THE DEVELOPMENT OF VISUAL EXPECTATIONS IN NINE- TO TWELVE-MONTH-OLD INFANTS

by

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Under the direction of Janet E. Frick, Ph.D.

ABSTRACT

The Visual Expectation Paradigm (VExP) is used to measure future-oriented anticipatory processing and visual reaction time (RT) in young infants. Fifty-two infants (age 9, 10, 11, and 12 months) were presented with an alternating sequence of visual images and eye movements to the stimuli were videotaped and analyzed frame-by-frame. Anticipations were indicated when infants moved their eyes toward the location of a target prior to its appearance or within 167 ms of its appearance. Previous research has suggested that infants become less skilled at making anticipations from 9 to 12 months, whereas RT remains stable across these ages. The current results indicate that whereas RT remained stable from 9 to 12 months, the percentage of trials on which infants showed anticipations increased across these ages. Results are relevant to understanding the development of attention in 6- to 12-month-olds, which has been under-examined relative to the first six months of life.

INDEX WORDS: Visual Expectation Paradigm, Infant development, Development of attention, Anticipation formation, Visual expectations, Saccadic eye movements, 9 month olds, 12 month olds

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DEDICATION

This thesis is dedicated to my parents, George and Patty Sullivan, for their love, unending support, and encouragement to develop my full potential throughout my life. Words cannot express my gratitude. Thank you so much Mom and Dad! I love you!

"Anticipate the good, so that you may enjoy it."

\- Ethiopian Proverb

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CHAPTER 1

INTRODUCTION AND LITERATURE REVIEW

Development of the Visual Expectation Paradigm

Much of an infant's time is spent visually exploring a constantly changing environment. Through such exploration, the infant learns general rules about the environment such as cause-effect relationships. For example, an infant learns early on to expect the appearance of his mother after he begins to cry and he learns that pointing to a bottle will elicit a response of handing over the bottle from the nearest caregiver. Behaviors such as these represent future-oriented processing or expectation formation. Expectations might be developed in order to help babies deal with the continuous flow of dynamic visual information they receive (Haith, Hazan, & Goodman, 1988); therefore, infants would be at an advantage if they showed expectations early in life. By bringing visual behavior under self control and forming expectations they are less controlled by their environment and they may choose to what stimuli in their environment they will attend.

A large body of literature is available on the violation of expectancy during infancy. For example, many studies have been conducted on infants' reactions to violations of social expectancy. Within this domain, the still-face procedure examines infants' ability to form social expectations in dyadic interactions (Lamb, Morrison, & Malkin, 1987). Results from studies with the still-face procedure have found that infants do detect a violation of social expectancy and exhibit the detection by becoming distraught or looking away when their dyadic partner discontinues interaction by adopting a "still-face." In addition to the still-face procedure, operant conditioning and expectancy formation has been studied in depth. In these studies, infants are conditioned to an event such as the movement of a mobile after a leg kick. When the contingency is removed, infants demonstrate less interest in the mobile and more anger (Shapiro, Fagen, Prigot, Carroll & Shalan, 1998), presumably due to a violation of the infants' expectation for the movement of the mobile. Whereas a large degree of research is available on the violation of expectancies in infancy, there is a relatively small amount of research studying the formation of expectations.

Based on the clear absence in the literature of procedures designed to measure expectation formation, Haith et al. (1988) developed a paradigm to measure future-oriented processing. Until the time Haith and colleagues introduced the visual expectation paradigm, most of the procedures used to study infant visual attention, such as the familiarization and novelty preference procedures, were limited to accessing cognitive processing of past and present events. Indeed, in the familiarization/novelty preference procedure, infants are continually presented with a stimulus until they become habituated, or "bored" with it and no longer attend to the stimulus. During the test phase, infants are presented with the habituated, or familiarized stimulus and a novel stimulus. The percent of time spent gazing at both the familiarized and novel stimulus is then measured. A procedure such as familiarization/novelty preference measures infants' memory for a previous event (the familiarized stimulus) (Fagan, 1970). Similarly, in habituation studies, infants exhibit a decrease in responsiveness to a stimulus after repeated exposure or when the stimulus becomes familiar (Smothergill & Kraut, 1989).

Interestingly, in subsequent literature, Haith, Wentworth, and Canfield (1993) addressed the habituation method from a novel perspective. They proposed that habituation procedures can be interpreted as measuring infants' expectations. This is the case because over several presentations of a stimulus, an infant presumably develops a mental model of the stimulus (Sokolov, 1963). Upon repeated exposure to the stimulus, infants compare the current stimulus to the mental model they created. Thus, an expectation for what will be presented next is formed based on the mental model. When a novel stimulus is presented, it is hypothesized that a violation of expectation occurs. Infants demonstrate cognitive processing of the differing stimuli and attempt to reconcile the violation by looking longer to the novel stimulus. However, it is suggested by Haith et al. (1993) that it is still unclear if infants expect the familiarized stimulus to appear, or if they are merely showing recognition of the familiarized stimulus. Because an uncertainty in exactly what behavior the infant is exhibiting (expectation or recognition) exists, it was necessary to develop a paradigm specifically designed to assess expectation formation and potential rule learning. As a result, Haith and colleagues argue that in addition to studies conducted on infants' memory for a previous event, research should also be conducted on infants' abilities to predict future events. They argue that because a great deal of adult cognition relies on the ability to form expectations about one's environment and anticipate what is to occur, the development of expectations should be tested in infancy. By designing the visual expectation paradigm (VExP), Haith et al.

