Attention in preschool children with and without signs of ADHD.
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Chapter 2: Information Processing Theories and Ethology: Their Use for the Study of Attentional Processes in Preschool Children

2.1 Introduction

The study of developmental aspects of attention can play an important role in our understanding of cognitive functioning. Studies of attention in preschool children provide an indication of later functioning like school achievement and intelligence (Palisin, 1986), and may give us insight into possible precursors of later attentional problems that will interfere with school performance (Campbell, Szumowski, Ewing, Gluck, & Breaux, 1982; Campbell, Ewing, Breaux, & Szumowski, 1986; Ruff, Lawson, Parrinello, & Weissberg, 1990). At present we are not able to identify a child with these kinds of problems earlier than at an age of six or seven years. One of the main aims of the underlying study is to investigate what happens before the child eventually turns into a problem child. What occurs when a child develops into a hyperactive child with attentional problems? Because very little is known about the normal development of attentional processes during this early age, it is important first to investigate these processes, before entering into the problems of suboptimal development. The information processing theory provides a very influential basis for knowledge about attentional processes. For this reason we will start our search for insight into the early development of attentional processes within this theory. The paradigm has one main disadvantage: it addresses primarily adult information processing. Although the theory has proven useful for studying attentional processes in normal as well as ADHD children, few researchers have tried to extrapolate the findings to children younger than seven years. In our study we will try to extrapolate the research methods of the information processing theories to children from four to six years of age. Since it was unclear whether these young children would be willing to undergo the very strict task demands of this method, we adopted a second line of theorizing. Within developmental psychology and neuropsychology the method - derived from ethology - of observing the behaviors of children during free play is often used to study - among other aspects - the dividing or focusing of attention.
Although it is not unlikely that this method might provide only a shallow view of 'attentional processes', we used this method, because we could be quite sure that children, even as young as two years old, would be willing to play. Because the two lines of research we used are quite different, in the last part of the chapter we will investigate if they have anything in common. How do the two approaches conceptualize the (normal and deviant) development of attentional processes?

2.2 Theories on Attention

What precisely is attention? It is easy to agree with James (1891) that everyone knows what attention is. But to find a clear-cut definition of this concept is more difficult. Many researchers agree that attention plays a very important role in the study of cognitive functioning (Gibson & Rader, 1979; Allport, 1989; Enns, 1990). Cooley and Morris (1990) claim that "Attention is considered to be the foundation of most cognitive and neuropsychological functions". In a review of literature on attention Johnston and Dark (1986) stated that they were struck by the reluctance to define attention. Their conclusion was, that after almost a century of research since James, hardly any gain in knowledge about the content of the concept can be found. Therefore, the best thing to do is to cite James (1891), as he wrote: "Everyone knows what attention is. It is the taking possession of the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought. Focalization, concentration of consciousness are of its essence. It implies withdrawal from some things in order to deal effectively with others, and is a condition which has a real opposite in the confused, dazed, scatterbrained state (...)" (pp. 403-404).

2.2.1 Leading Models on Human Information Processing

Within cognitive psychology the information processing theory with its coherent system of models is seen as a very important method for the study of attentional processes. These models describe elementary structural and energetic functions which play a role in the perceptual-motor operations during the processing of information. It is assumed that during development changes in the processing of information are a result of structural (Clark, 1982a, 1982b), as well as energetic (Wickens & Benel, 1982; Sanders, 1983), and strategic aspects (Chi, 1977; Chi & Gallagher, 1982). In the following sections we will present a brief overview of some of the most influential theories of human information processing.
The Subtraction Theory of Donders

In 1868, Donders (see the posthumous publication: Donders, 1969) postulated one of the first important theories of human information processing, the so-called subtraction method. According to Donders the incoming information will be internally processed in a sequence of stages which result in a specific task performance. Different types of tasks have their impact on different processing stages, which implies that by means of the subtraction method the processing time of one specific stage can be measured (figure 1).

Figure 1. Donders' subtraction method

The subtraction method is quite simple. The difference between a simple reaction time task (press a button on appearance of a light) and a discrimination reaction time task (press only when a red light appears, not when a green light appears) is that, in the second task, an extra process is needed for a correct response, namely the process of discriminating the two different stimuli. Donders argued that the reaction time on the discrimination reaction time task is always longer than the reaction time on the simple reaction time task, which is caused by the time the discrimination process takes. By simply subtracting the reaction times on the simple reaction time tasks from the
reaction times on the discrimination reaction time tasks we can get a very accurate representation of the time the process of discriminating between two stimuli takes. According to the same arguments one can achieve additional information about the time of the choice process. Donders used, surprisingly enough, an extremely accurate method for measuring reaction time: "Measuring the somewhat inconstant duration of mental processes, a determination in thousandths of seconds is sufficient(!) (...) We need an accurately known chronoscopic unit. These are found in the recorded vibrations of a tuning-fork. The vibration speed of the tuning-forks used was determined directly by simultaneous recording of their vibrations and of the seconds of a clock." (Donders, 1969, p. 426). The vibrations were recorded on a turning cylinder. The moment of stimulus presentation was marked on the same cylinder, while the response time of the subject recorded with a phonautograph (for vowel-sound responses) or a wooden rod which marked physical responses. With this method, Donders was able to measure reaction times with a precision of about .0003-.0007 seconds: "With 261 vibrations per second, fifths and even tenths of a vibration could be read quite well" (p. 427)! The method of using reaction time experiments to determine the speed of mental processes has become synonymous with information processing theories. In the last decades the reaction time task has become a (micro) computer experiment in which the subject has to push (or release) highly accurate buttons in response to a stimulus, mostly a character presented on a computer screen. The computer then measures the exact time between stimulus presentation and response, with an accuracy of about one-thousandth of a second, which is no more accurate than the method used by Donders, more than one century ago!

