated the relevant features. If the subject followed the procedure correctly, the remaining instructions were given.

"Very good. I will leave the room while you are watching the pictures, but I will come back as soon as all the pictures have been shown. Do you have any questions? Fine, we will start in just a minute."

The experimenter departed from the observation room and started the slide presentation.

Instructions for the Habituation Procedure
Used in Experiments I and II

"In front of you is a screen and an orange light. Sometimes the orange light will blink. When it blinks I want you to watch it. Try to sit as quietly as you can and watch the light when it blinks. While you're here I'll also show some pictures on the screen. Any questions? I'll be in the next room and will come out every few minutes to change the pictures. O.K. We'll begin in a minute."

Newman-Keuls Multiple Comparisons of First Fixation
 Trial Means Collapsed Across Grades in Experiment I (N:60)

Means	Trials							
	5	4	3	6	8	2	1	7
$\bar{X}_5 = 65.43$	-	3.62	13.30	14.50	21.17**	25.94**	34.57**	70.47**
$\bar{X}_4 = 69.05$		-	9.68	10.88	17.55**	22.32**	30.95**	66.85**
$\bar{X}_3 = 78.73$			-	1.20	7.87	12.64	21.27**	57.17**
$\bar{X}_6 = 79.93$				-	6.67	11.44	20.07**	55.97**
$\bar{X}_8 = 86.60$					-	4.77	13.40	49.30**
$\bar{X}_2 = 91.37$						-	8.63	44.53**
$\bar{X}_1 = 100.00$							-	35.90**
$\bar{X}_7 = 135.90$								-

* $p < .05$

** $p < .01$

Newman-Keuls Multiple Comparisons of Mean
Total Fixation Scores Across Grades in
Experiment I (N:20 per Grade)

Means	Grades		
	1	3	5
$\bar{X}_1 = 61.86$	-	19.98*	24.62*
$\bar{X}_2 = 81.84$		-	4.64
$\bar{X}_3 = 86.48$			-

* $p < .05$

APPENDIX 5

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Newman-Keuls Multiple Comparisons of Total Fixation
 Trial Means Collapsed Across Grades in Experiment I (N:60)

Trial Means	Trials							
	4	6	5	8	3	2	1	7
$\bar{X}_4 = 61.55$	-	.02	2.53	7.97	8.22	11.77	38.45**	52.45**
$\bar{X}_6 = 61.57$		-	2.51	7.96	8.20	11.75	38.43**	52.43**
$\bar{X}_5 = 64.08$			-	5.45	5.69	9.24	35.92**	49.92**
$\bar{X}_8 = 69.53$				-	.24	3.79	30.47**	44.47**
$\bar{X}_3 = 69.77$					-	3.55	30.23**	44.23**
$\bar{X}_2 = 73.32$						-	26.68**	40.68**
$\bar{X}_1 = 100.00$							-	14.00
$\bar{X}_7 = 114.00$								-

* p < .05

** p < .01

Newman-Keuls Multiple Comparisons of Total Fixation
Trial Means Within Grades I and III in Experiment I
(N:20 per Grade)

Grade I Means	Trials							
	6	4	3	5	8	2	7	1
$\bar{X}_6 = 42.70$	-	2.10	5.30	6.60	9.20	17.85*	54.90**	57.30**
$\bar{X}_4 = 44.80$		-	3.20	4.50	7.10	15.75	52.80**	55.20**
$\bar{X}_3 = 48.00$			-	1.30	3.90	12.55	49.60**	52.00**
$\bar{X}_5 = 49.30$				-	2.60	11.25	48.30**	50.70**
$\bar{X}_8 = 51.90$					-	8.65	45.70**	48.10**
$\bar{X}_2 = 60.55$						-	37.05**	39.45**
$\bar{X}_7 = 97.60$							-	2.40
$\bar{X}_1 = 100.00$								-

Grade II Means	Trials							
	6	4	5	2	8	3	1	7
$\bar{X}_6 = 60.20$	-	1.20	1.90	10.25	15.70	20.55*	39.80**	83.70**
$\bar{X}_4 = 61.40$		-	.70	9.05	14.50	19.35*	38.60**	82.50**
$\bar{X}_5 = 62.10$			-	8.35	13.80	18.65*	37.90**	81.80**
$\bar{X}_2 = 70.45$				-	5.45	10.30	29.55**	73.45**
$\bar{X}_8 = 75.90$					-	4.85	24.10**	68.00**
$\bar{X}_3 = 80.75$						-	19.25**	63.15**
$\bar{X}_1 = 100.00$							-	43.90**
$\bar{X}_7 = 143.90$								-