(1988) hoped to tap into an infant's ability to form expectations for future events and measure the expectation formation through anticipatory saccades made to a forthcoming stimulus.

<u>The Visual Expectation Paradigm</u>

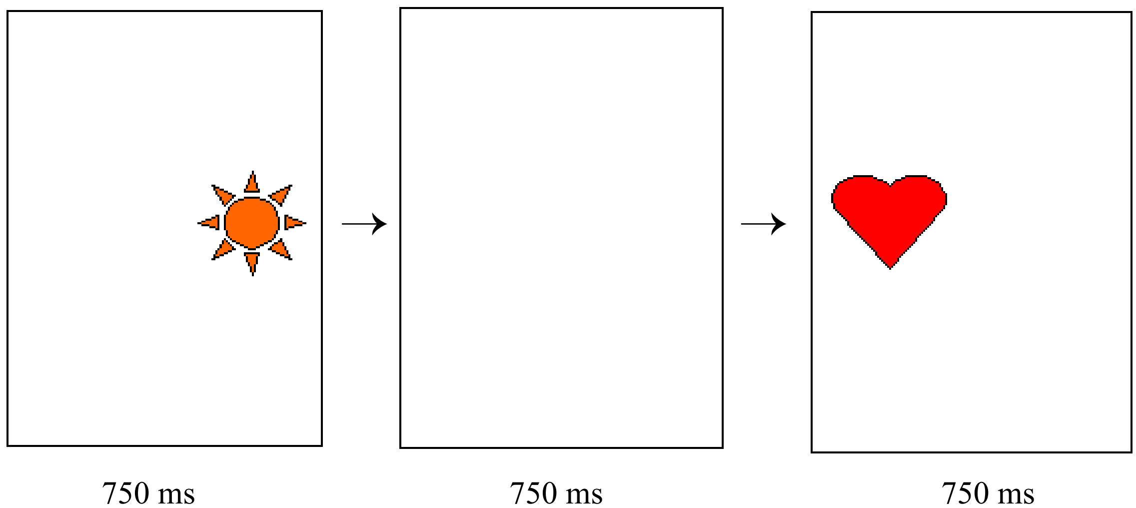
The VExP is a procedure that can be used on infants as young as 2 months (Canfield & Haith, 1991; Canfield, Smith, Brezsnyak, & Snow, 1997; Wentworth & Haith, 1992) and as old as 12 months (Canfield et al., 1997; Reznick, Chawarska, & Betts, 2000; Rose, Feldman, Jankowski, & Caro, 2002). The procedure varies somewhat from lab to lab; however, all studies implementing the VExP have several similar components. In the VExP, infants are presented with stimuli appearing on a computer monitor to the left and right of visual center. Typically, a "baseline" visual reaction time (RT) is measured prior to presentation of a "series" of stimuli in a predictable pattern. Baseline RT is measured by presenting to the infant a series of unpredictably patterned stimuli. A baseline is measured in order to determine if infants make quicker RTs when a predictable pattern is presented as compared to the unpredictable pattern. A simple (left-right) or complex (left-left-right) predictable series pattern is then presented and the infant's RT is measured by the length of time it takes the infant to shift her gaze from the location of the previous stimulus to the location of the subsequent stimulus.

In addition, researchers also use RT measures in the VExP to determine if expectations are being formed. Presumably, the infant begins to form expectations for what will occur in a series of sequential events that possess a regular pattern. The expectations are illustrated through anticipatory saccades in the direction the stimulus is to appear. An anticipatory saccade is defined as a change in the direction of gaze toward a stimulus prior to it appearing, or so immediately after it appears that it is impossible that the stimulus would have elicited the saccade (Haith et al., 1988). Originally, an anticipation was estimated to be any eye movement in the direction of the stimulus before it appeared or within 200 ms after its presentation, an amount of time considered too immediate to have been elicited by the presentation of the stimulus (Haith et al., 1988). The determination of anticipation latency, including whether it should be less than the originally suggested 200 ms, will be revisited below. The measurement of anticipatory saccades provides the percentage of anticipation (%ANT) displayed by the infant. Percentage of anticipation is calculated by dividing the number of anticipatory saccades by the total number of trials to which the infant attended and then multiplying by 100. Figure 1 gives an example of the stimulus sequence implemented in the VExP.

Interpretation of VExP Measures

Individual differences in various measures of infant cognitive processing have been shown to predict childhood IQ (see Colombo, 1993). Which measures and to what extent they predict has been an issue of debate in the past several decades. Fagan (1984) and Bornstein and Sigman (1986) have proposed that measures of speed of information processing serve as reliable predictors of later IQ. They argue that infants who have shorter fixation durations, habituate more quickly, or prefer novel over familiar stimuli have these capacities because of faster encoding capabilities. The result of faster encoding in infancy and throughout the toddler years is a greater accumulation of knowledge and thus higher scores on childhood cognitive assessments. Further,

Figure 1. Stimulus Sequence Presentation



Colombo (1993) argued that measures of individual differences in encoding, storage, or retrieval of memory serve as reliable predictors of childhood cognitive abilities. As such, infants who encode, store, or retrieve a stimulus optimally will habituate quickly and show higher levels of recognition memory for the familiar stimulus, thus preferring the novel stimulus. However, Colombo proposed that stability of individual differences in cognitive abilities are mediated by both speed of processing and memory capabilities.