The Additive Factor Method of Sternberg
On the basis of the Donders’ method, Sternberg formulated in 1969 (1969a, 1969b) his additive factor method. In this theory the following assumptions are made: a) information is processed in different, independent stages, b) each stage gets its input from the preceding stage, c) the processing of information in one particular stage is independent from the processing in preceding stages, and d) the total processing time is the sum of the processing time of each stage (figure 2). This additive factor method can be seen as an extension of Donders’ subtraction method. Its main focus is on validating the different processing stages, instead of measuring the speed of different processes, which was the aim of Donders (Donders, 1969, Sternberg, 1969a, 1969b).
Figure 2. The additive factor method of Sternberg

Sanders: A Model of Stress and Human Performance

In 1983, Sanders added an energetic dimension to the model of Sternberg. This dimension consists of three mechanisms: arousal, effort, and activation. According to Sanders, the computational (or structural) stages in the model rely upon these three types of energetical supply or resources. These resources can regulate the information processing system in order to achieve a task performance which is as optimal as possible (figure 3). In this model the idea is that the evaluation mechanism receives input about the type of response given, the state of arousal of the individual, and the state of activation. The effort mechanism employs this information in order to correct the effects of too high or too low a level of arousal, or too high or too low a level of activation. If the effort mechanism is either seriously overloaded over time or falls altogether short in accomplishing the necessary energetical adjustments, stress will arise. The significance of the Sanders' theory is that it gave us a better understanding of for example the effects of suboptimal conditions on performance. How can the individual compensate for less optimal task conditions, and what happens when the compensation mechanisms fail?
The Three-Stage Memory Model of Atkinson and Shiffrin

The above mentioned theories implicitly assume the existence of a memory system, in which incoming information can be stored for future use. In 1968 Atkinson and Shiffrin postulated their three stages memory model. The three stages are respectively a sensory register, a short term store, and a long term store (figure 4). "Incoming information first enters the sensory register, where it resides for a very brief period of time, than decays and is lost. The short-term store is the subject's working memory; it receives selected inputs from the sensory register and also from long-term store. Information in the short-term store decays completely and is lost within a period of about 30 seconds, but a control process called rehearsal can maintain a limited amount of information in this store as long as the subject desires. The long-term store is a fairly permanent repository for information, information which is transferred from the short-term store." (Atkinson & Shiffrin, 1968, pp. 90-91). Although this three stage memory system has been adapted several times after the first presentation, it can still be seen as the basis for theorizing about the human memory system.
Figure 4. The structure of the memory system, according to Atkinson and Shiffrin (1968)

Shiffrin and Schneider: Controlled and Automatic Human Information Processing

After reading these short overviews, the innocent reader may have the idea that the human information processor is some kind of robot that will automatically produce a response after information input. What do we need attention for, if everything works automatically? The following theory partly gives an answer to this question. Shiffrin and Schneider (Schneider & Shiffrin, 1977; Shiffrin & Schneider, 1977), formulated a theory of information processing based on two fundamental processing modes: controlled and automatic. "In the context of search studies, these modes took the form of controlled search
and automatic detection. Controlled search is highly demanding of attentional capacity, is usually serial in nature with a limited comparison rate, is easily established, altered, and even reversed by the subject, and is strongly dependent on load. Automatic detection is relatively well learned in long-term memory, is demanding of attention only when a target is presented, is parallel in nature, is difficult to alter, to ignore, or suppress once learned, and is virtually unaffected by load." (Shiffrin & Schneider, 1977, p. 127). According to these authors, attention plays a very important role in responses that are not over-learned. Repeatedly giving the same response to a specific stimulus will eventually result in an automatic process, which is no longer under control of attention.

Summary
In this section we tried to give a (very short) overview of some of the most important theories that form the basis of most modern theories on attention and information processing. The theories, however, also share one main disadvantage: they mainly address adult information processing. The question arises in how far these theories are applicable to the development of attentional processes. Cooley and Morris (1990) have warned against the inappropriate use of adult-based paradigms in the study of attention in children. These authors concluded that "The theoretical constructs of attention are numerous and increasingly complex. Unfortunately, the operationalization and assessment of such theoretical constructs have not been approached in a systematic manner. This has been especially true in the study of attention in children where adult-based paradigms have frequently been inappropriately used. For those interested in the study of the relationships between developing brain systems to the development of the multidimensional components of attention, the lack of a useful and systematic assessment model has limited progress." (p. 267). Weissberg, Ruff, and Lawson (1990), who used reaction time tasks in their study of attention and organization of behavior in young children, stated that: "The developmental aspect of sustained attention and behavioral organization within the context of reaction time tasks continues to challenge researchers of preschool children because of difficulties in making the well-known paradigms appropriate for that age group" (p. 59). In fact, these researchers were among the first to seriously attempt an application of knowledge from the information processing theories to study attentional processes in preschool children. Recently, Kail (1991) presented an overview of studies concerning the development in speed of processing. Of the more than 50 studies cited, only four included children younger than 5 years, and only one included children of three years (3.58 yr, Townsend & Ravelo, 1980)!
In the next section we will discuss the developmental aspects of attentional processes, especially from the information processing paradigm's point of view. The reason for this choice is that we are interested in the information processing of young children, and how these processes develop. Until now, we have only discussed the basic theories, which are of a more common nature. But are there also models concerned with information processing in children, in preschool children, and in the developmental aspects of the processing of information?

2.3 The Development of Attention

2.3.1 Possible Explanations for Developmental Differences in the Speed of Processing

It is commonly accepted that, compared with adults or older children, young children are very slow processors of information (Chi, 1977; Chi & Gallagher, 1982). It is suggested that the attentional capacity of young children is more limited than that of older children and adults. During development there are changes in internal processing mechanisms which increase this capacity. Kail (1991) presented some plausible explanations to account for the difference in speed of processing during development: positive transfer between speeded processes (skills used for particular tasks are said to generalize to other domains); the quantity of processing resources available for the executed speeded processes (increased processing speed across tasks reflects an age-related increase in the processing resources that can be allocated to the task); and a computer hardware analogy (if two computers have the same software but a different cycle time, the one with the slower cycle time will execute all processes more slowly, dependent on the total number of instructions to be executed); a developmental decrease in the human cognitive cycle time would be associated with decreased time to complete cognitive operations. According to Lane and Pearson (1982), younger children process too much irrelevant information, and as a result, use up some of their attentional capacity. Furthermore, their ability to allocate attention may be less flexible. In the reaction time studies used in the information processing studies the differences in speed of processing occur in the form of a difference in intercept: children show slower reaction times than adults in different tasks. If we try to locate the developmental differences of processing speed in terms of the Sanders (1983) model for example, we must find a difference in the slope of the reaction times: if a task becomes more complex, the decrease of reaction times of (young) children as compared with adolescents or adults is signifi-
canty greater. Most studies concerning structural information processing stages seem to locate these differences in the output-related processes (Luria, 1959; Wickens, 1974; Levy, 1980; Sergeant, 1981; Chi & Gallagher, 1982; Van der Meere, 1988; Bjorklund & Harnishfeger, 1990). Therefore, we will focus here on the output-related processes.