* p < .05

** p < .01

APPENDIX 7

Newman-Keuls Multiple Comparisons of Total Fixation
Means at Trials 3, 4, 6 and 7 Across Grades
in Experiment I (N:20 per Grade)

184

Trial 3 Means	Grades		
	1	5	3
$\bar{X}_1 = 48.00$	-	32.55*	32.75*
$\bar{X}_5 = 80.55$		-	.20
$\bar{X}_3 = 80.75$			-
Trial 4			
	1	3	5
$\bar{X}_1 = 44.80$	-	16.60	33.65*
$\bar{X}_3 = 61.40$		-	17.05
$\bar{X}_5 = 78.45$			-
Trial 6			
	1	3	5
$\bar{X}_1 = 42.70$	-	17.50	39.10*
$\bar{X}_3 = 60.20$		-	21.60
$\bar{X}_5 = 81.80$			-
Trial 7			
	1	5	3
$\bar{X}_1 = 97.60$	-	2.80	46.30**
$\bar{X}_5 = 100.40$		-	43.50**
$\bar{X}_7 = 143.90$			-

* $p < .05$ ** $p < .01$

APPENDIX 8

185

Sample Stimulus Order for 12 Trial Incidental
Learning Task with Stimulus and Probed Position
Noted in Experiment II

Display Number	Stimulus Number					
1	3	1	5	2	4	(6) ^a
2	2	3	4	6	(5)	1
3	5	6	1	(4)	3	2
4	6	4	(3)	1	2	5
5	4	(2)	6	5	1	3
6	(1)	5	2	3	6	4
7	1	2	4	5	(6)	3
8	3	6	(5)	4	1	2
9	6	(4)	3	1	2	5
10	4	1	2	(3)	5	6
11	(2)	5	1	6	3	4
12	5	3	6	2	4	(1)

Note: Each subject received a different random order of display card.

^a Numbers in parentheses indicate the stimulus and position probed.

Instructions for Habituation Training
Procedure in Experiment II

"Today I'm going to show you some more pictures and like before the orange light will blink before the picture comes on. Only this time there aren't as many pictures, and they won't be shown for as long. After the pictures are finished we will play a game. Are you ready? Okay, good. I'll be in the next room and will come back when the pictures are finished. See you later."

Instructions for Incidental Learning
Procedure Used in Experiments II and III

Central Task

"The first thing we are going to do is to play a short memory game together. I will show you a series of six (five for Experiment III) cards with pictures of animals and household objects on them. I will show them to you for only a short period of time, about six seconds, so I want you to look at all of the cards very carefully. After I show you the cards I will turn them over and show you a card with an animal on it just like one of the animals that you have just seen. Then you have to point the spot on here (the experimenter points to the blank display card) where the animal was shown just before. Try to remember where the animals appear in the series of cards. Let's try one for practice. O.K., that's very good. Now let's start the game for real."

Incidental Task

"In front of you I have placed the five household objects that were on the cards with the animals. Again, I am going to show a card with one animal on it. I want you to look at it carefully then point to the household object that was shown with that animal before. After you have picked out which household object goes with that animal point to it on the card in front of you. O.K. Now here is the first animal. Which of the five household objects was shown with this animal? Pick it out, and point to it."

APPENDIX 11

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Sample Stimulus Order for 10 Trial Incidental
Learning Task with Stimulus and Probed Position Noted

Display Number	Stimulus Number				
1	2	5	(3) ^a	1	4
2	1	(4)	2	5	3
3	3	1	4	(2)	5
4	(5)	3	1	4	2
5	4	2	5	3	(1)
6	(1)	2	3	5	4
7	3	(4)	5	2	1
8	5	1	(2)	4	3
9	2	3	4	1	(5)
10	4	5	1	(3)	2

Note: Each subject received a different random order of display card.

^a Numbers in parentheses indicate the stimulus and position probed.