It has been proposed that RT in the VExP taps processing speed whereas %ANT taps memory and future-oriented processing (Dougherty & Haith, 1997). RT is thought to tap speed of processing because the amount of time an infant takes to react to a stimulus is related to how quickly the infant can process or encode the information provided by the stimulus. In other words, infants with faster RTs process information more quickly and infants with slower RTs require more time to process the same amount of information. It is thought that %ANT taps memory because infants presumably begin to show some memory for the predictable series being presented and exhibit this memory through anticipatory saccades in the direction of a forthcoming stimulus. Infants with better memories therefore show a higher %ANT than infants whose memories are not as developed.

Colombo (1993) speculated that processing speed and memory are two processes that underlie individual differences in intelligence and are tapped by measures of habituation and novelty preference. Similarly, based on his finding that expectancy and habituation indexed the intelligence measure "*g*," Schafer (1985) argued that adults with higher IQ scores tend to make more effective anticipatory judgements and display a greater decline in responses to familiar or unimportant stimuli. Dougherty and Haith (1997) found that %ANT at 3.5 months was related to verbal IQ at 4 years, a result they argued lends support to the notion that a process that involves memory plays a role in cognitive processing between infancy and childhood. Further, they found that RT at 3.5 months was related to Performance IQ (a timed measure of performance on tasks such as object assembly, block design, etc.) on the WPPSI at 4 years, a result they argued lends support to the notion that a speed of processing component plays a role in cognitive processing between infancy and childhood. Based on previous research with both the VExP and adult measures, it can be argued that RT as measured in the VExP is possibly tapping into the underlying mechanism of speed of processing and %ANT as measured in the VExP is possibly tapping into the underlying mechanism of memory.

Jacobson et al. (1992) conducted a study with infants at 6.5, 12, and 13 months. They tested infants at 6.5 months on the VExP and obtained RT and %ANT measures; they also compared mean fixation duration and novelty preference in a visual recognition memory task at 6.5, 12, and 13 months. Jacobson et al. performed a factor analysis on %ANT, RT, fixation duration, and novelty preferences. The analysis suggested that novelty preferences loaded on the same factor as anticipation frequency in the VExP, a result that Jacobson et al. interpreted as a memory and attention component. Separately, they found that average fixation duration loaded on the same factor as RT in the VExP, which they interpreted as a processing speed component. Jacobson et al. also found that RT and %ANT were related; however, they suggested that it is likely that the measures reflect separate components of cognitive processing because they loaded on different factors which indicates different underlying mechanisms of cognitive processing. Jacobson et al. concluded that %ANT in the VExP likely taps an underlying memory and attention component whereas RT likely taps the underlying mechanism of processing.

Canfield et al. (1997) proposed that the variability of RT over a VExP session could be another indicator of future cognitive ability. They make this argument based on the work of such researchers as Jensen (1992) who found that individual differences in variability of RT (SDRT) across a test session are more predictive of individual differences in the intelligence measure *"g"* than differences in mean RT in adults. Canfield and colleagues conducted a longitudinal study using both a simple (left-right) and complex (left-left-right) series on 16 infants and found a linear decrease in SDRT across the first year. They also found that infants vary in their "starting points" of variation in RT, but that the linear decrease was similar regardless of starting point. Although Canfield et al. did not find within-subject stability of SDRT due to a small sample size, they conclude that it is likely stability does exist.

Rose et al. (2002) used a longitudinal sample of pre-term and term 5-, 7-, and 12-month-olds to test development of expectations using the VExP in the first year. They set out to replicate Canfield et al.'s (1997) results with a larger sample and fewer test sessions. They found that SDRTs decreased significantly over age on baseline and regular series trials. Furthermore, Rose et al. examined whether RTs and SDRTs were independently related to some external cognitive dimension in infancy because SDRTs have been shown to be related to *"g"* in adulthood and this relationship is independent of RT. Rose et al. found that age related change in SDRT was independent of age related change in RT, indicating that SDRT possibly reflects some aspect of cognition that is separate from RT. Based on previous interpretation of the measures, RT in the VExP presumably taps the underlying mechanism of speed of processing whereas %ANT taps memory. Exploring individual differences in these domains is worthwhile and could provide information on the underlying mechanisms and their relation to each other.

Methodological Issues

Selecting an Anticipation Criterion. In this section, methodological issues concerning the VExP will be addressed first followed by substantive issues. Since the initial VExP study was published, a degree of controversy has surrounded the determination of exactly what is considered an anticipation and what is considered a reactive saccade elicited by the stimulus. The equipment that labs use in a VExP session puts a time code on each frame of videotape. Sampling rate for VCR resolution is limited to 30 frames/s (33 ms/frame); thus, in all the literature, visual responses must be assigned to the nearest 33 ms "bin" (i.e., 133, 167, 200, etc.). Initially (Haith et al., 1988), 200 ms was thought to reflect the minimum amount of time possible to elicit a reactive saccade. Although no infant data were available on RTs in 3.5-month-old humans, Haith et al. cite numerous studies that found when adults are presented peripheral stimuli more than 4 degrees from the current fixation point, their fastest RT ranges from 180-200 ms (Becker, 1972; Saslow, 1967). Haith et al. confirmed the previous adult findings by testing adults using the VExP. They found the median adult RT to be 255 ms and the fastest RT to be 196 ms. Thus, based on previous research and their VExP results with adults, they chose a 200 ms anticipation cutpoint on the assumption that infants would not be faster than adults in eliciting reactive saccades.