What are output-related processes? Sternberg (1969a, 1969b) speaks of the processes 'binary decision' and 'response organization', Sanders (1983) distinguishes the processes 'response choice' and 'motor preparation'. Output related processes concern the choice of type of responses to be given, and, after this choice is made, the preparation of the motor system to give the chosen response. These output-related processes can be compared with what Logan (1985) calls the 'Executive Functions'. According to this author, executive control is required for the choice, construction, execution, and maintenance of optimal strategies for performing a task, as well as for the inhibition of strategies that become inappropriate with changes in goals or in task demands, or with the occurrence of errors.

In the next paragraph, we will discuss the method of studying the output related processes of young children in more detail. The reader must keep in mind that most theories presented here are extrapolations from well-known 'adult-based' information processing theories and that most of the presented theories concern children older than six years.

2.3.2 Output Related Processes: Age Differences
Luria (1959) did some intensive observations of motor responses in very young children. He claimed that a child as old as two years experiences lots of difficulties in executing the command: 'When a red light appears, you have to press the balloon'. The child acts to each fragment of the command separately: "(...) on hearing the first part of the instruction it begins to look for the light, while to the second part of the instruction it reacts by affecting an immediate pressure, without waiting for the appearance of the conditioned signal" (p. 6). Inhibition of a once learned response is out of the question, as the author noticed: "If we attempt to reinforce the inhibitory part of the verbal instruction by stressing additionally that the child must be attentive and should not press the balloon before the light appears, the required effect will not be achieved; on the contrary, this will evoke even more intense and irritated pressing" (p. 6). Only at the age of about 3 years is the higher nervous system of the child capable of responding adequately to the verbal instruction "When a red light appears, you have to press the balloon", but the child still
experiences problems when the task is more complicated, like pressing the balloon in appearance of a red light and withholding a response in appearance of a green light. "Only at the age of 5-5.5 years does this diffuseness of the nervous processes disappear, and the verbal system begins firmly to regulate the motor reactions of the child. But even at this age a comparatively slight complication of the experimental conditions, for example, a transition to complex forms of interchange of positive and inhibitory reactions, or to shorter signals in more rapid succession may result in the reappearance of symptoms of disequilibrium and diffuseness of the nervous processes." (p. 7).

Wickens (1974) proposed that young children are more easily distracted and initially less able to focus attention on the location of stimulus occurrence. They also have more difficulty maintaining a high level of preparedness, when compared with older children and adults. This is especially true when, for example, the waiting time (or preparation time) before the appearance of a stimulus is lengthened or made unpredictable. Chi and Gallagher (1982) tried to locate the differences in speed of processing between adults and children in terms of the Sternberg (1969a, 1969b) model. "In any subpopulation that does not perform at the level of adults, whether in reading, memorizing, or problem solving, there are two general sources of limitation. The first possible source is inadequate knowledge, including the inefficient use of strategic knowledge. The second source is more structural in nature, relating to either the capacity of working memory or the general speed with which individuals process information" (p. 23). This also counts for children when compared with adults. After reviewing the four processing stages (encoding, manipulation and decision, response selection, and response execution) the authors concluded that the major retardation in children's information processing lies in the response selection stage. Another consistent pattern that emerged in their studies was that complexities always seemed to hinder children's performance more than adults'. According to the authors, one reason for this finding could be the fact that a more complex task offers better opportunities to use different strategies and approaches. Apparently, the children mostly do not choose the most efficient strategy, probably due to the fact that they are hindered by task-irrelevant information. This inefficient use of task-irrelevant information also plays an important role in the theory of inefficient inhibition of Bjorklund and Harnishfeger (1990). Their theory is based upon a model developed by Hasher and Zacks (1989) which accounted for developmental differences in working memory among adults. Bjorklund and Harnishfeger (1990) extended this model to account for developmental differences in children's cognitive task performance. Hasher and Zacks (1989) proposed that, with aging, inhibitory processes become less efficient. According to
Bjorklund and Harnishfeger (1990) inhibitory processes become more efficient over childhood, resulting in less irrelevant information entering working memory with age, yielding increased processing efficiency and increased functional capacity of working memory. Thus with development, changes in children's neurological system leads to increased efficiency of inhibitory processing, contributing to increases in selective attention and ability to keep task-irrelevant information out of working memory. Support for this theory was provided by Levy (1980), who employed an adaption of a 'Draw-a-Line test' and demonstrated a clear age development in motor inhibition in children between 4 and 6 years of age.

Summary
The theories presented here suggest that the differences in the speed of processing between children and adults, or between young and older children, are located mainly in the output-related processes. Wickens (1974) focuses more on the preparation of a response, Luria (1959) suggests the problems occur both with the preparation of a response and with the selection of the right response, Chi and Gallagher (1982) clearly state that children's retardation in information processing lies in the response selection stage, which is also proposed by Bjorklund and Harnishfeger (1990), who suggest developmental differences in inhibition. The studies reported in this dissertation will focus on those processes. Within the reaction time paradigms, response preparation can be manipulated by time uncertainty, and response selection, especially response inhibition, with response uncertainty.