APPENDIX 12

Order of Letter Presentation for Continuous Performance
Test in Experiment III

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<u>Trial</u>	<u>Letter</u>	<u>Trial</u>	<u>Letter</u>	<u>Trial</u>	<u>Letter</u>
1	A	26	O	51	G
2	O	27	C	52	S
3	A	28	A	53	X
4	X	29	X	54	X
5	B	30	X	55	B
6	H	31	T	56	X
7	A	32	H	57	H
8	X	33	A	58	A
9	T	34	X	59	X
10	L	35	O	60	P
11	A	36	L	61	A
12	C	37	L	62	X
13	A	38	A	63	S
14	X	39	X	64	E
15	G	40	S	65	L
16	B	41	P	66	A
17	E	42	X	67	A
18	X	43	A	68	X
19	T	44	X	69	S
20	O	45	T	70	A
21	C	46	C		
22	G	47	B		
23	A	48	E		
24	X	49	A		
25	P	50	X		

Instructions for Continuous Performance
Test in Experiment III

"Now we are going to play a game called find the X's. Do you know what the letter X looks like? I'm going to show some letters on this screen one at a time. Your job is to press this button when you see an X but only if the X comes right after an A. That is when you see an A and then an X press the button on the X. Don't press the button for any other letter following an A except for X, and always press it then. Remember now, when you see the letter A get set; if an X comes right after it, press the button. Let's try a few letters for practice. O.K. That was very good. We'll begin the real game in just one minute. Ready, begin."

Instructions for Finger Tapping Procedure
in Experiment III

"For the third game we are going to use this telegraph key. Most people use them to send Morse code messages to each other, but all I want you to do is when I say GO I want you to tap this key as fast as you can until I tell you to STOP. Try tapping the key a few times to see how it works. Fine. O.K. When I say READY - SET - GO I want you to start tapping as fast as you can until I tell you to STOP. I'll have you tap for about 15 seconds before I say STOP. Then I'll let you rest for about 30 seconds so that your finger doesn't get too tired. Any questions? O.K. READY- SET - GO."

APPENDIX 15

Newman-Keuls Comparisons of Mean Central
Learning Scores for Grades Averaged Across
Trial Blocks in Experiment III

Mean	Grade		
	1	3	5
$\bar{X}_1 = 3.0$	-	1.0	1.7*
$\bar{X}_3 = 4.0$		-	.7
$\bar{X}_5 = 4.7$			-

* $p < .05$

Newman-Keuls Comparisons of Mean Correct
Detections on Continuous Performance Test
Across Grades in Experiment III (N:20 per Grade)

Mean	Grade		
	1	3	5
$\bar{X}_1 = 21.20$	-	1.10	2.35**
$\bar{X}_3 = 22.30$		-	1.25
$\bar{X}_5 = 23.55$			-

** p < .01

APPENDIX 17

Newman-Keuls Comparisons of Mean Commission
Errors on Continuous Performance Test Across
Grades in Experiment III (N: 20 per Grade)

Mean	Grade		
	5	3	1
$\bar{X}_5 = 1.35$	-	.60	4.35**
$\bar{X}_3 = 1.95$		-	3.75**
$\bar{X}_1 = 5.70$			-

** p < .01

APPENDIX 18

Newman-Keuls Comparisons of Mean
Suppression Ratios Across Grades in
Experiment III (N: 20 per Grade)

Mean	Grade		
	1	5	3
$\bar{X}_1 = .4736$	-	.0131**	.0146*
$\bar{X}_5 = .4867$		-	.0015
$\bar{X}_3 = .4882$			-

* $p < .05$

** $p < .01$

APPENDIX 19

Mean Finger Tapping Suppression Ratios
Across Grades and Trials in Experiment III
(N: 20 per trial)

Grade	Trials						
	1	2	3	4	5	6	7
1	.4310	.4710	.4855	.4900	.4810	.4835	.4730
3	.4595	.4925	.4910	.4860	.4990	.4980	.4915
5	.4830	.4805	.4995	.4945	.4850	.4860	.4810

APPENDIX 20

Newman-Keuls Comparisons of Mean Suppression
 Ratios Collapsed Across Grades in Experiment III
 (N:60 per trial)

Mean	Trial						
	1	7	2	5	6	4	3
$\bar{X}_1 = .4578$	-	.0232**	.0234*	.0305**	.0314**	.0324**	.0342**
$\bar{X}_7 = .4810$		-	.0003	.0073	.0082	.0092	.0110
$\bar{X}_2 = .4813$			-	.0070	.0079	.0089	.0107
$\bar{X}_5 = .4883$				-	.0009	.0019	.0037
$\bar{X}_6 = .4892$					-	.0010	.0028
$\bar{X}_4 = .4902$						-	.0018
$\bar{X}_3 = .4920$							-

* $p < .05$

** $p < .01$

END

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FIN