Canfield et al. (1997), however, suggested that a 200 ms cutpoint might be too liberal and instead proposed a 133 ms minimum RT such that an anticipation was thought to occur within 132 ms or less after stimulus presentation. Canfield and colleagues called for a change in criterion for minimum amount of time to elicit a reactive saccade to a stimulus because previous research showed that adults and children can react more quickly than 200 ms to a predictable stimulus (Cohen & Ross, 1977; Findlay, 1981; Ottes, Van Ginsbergen, & Eggermont, 1985). Furthermore, Canfield et al. (1997) urged a reexamination of anticipation latency particularly for older infants because Canfield and colleagues previously determined (Canfield & Haith, 1991; Canfield, Wilken, Schmerl, & Smith, 1995) that infants show facilitation (i.e. improvement in RT speed) across a test session.

More recently, studies conducted with the VExP have followed the lead of Canfield et al. (1997) and maintained a more conservative anticipation cutpoint. Reznick et al. (2000) chose to use the same 133 ms minimum RT as Canfield and colleagues and found similar results, particularly for the ages of 9 to 12 months. Rose et al. (2002) analyzed results based on two different cutpoints. First, they used the traditional 200 ms cutpoint and found a significant increase in anticipations between 5 and 7 months and between 7 and 12 months. Next, they used a 150 ms cutpoint, indicating a 133 ms anticipation and a 167 ms RT, and found results similar to those found with the 200 ms cutpoint (e.g. a decrease in RT) with the exception of finding no significant age differences in anticipations. Because measuring anticipations are central to the VExP, Rose et al. focused their discussion on results found with the 200 ms cutpoint. Because such a variety of results have been found using a number of different cutpoints, determining an appropriate cutpoint, specifically for older infants, is of particular interest in the current study.

ISI. Inter stimulus interval (ISI) refers to the amount of time elapsed between presentation of stimuli. Although ISI in the VExP has not been directly addressed in previous literature, it is worthwhile to examine differences in ISI across labs and speculate about how the various ISI selections may have affected results. An ISI that is too long may cause an infant to quickly lose interest in the procedure. An ISI that is too short may overwhelm the infant and hinder learning of the series or ability to anticipate. All of the published VExP studies have utilized an ISI between 720 ms and 1100 ms. The shortest ISI was used by Rose et al. (2002), whereas most studies (e.g., Canfield et al., 1997) maintained a 1000 ms ISI originally suggested by Haith et al. (1988). ISI differences, although small, are interesting. For example, at 12 months, infants in the Canfield et al. (1997) study showed fewer anticipations (9%) compared to Rose et al. (24.5%) but showed no difference in mean RT (292 ms) compared to Rose et al. (293 ms). This could possibly indicate that a longer ISI, particularly for older infants, hinders performance in the VExP. Perhaps infants become less challenged by the paradigm as they develop across the first year and require a shorter ISI to show expectations. As a consequence of longer ISIs, older infants may become bored by the task or shift gaze away from the monitor during the ISI.

Substantive Issues

Off-task Behavior. The following section will discuss substantive issues raised by the VExP. Previous research with the VExP has shown that time spent off task is relatively low, but nonetheless present, in the VExP. In many previous studies, the authors reported that most infants became distracted at some point during the session, and looked away from the viewing monitor. A measure of off-task behavior is typically taken by calculating the total number of attended-to stimuli and dividing that by the total number of presented stimuli. In the literature in which it was reported, off-task behavior was typically found in the 30% range (Canfield, et al., 1995; Rose et al., 2002). Off-task behavior is therefore perhaps an important index of infants' interest in the paradigm. It is perhaps a measure of infants ability to sustain attention; measurement of off-task behavior could provide information on individual differences. Further, maintaining an off-task behavior percentage similar to previous studies is important in determining validity of the current study.

Reaction Time. Previous studies with the VExP have shown that RT is a useful measure in assessing individual differences and may be a component of infant processing speed. In longitudinal studies, infants show consistent improvement in RT over several days (Haith & McCarty, 1990), months (Canfield et al., 1995; Wentworth & Haith, 1992), the first year of life (Canfield et al., 1997; Jacobson et al., 1992; Rose et al., 2002), and into early childhood (Dougherty & Haith, 1997). Further, RT was found to decrease across the duration of the test for 3-month-olds when a predictable (left-right) sequence was presented (Haith et al., 1988) indicating that facilitation may occur across a test session.

In the domain of RT and individual differences, several studies have reported finding a decrease of mean RT through the first 12 months and in both term and preterm infants (Canfield et al., 1995, Canfield et al., 1997; Rose et al., 2002) whereas individual differences in RT remain stable. In other words, infants with faster RTs at 2 months have faster RTs at 12 months and infants with slower RTs at 2 months have slower RTs at 12 months. Dougherty and Haith (1997) showed that infants' mean RT in the VExP at 3.5 months was related to childhood IQ at 4 years. Saccade RT can therefore be considered a promising measure to be used for developmental analysis due to the correlations found for stability across ages and its possible usefulness for cognitive assessment.