Critical Remarks
Although the methods of manipulating the response preparation and response inhibition seem to be strong candidates for gaining more insight into the developmental aspects of attentional processes in preschool children, some words of caution are needed. As we noted several times before, these methods are derived from a paradigm that focuses mainly on adult information processing. These methods make use of reaction time tasks, which will also be used in our study. Adults and older children can easily be 'forced into the curb' of a reaction time task, that is, they are willing to perform a dull and strenuous task like pushing a button as quickly as possible after the appearance of a specific character on a screen, and to repeat this action hundreds of times, without questioning the purpose of it all. The preschool child, on the other hand, may start very eagerly with the task, but after some repetitions may want to investigate alternative strategies, like pushing the button as late as possible, or pushing the left button with the right hand, and vice versa. Or
the child may decide to respond to every second stimulus. Of course reaction times will be generated from the experiment with this child, but how must these reaction times be interpreted? One may question whether differences found in reaction times on response preparation task or response inhibition are really a result of non-optimally functioning output-related process or some other mechanism, or maybe have a strategic cause. Especially in young children the distinction between energetic mechanisms, output-related processes and strategy may be vague. The attainment of motor preparation is typically a structural mechanism, whereas sustaining this preparation is affected by the energetic mechanism. But in young children, a strategic component may also influence the performance. The information processing paradigm holds specific task manipulations responsible for changes in specific processes or mechanisms. However, one may seriously question whether these task manipulations have the same effect on these processes in preschool children, or for example simply influence the task attitude of the children. A possible solution of this problem may lie in observing the behavior of the children during task performance. In chapter 3 we will discuss this option further.

As we mentioned before, the theories presented above have one major disadvantage: they are based on research with information processing in adults. Even among the authors who are concerned with information processing in children, only a few consider preschool children (for example Luria, 1959; Weissberg, Ruff, & Lawson, 1990; Harper & Ottinger, 1992). In the following paragraphs we will argue that important research methods, derived from ethology, can be used to study attentional processes in young children. As a prelude to the ethology-approach, we will briefly present some important issues from infancy research, in which the methods of direct and indirect observations are used to study information processing. The habituation paradigm can be seen as one of the most influential ones among infant theories; this paradigm is an especially important starting point for the study of attentional processes in preschool children, because it provides us with a strong theoretical basis for an ethological approach.

2.3.3 Infancy Research: A Basis for a Developmental Model of Attention?
Olson and Sherman (1983) provide a theoretically inspired overview and a guide for future research on infant attention, learning, and memory. In this overview they pay much attention to what they call one of the most extensively studied phenomena in infants behavior, the habituation phenomenon.
Habituation is a term that is used to describe the decrement in attention which infants manifest to an aspect of the environment that is unchanging. In fact, attention to stimuli decreases (or habituates) as the stimuli are presented repeatedly. The logic of the habituation method is simple. A stimulus is presented and some measure of orientation or attention to it (for example looking time) is monitored. A novel stimulus will draw the attention of the infant directly. If the stimulus is presented for a prolonged period or a number of times in succession, the attention of the infant will wane. This experiment also demonstrates the existence of a memory system in infants, because the child has to remember that it has seen the stimulus before, otherwise there would be no difference between attention to a new stimulus and attention to an 'old' stimulus (recognition memory). According to Bornstein (1990) the study of attentional processes in infants is extremely important, because: "Attention has long been considered to be a basic component of cognitive functioning, and attention has traditionally been viewed as a key feature of intelligence. Because of its central role in thinking, attention in infants is especially significant. Normally, only what is attended to can be learned and remembered and contribute to mental and social life. Attention therefore underlies the infant's growing awareness, experience, knowledge, and interpretation of the world." (pp. 3-4). What is the importance of the habituation paradigm? According to Bornstein (1990), infants and young children who habituate efficiently tend also to prefer complexity, to show advanced sensorimotor development, to explore their environment more rapidly, to play in relatively sophisticated ways, to solve problems quickly and to attain concepts efficiently, and to excel at oddity identification, picture matching, and block configuration in traditional tests of intelligence. But the most important conclusion is that information-processing measures of the habituation of attention in infancy have strong predictive validity for cognitive functioning in childhood.

What can we learn from the habituation paradigm? Basically, two things. Firstly, because the paradigm focuses on attention and memory in infants, who cannot be asked to perform a specific action after a certain occurrence, the researchers must make use of more indirect measures, which are mostly carried out by observing the behaviors of the infants. Infant research shows us that the observation of behavior can tell us a lot about underlying processes like attention and memory. Secondly, one basic assumption in the habituation paradigm is that a novel stimulus will automatically draw the attention of the child. It seems as if children have an 'inborn' curiosity for novel stimuli. In fact, it has traditionally been accepted that the young of most mammalian species manifest a high degree of curiosity.
2.3.4 Towards an Ethological Approach

Berlyne (1960), one of the first authors to study the novelty phenomenon in humans, stated that the human child reacts to novelty (and complexity) with exploratory behavior. According to Hutt (1970) "Exploratory behaviour is essentially stimulus selection behaviour, and as such is a characteristically pervasive behaviour of many young mammals. It thus has an immediate attraction for those interested in the activities of such organisms when they are not constrained, restricted, nor limited by the demands of experimental situation." (p. 138). The function of this exploration is to acquire information about the environment. Berlyne (1960) predicted that exploration should wane with continued exposure to a novel stimulus. The reason for this is that the child habituates to the stimulus. He distinguished two types of exploration: specific and diversive exploration. The first type of exploration is extrinsically motivated, that is, elicited by a novel stimulus, and is characterized by response stereotypy. Diversive exploration on the other hand, is intrinsically motivated, that is, occurs in absence of a specific environmental stimulation, and is characterized by response variability. Hutt (1970) tried to explain the behaviors of young children to novel objects. She used the terms investigation and play, investigation being interchangeable with specific exploration, and play being a part of the more broader term diversive exploration. "(...) it is apparent that specific exploratory responses are essential for the survival of the organism in that they most effectively obtain information for the animal from its particular habitat. (...) Diversive exploration, one form of which is play, is expendable and serves no specific function for the organism (...) the extent and variety of its diversive activities is a measure of its flexibility and adaptability. Diversive exploration in young children is most likely to take the form of play, both since they are physically more active than adults and since their lack of linguistic proficiency would limit their symbolic activities." (pp. 168-170). These findings are important for various reasons. Firstly, the approach by Hutt (1970) gives us a good starting point for the study of attentional processes in young children. How does a child explore a novel object? Are there developmental differences in exploratory behavior? Do children with attentional problems differ from normal children in the way they explore new objects? We will discuss these and more questions in another part of this chapter. A second important aspect is, as Bornstein (1990) already noted, that information-processing measures of the habituation of attention (and thus also of exploration and play) have strong predictive validity for cognitive functioning in later childhood. The third reason can be found in the statement of Hutt (1970) that the study of exploratory behavior has an immediate attrac-
tion for those interested in the activities of for example young children when they are not restricted by the demands of an experimental situation.