<u>Standard deviation of RT</u>. As mentioned above, SDRT, a measure of the variability in RT, is thought to reflect some aspect of cognition that is separate from RT. Age related change in the variability of RT over trials has not been reported frequently in the VExP literature; however, those studies reporting SDRT suggest that it may be an important measure of cognitive processing (Canfield et al., 1997; Rose et al., 2002). Rose et al. (2002) suggested that SDRT perhaps measures "on-task" behavior, which taps into a sustained attention mechanism. SDRT in the Rose et al. (2002) study showed a small but significant decrease from 5 to 12 months, indicating more on-task behavior and thus, presumably a greater degree of sustained attention.

<u>Facilitation of RT</u>. Although it has not been largely discussed in the literature since, Haith et al. (1988) suggested that infants possibly exhibit an "enhancement" in

behavior after an event occurs, which they termed "facilitation." Essentially, it was hypothesized that an infant may not form a large number of anticipations, but may detect the predictability of a sequence and show faster RT after a period of exposure to the predictable series trials. Haith et al. (1988) conducted two types of analyses and found that 3.5-month-olds indeed show facilitation. First, they compared irregular series median RT and alternating series median RT and found that the alternating series median RT was significantly lower than the irregular series. Next, they carried out analyses on "fast" RTs (between 200 ms and 300 ms) and "slow" RTs (between 450 ms and 700 ms) to determine if fast RTs were more prevalent in one series type over another. They found a significantly higher percentage of fast RTs occurring in the alternating series (28.7%) over the irregular series (20.6%), regardless of whether the alternating series was presented first or last. Together, these two analyses provide evidence that facilitation does occur in infants as young as 3.5 months.

Recently, Rose et al. (2002) examined facilitation in 5-, 7-, and 12 month-olds. They compared mean baseline RT to mean series RT and found a significant difference at 5 months, a marginal difference at 7 months, and no difference at 12 months. Although no facilitation effects were found at 12 months, it is possible that infants exhibit facilitation through 7 months. One possible explanation for a lack of facilitation at 12 months in the Rose et al. study could be due to the change in stimulus presentation. Rose et al. presented the stimuli for 700 ms to the 5- and 7-month-olds and decreased the presentation time to 500 ms for the 12-month-olds, which could have affected their ability to show facilitation. Although facilitation has not yet been found with 12-month-olds, the presence of facilitation at any age may thus indicate that infants are detecting regularity cues in a series, but are not fast enough to exhibit an anticipation based on the regularity.

Anticipation. Haith et al. (1988) suggested that measuring anticipations would serve as an indicator of infants' understanding future-oriented events and that %ANT, in addition to RT, may be a possible indicator of cognitive processing, namely, memory. Results from their study indicate that 3-month-olds have an average anticipation of 18% of all usable trials. Although this seems to be a low percentage, Haith et al. argue that infants should show no anticipations if they were incapable of future-oriented processing. Therefore, showing any anticipations is impressive. In addition, studies that assess infant performance in the VExP over several months report a slight improvement in %ANT with a regular series pattern presentation over 2 to 9 months (Canfield et al., 1997), and a significant difference between 4 and 8 months (Reznick et al., 2000) and 5, 7, and 12 months (Rose et al., 2002). These findings are similar to the developmental improvements with RT, but are not nearly as dramatic. Further, very few studies have found correlations between %ANT and RT in the VExP. Dougherty (unpublished) suggests that whereas %ANT does not correlate well with other measures in the VExP such as RT, it may be tapping into some other cognitive process such as memory.

Previous results with the VExP have demonstrated several methodological and substantive issues in the literature. Clearly, determining an anticipation criterion, an issue which remains unsettled, has been of recent interest in the literature whereas ISIs have gone fairly unnoticed but may be an important aspect of the methodology. Measures such as RT and %ANT have been shown to be possible measures of the underlying mechanisms of speed of processing and memory and remain a central issue in the literature. A less frequently studied measure, SDRT, may be a possible measure of another mechanism such as sustained attention whereas facilitation may be merely the ability to detect regularity in a predictable series; both SDRT and facilitation deserve more attention in the literature. Finally, considerable attention should be given to integrating the methodological and substantive issues while studying older infants, as it has not been accomplished in the literature to date.

Unexpected Results. All of the reported literature with the VExP has used the procedure to test infants ranging in age from two to twelve months. Researchers have studied infants longitudinally (Canfield, 1997; Dougherty & Haith, 1997; Rose et al., 2002; Wentworth & Haith, 1992) and cross-sectionally (Reznick, 2000) across the first year of life. For example, Canfield et al. (1997) conducted the most extensive longitudinal study to date, investigating infants from 2 to 9 months and then again at 12 months. Other researchers conducted longitudinal studies with 20- and 30-week-olds (Canfield et al., 1995), 3-month-olds over a two day period (Haith & McCarty, 1990), and 4-year-olds that had been previously tested at 3.5 months (Dougherty & Haith, 1997), enabling researchers to analyze stability of individual differences across age. Reznick et al. (2000) used the cross-sectional approach to measure 6-, 9-, and 12-month-olds in one experiment and 4-, 8-, and 12-month-olds in a second experiment. Reznick et al. argued that using cross-sectional data would eliminate learning effects. However, using a longitudinal sample of 5-, 7-, and 12-month-olds, Rose et al. (2002) found RT and %ANT results strikingly similar to Canfield et al. (1997); thus, if infants from the

Canfield et al. study were showing practice effects, Rose et al. would not have replicated their results.