One method of studying the exploratory and play behaviors of children is by means of observation of free play behavior. In the next paragraph we will discuss this topic in more detail and we will provide arguments for the importance of this method for the study of attentional processes in young children.

2.3.5 The Study of Attentional Processes of Preschool Children during Free Play

Kalverboer (1988) stressed the importance of behavioral observations as an addition to the experimental method, based on the information processing paradigm, for the study of attentional processes in young children. He argued that "the information processing approach has a limitation that the child has to be highly restricted in his responding. The large gap between the natural and the experimental condition can partly be bridged by systematic observation in well-defined environments." (p. 39). Ruff and Lawson (1990) studied sustained and focused attention in children between 1 and 4.5 years of age during free play. They found developmental changes in the following aspects of the recorded behaviors: the proportion of focused attention during the free play increased as a function of age, as did the frequency of focused attention per 100 seconds and the mean duration of one episode of focused attention (focused attention was operationalized as the concentration of a child on an object (toy) or some activity with that object). According to the authors, these developmental differences in focused attention may be explained by the finding that the younger children may have been responding to the toys in a way that differs considerably from the responding of the older children. The explanation might be that the attention of the younger children was controlled by the physical properties of the objects, whereas the attention of the older children was governed more by the complexity of activities during play. All children will start to explore the objects (novelty elicits curiosity), and as the children grow accustomed to them, their attention will wane (habituation). But according to Ruff and Lawson, the younger children are not capable of counteracting the response decrement due to habituation by more cognitively sophisticated schemes and activities. Although the attention of the older children in their study also showed a temporal pattern typical of habituation, their attention during free play seemed to be concentrated on more open-ended activities, such as construction and play. These differences were most visible in the youngest age groups of their study. Ruff and Lawson concluded
that the increase of attention in the older age groups is accounted for by the development of increasingly complex play.

The observation of behavior during free play appears promising for the study of attentional processes in young children. But one has to be careful. As Weisler and McCall (1976) have noted, the huge amount of literature since the beginning of this century does not present a unanimous picture on exploration and play. Nevertheless, these authors present clear definitions of the two categories: exploratory behavior consists of a relatively stereotyped perceptual-motor examination of an object, situation, or event, the function of which is to reduce subjective uncertainty (that is, acquire information). Play, on the other hand, consists of behaviors and behavior sequences that are organism-dominated rather than stimulus-dominated, behaviors that appear to be intrinsically motivated and apparently performed for 'their own sake' and that are conducted with relative relaxation and positive affect. Kalverboer (1971, 1975, 1977) conducted several studies on play and exploration in young children. He distinguished no less than five levels of play, at least one of which can be interpreted as exploration (play activity level II E, see Kalverboer, 1975; 1977). Although this distinction into more subcategories may go beyond the scope of the underlying study, the studies of Kalverboer indicate that it may be too simple to consider play as just one broad behavioral category.

Another question that may arise is whether the child will exhibit behaviors other than the toy-oriented categories like exploration and play, which may give us some more information about the underlying attentional processes. Ruff, Lawson, Parrinello, and Weissberg (1990) identified several quantitative measures of inattention at 2 years of age, which were predictive of comparable measures at 3.5 years. They operationalized inattention as all off-task behavior, like physical movement away from the task, not looking at the toys, etcetera. One conclusion of the authors was that the domain of inattention is not the simple inverse of focused attention, and different measures of it may reflect meaningful subcategories.

Summary
The literature gives us strong indications that one of the best ways of studying attentional processes in young children is by means of observation of their behaviors during free play. One of the main advantages of this method is that the children can play in a semi-natural environment with no restrictions like the demands of an experimental situation. Measures of attention and
inattention, operationalized as exploration, different levels of play behavior, and different types of off-task behavior, may give us good indications of the developmental aspects of attentional processes in young children.

This paragraph concludes our section on the normal development of attention. We argued that the focus has to be on two different methods: one derived from the information processing approach, and the second of a more ethological nature. Because one of the aims of our study is to compare normal and deviant development of attentional processes, it seems obvious to use the same methods for the study of the deviant development of attention as proposed in the foregoing paragraphs. But the question arises whether these methods can also be used in children with a non-optimal developmental course. In the next part of the chapter we will try to address these questions.

2.4 The Non-optimal Development of Attention

2.4.1 Clinical Diagnosis of Attentional Problems
Thus far, we have concentrated on the normal course of attentional development. But what happens when attention develops in a less optimal way? Attentional problems are diagnostically referred to as Attention-Deficit Hyperactivity Disorder, or ADHD (American Psychiatric Association, 1987), which is commonly considered as one of the most complex disorders of childhood. According to Rutter (1984) the disorder can be characterized by two crucial features, namely developmentally inappropriate inattention (as shown by a failure to finish tasks, easy distractability, not seeming to listen, or having difficulty concentrating), and impulsivity (as shown, for example, by difficulties in organizing work, acting before thinking, or calling out in class). The onset is typically before age 3 years and invariably before 7. Rutter claimed that hyperactivity is a non-obligatory property in the diagnosis. He based this statement on the third edition of the Diagnostic and Statistical Manual of Mental Disorders, published by the American Psychiatric Association, where the disorder was divided in Attention-Deficit Disorder (ADD) and Attention-Deficit Disorder with Hyperactivity (ADD-H) (American Psychiatric Association, 1980). In the second edition of the Manual the disorder was originally referred to as Hyperkinetic Reaction of Childhood (American Psychiatric Association, 1968). After dropping the hyperactivity category in the DSM-III-R (American Psychiatric Association, 1987), the DSM-IV distinguishes three subtypes: 1) Attention-Deficit/Hyperactivity Disorder, Combined Type; 2) Attention Deficit/Hyperactivity Disorder, Predominantly Inattentive Type;
3) Attention-Deficit/Hyperactivity Disorder, Predominantly Hyperactive-Impulsive Type (American Psychiatric Association, 1994). This discrepancy found in different editions of the same manual is a typical example of the problematic definition and description of the phenomenon. Furthermore, the terms ADHD and Minimal Brain Dysfunction (MBD) are often confused. In the majority of publications the term MBD is reserved for identifying "children in the normal range of intelligence who show patterns of behaviour and learning disorders that are assumed to be related to 'minimal' dysfunction of the nervous system" (Touwen & Kalverboer, 1973, p. 79). Furthermore, clumsiness is one of the possible characteristics of MBD, but not of ADHD. In the International Classification of Diseases (World Health Organization, 1978, 1992) the disorder is labelled 'hyperkinetic disorder'. The discussion about which label to use best goes beyond the scope of this chapter, and we will return to this topic in another chapter. Because the DSM system has gained world-wide acceptance, from now on we shall use the label as proposed in DSM-III-R and DSM-IV, 'Attention Deficit Hyperactivity Disorder' (ADHD).

2.4.2 Hypotheses on the Causes of Attentional Problems

Given these definitional problems, it is not surprising that many competitive hypotheses exist concerning the cause(s) of the disorder. It is hard to find a common factor. According to Goldstein and Goldstein (1990), ADHD may result from heredity or from a variety of prenatal or postnatal environmental factors. Kalverboer (1994) presents a scheme (which is a modification of the Rose (1976) scheme) in which various levels of explanation for the etiology of the disorder are given: a neuroanatomical; a biochemical; a neurological/neurophysiological, a psychological, and a sociological explanation.

From the foregoing discussion it may have become clear that ADHD is a very complex disorder, with no simple or common cause. The question arises whether treatment of the disorder is possible. According to Goldstein and Goldstein (1990) ADHD is a disorder that can eventually be managed, but not cured. They present a multidisciplinary/multitreatment model in which medical treatment, parent training, behavioral management at home and school go hand in hand. It is commonly assumed that the disorder can be 'managed' in the most optimal way if treatment begins at a very early age. The question arises, whether it is possible to detect the problems at an early age and whether it is possible to predict which young children will later have attention deficits that will interfere with school performance. A number of studies conducted by Campbell and her colleagues (Campbell, Endman, & Bernfeld,
1977; Campbell, Breaux, Ewing, & Szumowski, 1984; Campbell, Ewing, Breaux, & Szumowski, 1986) concerning young children referred by parents for hyperactivity, show that some measures taken between 3 and 3.5 years are predictive of classroom behavior at 6 and 7 years. However, only a few studies have tried to find early precursors, other than clinical or parental impressions, of later attention deficits (Ruff, Lawson, Parrinello, & Weisberg, 1990) and to develop objective measures for early diagnosis of ADHD. The fact that most research in this area has focused on children older than six or even seven years of age may be caused by the extremely complex identification of ADHD preschool children. Why is this identification so complex? The problematic behavioral pattern of the ADHD child is frequently considered a normal behavioral pattern in preschool children. "Preschoolers, who are learning about the world and how to master its complexities, are expected to exhibit boundless energy, to attend readily to the new and novel, and to demonstrate unrestrained enthusiasm and exuberance. When, therefore, does a shift in activity and interest signify curiosity and exploration and when does it reflect a too rapid change in focus and inadequate investment of attention?" (Campbell, 1985, p. 407).

Taken together, we do not have a clear picture of the preschool ADHD child and furthermore, it seems very difficult to diagnose the disorder objectively at that age. It is therefore very important to obtain a good overview of the problem at this early age, and, if possible, to develop an objective instrument with which we can make a contribution to the diagnosis of preschool ADHD children.
2.4.3 A Developmental Delay or a Structural Problem?
If we take a look at the behavioral repertoire of ADHD children, we may question whether the problems merely reflect a developmental delay or whether ADHD is a more structural problem with a unique developmental course. After reviewing most important recent research, Pearson and Lane (1990) did not dare to draw a hard conclusion to the question "Is there evidence for developmentally immature attention in ADHD children?". Although they found some evidence for developmental immaturity in attention skills in hyperactive children, they concluded that more research with a strong developmental component has to be done before we will be able to determine which facets of attention are indeed developmentally immature in ADHD children. Douglas (1980) hypothesized that most of the behavior and cognitive abnormalities of ADHD children result from a constitutional predisposition, possibly of a neurological or neurochemical nature. The constitutional predisposition is exhibited via the malfunctioning of three closely related mechanisms which govern 1) sustained attention and effort, 2) inhibitory control, and 3) the modulation of arousal levels to meet task or situational demands. These three defective mechanisms then lead to impairment or limitations in the development of higher-order schemas, meta processes (including search strategies), and effectance motivation, which will result in experiencing a higher-than-normal incidence of failure. The result of this is that the ADHD child shows more and more avoidance behaviors, which lead to even greater decreases in concentration, as well as increases in impulsive responding and unregulated fluctuations of arousal levels (Douglas, 1980). One can easily imagine that according to this script the child will end up in a vicious cycle, with impaired ability and motivation to undertake effective problem solving, more experience of failure, and so on (see also figure 5).

Summary
We can state that although ADHD is a commonly observed problem in young children, the early diagnosis of this disorder is still problematic. Because we assume that the disorder is not merely a developmental delay in specific attentional functions, we must try to identify which attentional processes are disturbed in ADHD children and in which direction the problems will develop. In the next section we will present an overview of studies explaining the course and causes of the disorder. As we did in the section on the normal development of attentional processes, we will start our search from an information processing perspective, and will proceed with an overview of research from an ethological perspective: the observation of attentional processes during free play.
Hyperactivity

A constitutional predisposition toward

- impaired ability to sustain attention and effort
- poor inhibitory control
- poorly modulated arousal tendency to seek stimulation and salience
- limited development of higher order schemata
- impaired effectance motivation
- impaired meta-processes
- limited development of higher order schemata

Failure experiences
- avoidance behaviors
- increasing

Concentration problems
- impulsivity
- fluctuations in arousal level and stimulus-seeking behaviors

Further impairment of ability and motivation to undertake effective problem solving
- increased likelihood of failure experiences
- cycle continues

Figure 5. A schematic representation of the development and the sequelae of attentional problems in ADHD children, according to Douglas (1980)
2.4.4 The Study of ADHD from an Information Processing Point of View

Numerous studies based on the information processing perspective have been carried out on the concept of attentional deficit and hyperactivity. As mentioned before, most studies concentrate on the ‘older’ children, from 7 years onward, although it can easily be seen that solving the problem will require more insight in the problem at a much earlier age.