Table 1 provides information from previous studies conducted using the VExP and results based on the ISI and anticipation criterion chosen and ages at which infants were tested. A few items are evident upon review of the table. First, mean RT reported within each age is relatively similar across labs. This indicates that RT may be an accurate and useful measure of processing speed and is not strongly affected by methodological differences between labs. Second, %ANT within each age varies tremendously. There are several possible explanations for the differences in %ANT across labs. Procedures across labs vary such that %ANT results from a simple left-right series are being compared to %ANT results from a more complex series. Coding schemes also vary in that what one lab codes as a preliminary anticipatory shift, another lab may code as off-task behavior. Third, the anticipation criterion was not examined or altered below the 200 ms cutpoint prior to the Canfield et al. (1997) study. It has been shown in several recent studies (Canfield et al., 1997; Rose et al., 2002) that decreasing the cutpoint can affect %ANT by as much as 12 or 13 percent. The criterion change has therefore made significant results with age differences in %ANT non-significant (see Rose et al., 2002). In other words, when a more conservative cutpoint is selected (e.g., 133 ms), age differences in %ANT are no longer significant as when a more liberal cutpoint (e.g., 200 ms) is selected.

Table 1
Previous VExP Results

Age, Study, Ant. Criterion, Condition	ISI (ms)	Mean %ANT	Mean Postbaseline RT (ms)
2 months			
Canfield et. al (1997)			
less than or equal to 100 ms			
left-right	1000	12	424
left-left-right	1000	13	451
3 months			
Canfield et. al (1997)			
less than or equal to 100 ms			
left-right	1000	20	437
left-left-right	1000	20	443
Haith and McCarty (1990)			
less than or equal to 200 ms			
session 1 left-right	1000	17.4	480
session 2 left-right	1000	19.4	445
3.5 months			
Haith et al. (1988)			
less than or equal to 200 ms			
left-right (first)	1100	10.4	409
left-right (second)	1100	33.7	373
4 months			
Canfield et al. (1995)			
less than or equal to 200 ms			
left-right	1000	26.7	428
Canfield et al. (1997)			
less than or equal to 100 ms			
left-right	1000	16	401
left-left-right	1000	11	411
Reznick et al. (2000)			
less than or equal to 133 ms			
left-right (exp. 2)	1000	20	365
up-down	1000	27	411
5 months			
Canfield et. al (1997)			
less than or equal to 100 ms			
left-right	1000	14	371
left-left-right	1000	20	383

Age, Study, Ant. Criterion, Condition	ISI (ms)	Mean %ANT	Mean Postbaseline RT (ms)
5 months			
Rose et. al (2002)			
less than or equal to 200			
right-right-left	720	15.7	367
6 months			
Canfield et al. (1995)			
less than or equal to 200 ms			
left-right	1000	18.3	347
Canfield et al. (1997)			
less than or equal to 100 ms			
left-right	1000	19	346
left-left-right	1000	24	377
Reznick et al. (2000)			
less than or equal to 133 ms			
left-right (exp. 1)	1000	15	303
top-left-bottom-left	1000	17	329
6.5 months			
Jacobson et al. (1992)			
less than or equal to 200 ms			
left-right	1000	28.1	322.9
7 months			
Canfield et. al (1997)			
less than or equal to 100 ms			
left-right	1000	15	320
left-left-right	1000	20	335
Rose et. al (2002)			
less than or equal to 200			
right-right-left	720	16.9	327
8 months			
Benson et al. (1993)			
less than or equal to 200			
right-left	750	44	n/a
right-right-left	750	49	n/a
Canfield et. al (1997)			
less than or equal to 100 ms			
left-right	1000	20	312
left-left-right	1000	17	330

Age, Study, Ant. Criterion, Condition	ISI (ms)	Mean %ANT	Mean Postbaseline RT (ms)
8 months			
Reznick et al. (2000)			
less than or equal to 133 ms			
left-right (exp. 2)	1000	52	253
up-down	1000	27	305
9 months			
Canfield et. al (1997)			
less than or equal to 100 ms			
left-right	1000	24	280
left-left-right	1000	20	296
Reznick et al. (2000)			
less than or equal to 133 ms			
left-right (exp 1.)	1000	39	274
top-left-bottom-left	1000	40	283
12 months			
Canfield et. al (1997)			
less than or equal to 100 ms			
left-right	1000	13	281
left-left-right	1000	9	292
Reznick et al. (2000)			
less than or equal to 133 ms			
left-right (exp. 1)	1000	35	264
top-left-bottom-left	1000	33	289
left-right (exp. 2)	1000	35	245
up-down	1000	41	324
Rose et. al (2002)			
less than or equal to 200			
right-right-left	720	24.5	293

A surprising finding from studies including older infants (9 to 12 months) is that infants become less skilled at making anticipations whereas their RT remains stable or continues to decrease at non-significant levels (Canfield et al., 1997; Reznick et al., 2000). Canfield et al. (1997) conducted a longitudinal study with the VExP testing infants monthly from 2 to 9 months and then again at 12 months. The first trial session was conducted with the stimuli presented in a left-right alternating series followed by the second trial session with stimuli presented in a left-left-right series. Results revealed that for the left-right series, the 9-month-old mean RT was 280 ms and the 12-month-old mean RT was 281 ms. Further, for the left-left-right series the 9-month-old mean RT was 296 ms and the 12-month-old mean RT was 292 ms. The %ANT for the left-right series was reported as 24% for 9-month-olds and 13 % for 12-month-olds. The %ANT for the left-left-right series was reported as 20% for 9-month-olds and 9% for 12-month-olds. Such decrements in %ANT from 9 to 12 months were not expected.