Sergeant (1981) investigated if ADHD children had a disorder in their selective attention. According to Shiffrin and Schneider (1977) selective attention can be defined as the ability to encode, search and decide in working memory. These processes take place in the first three stages of the Sternberg (1969a,b) model: encoding, search, and binary decision. After investigating these three information processing stages in different groups of children (control children, moderately hyperactive children, and hyperactive children), Sergeant concluded that he could not find a disorder in the selective attention in ADHD children. A popular belief is that ADHD children have problems with the ability to remain vigilant over long periods of time: in DSM-III-R this is described as: "has difficulty sustaining attention in tasks or play activities" (American Psychiatric Association, 1987). This idea is also supported by Douglas (1983) and Douglas and Peters (1979). In scientific research, however, there is much disagreement about this subject. Schachar, Logan, Wachs- muth, and Chajzyk (1988) concluded after an intensive study on this phenomenon that the performance of hyperactive children on a sustained attention task was not more adversely affected with increasing time than the performance of control children. This finding was supported by Van der Meere, Weckking, and Sergeant (1991). But Seidel and Joschko (1990) did find evidence of difficulties in sustained attention in children with ADHD. In a search for differences between control children and ADHD children Van der Meere (1988) investigated every information processing stage of the Sternberg (1969a,b) model. He could not find any structural differences between the two groups, except for the finding that ADHD children are slower responders than the control children in every stage of information processing. He concluded that differences should be located in either the energetic dimension of the Sanders (1983) model, or the output related processes. Schachar and Logan (1990a) also suggested that the deficits of ADHD children lie in response-related processes. They found evidence for this claim in the finding that ADHD is associated with deficient inhibitory control (Schachar & Logan, 1990b). In another study Tannock, Schachar, Carr, Chajczyk, and Logan (1989) showed that methylphenidate (MPH) improved the efficiency of the
central inhibitory mechanism in ADHD children. Because it is believed that psychostimulants, such as MPH, activate the so-called 'executive functions', this finding provides strong support for the hypothesis that ADHD children are deficient in their output-related processes. Van der Meere, Stemerdink, and Gunning (1995) found that ADHD children without tics had poor inhibitory control. They concluded that the common factor underlying the inappropriate responding of ADHD children is a state regulation problem and can thus be situated in the energetic system. Van der Meere, Vreeling, and Sergeant (1992) showed that the readiness to respond is delayed in ADHD children, especially when interstimulus intervals are long or unpredictable. They concluded that ADHD children have difficulty with motor presetting.

Summary
The studies presented in this paragraph indicate that the attentional problems of (older) ADHD children should be located either in the last stages of the information processing model, or in the energetic mechanisms of the Sanders (1983) model. Logan (1985) speaks of the 'executive functions', which are required for the choice, construction, execution, and maintenance of optimal strategies for performing a task, as well as for the inhibition of strategies that become inappropriate with changes in goals or in task demands, or with the occurrence of errors. In our study on deficient attentional processes in young ADHD children, we will focus on the output-related processes, which can be manipulated by for example time uncertainty and response uncertainty. But in an earlier part of this chapter we questioned whether the findings from studies with older children can be extrapolated to preschool children with impunity. This question is even more pressing in the study of preschool ADHD children, because the reaction time tasks derived from the information processing paradigms can be too demanding for these young ADHD children. It is known that ADHD children 'have difficulty remaining seated when required to do so, are easily distracted by extraneous stimuli' (American Psychiatric Association, 1987), and so on. Intuitively, this may be even more true for young ADHD children. Therefore, we searched for a method where the children were not forced to perform a demanding task and to remain seated behind a computer screen for a prolonged period of time. In an earlier paragraph we showed that the ethological approach offers us opportunities to investigate accurately the processes we are interested in, without the pressure of an experimenter or a demanding task. In the next paragraph we will present an overview of the literature concerning the observation of the behaviors of ADHD children.
2.4.5 Attentional Processes of Preschool ADHD Children during Free Play

As mentioned in an earlier section of this chapter, the observation of free play behavior seems to be a challenging method for the study of attentional processes in preschool children. Several authors have used this method to study the normal and deviant development of attentional processes in young children.

According to Krakow and Kopp (1983), who studied the effects of developmental delay on sustained attention in young children, the use of the method of observation of behavior during free play was dictated by the fact that play with toys constitutes a central facet of experience during the early years of life. Many authors share this opinion, like Berlyne (1960), Piaget (1962, 1966), Vygotsky (1967), Hutt (1970) and Bruner (1973). A further motive of Krakow and Kopp for their choice was that patterns of attention deployment during play should reflect qualitative disruptions in processing information. The authors found no differences between groups of children with Down Syndrome (DS), children with a developmental delay, and control children of about three years old, concerning 'developmentally appropriate manipulative and functional play'. The duration of sustained attention (engagement in play) of DS children did not differ from that of control children, but the children with a developmental delay spent significantly less time engaged in play with toys than did the DS children. The same was found concerning the exploration (or examination) of the toys: children with a developmental delay spent less time looking at or examining the toys than the other groups. An interesting aspect of this study is that the authors paid attention not only to the on-task behavior (attention towards the toys), but also to the off-task behavior. Off-task behavior was divided in the following categories: occupied with non-toy objects; socially occupied; unoccupied, and an unclassified rest-category. Whereas the control children spent their off-task time in either non-toy manipulation or social interaction, the DS children divided their off-task behavior roughly between non-toy manipulation and being unoccupied, and the children with a developmental delay spent more than 90 percent of their off-task time being unoccupied.

In the neurologic and behavioral assessment of children with Minimal Brain Dysfunction (MBD) Touwen and Kalverboer (1973) emphasized the importance of what they called the method of 'free-field' observation. In their article they pointed out how insight into the MBD child's behavior can be gained by means of this method. Behavioral aspects of importance in distinguishing
preschool MBD children from their control peers may be the visual exploration/inspection of objects, object manipulations, shifts of attention, and level of play behavior. A typical behavioral pattern of the MBD child in such a situation is as follows: the child enters the unfamiliar observation room and starts to manipulate the toys without first visually exploring them. Many different objects will be manipulated and play with one toy will suddenly be stopped in favor of another toy. Furthermore, the attention of the MBD children will often shift from one location to another, and the level of their play behavior will be lower than that of control children.

Kalverboer (1988) stressed the importance of systematic observations of free-play behavior for a better understanding of the attentional problems of ADHD children. According to this author, the consistency of behavioral patterns in various free-field situations is very low in young ADHD children. The method of observation of behavior during free play was also used by Campbell and her colleagues in a number of studies (Campbell, Szumowski, Ewing, Gluck, & Breaux, 1982; Campbell, Breaux, Ewing, & Szumowski, 1984; Campbell, Ewing, Breaux, & Szumowski, 1986) with ADHD preschoolers and older ADHD children. Campbell et al. (1982) concluded that children who were identified by their parents as problem children (more active, inattentive, difficult to discipline, and aggressive with peers than control children) shifted activities more during free play. Furthermore, these children showed more short-duration activities (less than 20 seconds) and fewer long-duration activities (longer than 120 seconds) than control children. During structured tasks, these children were more active and inattentive. In a one-year follow-up study Campbell et al. (1984) showed that at 5.5 years, children who were identified by their parents as problem toddlers one year earlier, persisted in the active behavioral repertoire during free play. They concluded that symptoms of attention deficit disorder can be identified in young children, but they must be differentiated from difficult, but typical toddler behaviors which are more evanescent in nature. In a follow-up study at age six, Campbell et al. (1986) found that one third of the children in the problem group still met DSM-III criteria for Attention Deficit Disorder. The studies of Campbell and her colleagues are important for different reasons. Firstly, they show that the observation of free play behavior is an excellent method for identifying problem behaviors of ADHD preschoolers. Secondly, the studies show that early measures of ADHD have predictive value, if they are properly applied.

Alessandri (1992) studied attention, play, and social behavior in ADHD preschoolers. He found differences between ADHD children and control
children in play as well as in nonplay behaviors: ADHD children engaged in less overall play, more functional (repetitive or sensorimotor) play, less constructive play (learning to use materials, creating something), and less dramatic (role taking and pretend) play than control children. The ADHD children exhibited more nonplay behavior than control children, especially concerning transitional behavior (moving from one activity to another). One of the conclusions of the author was that ADHD preschoolers can be differentiated from controls on observational measures of attention and on their level of cognitive play.

Summary
From the foregoing it may be clear that the observation of behaviors during free play is an excellent method for the study of attentional processes in young ADHD children, and furthermore, this method is well-studied by different authors. The studies give us strong indications that ADHD children differ from control children on different aspects of their play and nonplay behaviors. The main conclusions that can be extracted from the cited studies are that ADHD preschoolers show less exploration and investigation, less overall play behavior, more 'low-level' play, less 'high-level' play, more shifts of attention, less long-duration activities and more short-duration activities, and more nonplay behavior. In the present study we will try to investigate these behavioral patterns of ADHD preschoolers. Because these behaviors will also be investigated in the developmental part of our study, we hope to discover whether the problems of ADHD children are merely a developmental delay, or of a more structural nature with their own, unique, developmental course.

2.5 Information Processing Theories and the Observation Approach. Where do They Meet?

In our search for early indicators of attentional problems, we decided to build our research around two different theoretical points of view, namely a method derived from the information processing paradigm on the one hand and an ethological approach on the other hand. The advantage of the first method is that it is a well-studied paradigm, with clear concepts and easy-to-manipulate processes. The main disadvantage of this method is that the testing situation is highly structured and demanding. Furthermore, or maybe as a consequence of this, the paradigm mainly addresses adult information processing (or children from 7 years and older), and little research has been undertaken in
preschool children. The advantage of the ethological approach is that it addresses the shortcomings of the information processing approach in which the child is forced to perform a dull and highly demanding task in a laboratory-type environment: the observation of free play behavior can be undertaken in a semi-natural (observation room) situation, with no task demands or the presence of a strange experimenter. The disadvantage of this method is mainly that, because the free-play situation is unstructured, different types of behaviors are numerous and hard to define. Therefore, it will be very difficult to get a clear picture of the processes we are interested in. But it may be clear that both methods may complement one another to provide a better understanding of the normal and deviant development of attentional processes. This is exactly what Kalverboer (1988) has noted: "The approach of systematic observation may complement the experimental approach, based on the information processing paradigm. The information processing approach has a limitation that the child has to be highly restricted in his responding. The large gap between the natural and the experimental condition can partly be bridged by systematic observation in well-defined environments. (...) The least one can do, given the present state of knowledge, is to select groups for experimental study on the basis of precise and detailed observations and ratings with the application of reliable and well-validated instruments and to try to get converging information from various sources (school, home, standardized laboratory conditions)." (p. 39).

A question that will be addressed in this dissertation is how to relate the findings of the two approaches adequately to one another. The rationale behind this is the question whether (aspects of) the attentional process which both methods claim to measure, are aspects of the same process, whether they overlap, or form distinctive parts of the process. In how far can the results of both methods be compared? A great part of chapter 5 will be devoted to this topic.

2.6 Research Questions

The main aim of the present study was to obtain insight into the normal and deviant development of attentional processes in preschool children, with a particular focus on the occurrence of precursors of later attentional problems. Because the field is quite unexplored, we tried to find an answer to this question via two different theoretical starting points: the information processing paradigms and the ethological approach. Because we were interested in both
the normal as well as the deviant development, this resulted in four research questions:

- Are there specific (developmental) differences between children aged 4, 5 and 6 years, concerning the output-related processes as described in the information processing theories? Output-related processes are operationalized as response preparation and response inhibition; we expected that these functions will become more efficient during development.

- Can we find differences between output related processes in preschool ADHD children on the one hand and in their control peers on the other? It was expected that ADHD children would have specific problems with response preparation and response inhibition.

- Does task orientation during the free play behavior of children between 2 and 6 years develop in a specific way? It was expected that task orientation would develop from functional play towards more 'higher-level play'.

- How do ADHD preschoolers behave in a free play situation when compared with control children of the same age? We expected that the attentional processes of ADHD children, as reflected in their task orientation, would differ from those of control children in many different ways, including more shifts of attention, less task orientation, more off-task behavior, etcetera.

The first two research questions will be discussed in chapter 3, where the questions will be specified more fully and also specific hypotheses will be formulated. In chapter 4 we will try to find an answer to the third and fourth research questions.

References