Similar results were reported by Reznick et al. (2000). Reznick and colleagues presented 6-, 9-, and 12-month-olds with a mechanical monkey clapping a pair of cymbals. The stimulus was presented on one of four monitors placed in a cross-fashion. The first trial session consisted of the stimulus being presented in a left-right or right-left alternating series followed by the second trial session when the stimulus was presented in a top-left-bottom-left or top-right-bottom-right series. Results revealed that the 9-month-old mean RT to the left-right sequence was 274 ms and the 12-month-old mean RT to the left-right sequence was 264 ms. Nine-month-olds were found to have a mean %ANT of 39%, a significant increase from the 6-month-olds' mean of 19%. However, 12-month-old mean %ANT was only 35% which was not significantly different from the 9-month-old mean of 39%. Additionally, during the top-left-bottom-left sequence, the 9-month-old mean RT was 283 ms and the 12-month-old mean RT was 269 ms and the mean %ANTs were 40% and 33%, respectively. Although the decrement in %ANT between 9 and 12 months never reached significance, it does seem counter-intuitive because %ANT may be measuring a memory component and as infants develop, their memories should improve, thus displaying developmental improvements in %ANT similar to those found with RT. Because these findings are so unexpected, further research with older infants utilizing the VExP is crucial.

Results from ten- and eleven-month-olds have not been reported in any published study using the VExP. The study of this age group would aid in understanding previous studies such as Canfield et al. (1997) and Reznick et al. (2000) and the apparent discrepancies in infant performance, such as why RT remains constant whereas %ANT declines from 9 to 12 months. Including 10- and 11-month-olds in a study would also aid researchers in understanding the development of expectations in the latter part of the first year of life. Because infants seem to become less skilled at making anticipations between 9 and 12 months but no data is available for %ANT at 10 and 11 months, studying 9- through12-month-olds both may enable researchers to understand what is taking place in this time period.

<u>Attentional Development in Older Infants</u>

A large body of literature has been devoted to the study of the development of attention in the first six months of life (see Colombo, 1993 for a review). By contrast, there is little research devoted to the study of attentional development in the second half of the first year of life, with even fewer theories being developed or discussed. As the VExP presumably is a measure for underlying attentional processes, it is essential to examine the developmental progression of attention in the 9- to 12-month-old infant. Ruff and Rothbart (1996) have proposed a two-system model of attentional development. The first system is an early maturing system that underlies orienting and investigation of locations and objects. The first system develops beginning at 3 months and is fully operational by 9 months. During this time period, infants begin to attend selectively and show preference for novel events. Infants also show the ability to disengage attention more readily and develop expectations. The second system is a later maturing system that underlies goal-oriented attention and control of complex activity. The later maturing system begins to develop at 9 months and continues development into the preschool years.

The age of nine months brings a variety of developmental changes to the infant. She has become highly proficient at manipulating objects and visually explores novel objects. Her general memory becomes better, and according to Ruff and Rothbart (1996), infants seem “increasingly able to anticipate future outcomes on the basis of past experiences” (p. 45). The 9-month-old infant begins to develop stranger anxiety as well. The infant begins to use her parents as reference points when encountering ambiguous situations and may become distraught when a parent is not present. Ruff and Rothbart suggest that the developmental changes occurring beginning at 9 months are due to the rudimentary function of the frontal lobe, initiating the onset of the second attentional system. The maturation of the second system provides the foundation for goal-directed and future-directed behavior over the course of the next several years. The time from 9 to 12 months of age is thought to be a transition period, particularly in looking behavior. As attention comes under control of both systems, look duration during the transition period may show an increase compared to the previous 6 months when infants showed a constant decrease in look duration. For example Ruff and Saltarelli (1993) presented 7- and 9-month-olds with several toys simultaneously and were allowed to play by themselves for 5 minutes. Looking at the toys was significantly higher for the 9-month-olds than for the 7-month-olds. Some researchers argue that a decrease in look duration across the first 9 months followed by a subsequent increase is due to development of memory and cognition (Kagan, 1970), brought on by the use of the second attentional system. Over the first nine months, infants show a developmental decrease in look duration presumably because speed of processing increases and it does not take as long to process information as they develop whereas after nine months infants look duration subsequently increases because they are processing the object and perhaps performing a cognitive task with it as well. To illustrate, young infants look at an object long enough to recognize it. By contrast, older infants begin to formulate hypotheses based on their experiences. Because older infants spend time formulating hypotheses while attending to an object, looking increases.

Whereas Ruff and Saltarelli's (1993) study suggests that looking increases over the transition period, other studies show that looking continues to decline. These studies typically involve static displays and indicate a steady decrease in looking from 3 to 13 months (Lewis, Goldberg, & Campbell, 1969; Kagan et al., 1971; Oakes & Tellinghuisen, 1994). It has been argued that look duration continues to decrease because as infants develop, they process information quickly, thus spend less time looking at an object or event. It seems possible that because in some situations look duration increases as infants get older and other situations look duration continues to decrease, two different attentional systems may be operating. Presumably, the second attentional system underlies infants' hypothesis formation and is therefore responsible for the longer look durations seen when investigating a group of toys or a more complex, unfamiliar object. Similarly, the first attentional system is likely responsible for the continuing decrease in look duration found when infants explore static or familiar objects. Though 9-month-old infants begin to show rudimentary elements of executive control (goal-directed behavior, hypothesis formation), there are still many limitations on their actions and much is still unknown about the developing second attentional system. Testing infants between nine and twelve months on the VExP will give greater insight into the development of the second attentional system and may bring researchers closer to determining why older infants appear to perform poorly on anticipation tasks (e.g., Canfield et al. 1997; Reznick et al., 2000), perhaps because the second attentional system has not yet fully developed and the first attentional system is reorganizing in order to interact with the second.

Aims and Novel Contributions

In order to examine the development of visual expectations and RT, the current experiment tested 9- to 12-month-old infants with the visual expectation paradigm. The majority of previous research with VExP has focused on development across the first six months with only a few, relatively recent studies assessing older infants. None of the published literature with 9- to 12-month-old infants has investigated 10- and 11-month-old groups. Because basic attentional developments occur across the period of 9 to 12 months, including 10- and 11-month-olds in a study could enhance understanding of attentional processes across this age range. In addition, recent literature including older infants has led to unexpected results, and a definitive cutpoint between anticipatory and elicited saccades for the current age group is yet to be determined. Thus, the current experiment attempted to investigate these issues in order to clarify previous research and facilitate discussion of attention in older infants and the underlying processes governing attention including speed of processing and memory.

It was expected that some adjustment of anticipation criterion below the original 200 ms cutpoint would be made, but it was uncertain until after results were analyzed what that adjustment would be. Based on previous research with older infants in the VExP (Canfield et al., 1997; Reznick et al., 2000; Rose et al., 2002), it was expected that RT would decrease minimally, but not significantly from 9 to 12 months. Furthermore, based on previous results (Rose et al., 2002), it was expected that facilitation of RT would occur in the series trials when infants could learn the left-right rule and not in the baseline when trials were unpredictable. With respect to standard deviation of RT, it was expected that current study would find a decrease in SDRT from 9 to 12 months. The decrease was expected because it has been proposed that SDRT is a measure of the underlying mechanism of sustained attention. Presumably, as infants' second attentional systems develop over the 9 to 12 month period, their ability to sustain attention is also developing. Finally, it was expected that percentage of anticipations would increase, despite previous conflicting results (Canfield, et al., 1997; Reznick et al., 2000). An increase in %ANT was expected due to procedural modifications made to the current study such as the presentation of a simple (right-left) series and a shorter ISI (750 ms). Further, an increase in %ANT was expected based on the development of the second attentional system across the 6 to 12 month age period. Because function of the frontal lobe is present in older infants (Nelson, 1995), enabling goal-oriented cognitive processing, an increase in anticipations was likely.

With respect to individual differences, it was expected that results would replicate the Rose et al. (2002) findings that infants who showed faster baseline RTs would show faster RTs to series trials and have less variable RTs. It was also expected that infants who showed a faster baseline would show more anticipations during the series trials and spend less time off task. Analyses may reveal that an adjustment of the initial 200 ms anticipation criterion is not justified; this could indicate that there are several differences across laboratories in the VExP method or that older infants show no improvement in processing speed, making it difficult to show faster elicited saccades. Further, if analyses reveal no improvement of %ANT over age, this may be attributed to the development of the second attentional system and the integration of the first and second systems (Ruff & Rothbart, 1996). As infants become more proficient at using the two systems in conjunction, they should become more skilled at forming expectations for future events, but may initially show a decrease in performance.

CHAPTER 2

METHOD

Participants

Infants' names were obtained through newspaper birth listings and addresses and phone numbers were obtained through the phone book. Participants were contacted by letter 2 weeks before the upcoming birth date (9, 10, 11, or 12 month) of the infant. One week before the desired visit, parents were contacted by a telephone call explaining the nature of the study and inviting them to participate. If interested, the parent scheduled an appointment and upon completion of the experiment, the infant received a certificate. The protocol for selecting and testing infants was approved by the University of Georgia Institutional Review Board (Project # H1998-10273-7).

A total of 52 infants participated in the study; 13 nine-month-olds, 12 ten-month-olds, 13 eleven-month-olds, and 14 twelve-month-olds. Attrition rate due to inattentiveness or fussiness was very low for the current sample. Data were unavailable for one 9-month-old due to inattentiveness and data were unavailable for one 10-month-old and two 12-month-olds due to fussiness. Age adjustments were made on 3 preterm, but otherwise healthy infants, by placing them in the appropriate age group based on calculated age from the infant's due date rather than the infant's birth date. One premature 10-month-old's data was excluded from analyses, because her adjusted age was calculated to be 8 months. Finally, two 9-month-olds were determined to be statistical outliers and excluded from analyses. Thus, the final sample consisted of 46 infants; 10 nine-month-olds, 10 ten-month-olds, 13 eleven-month-olds, and 13 twelve-month-olds.

Infants' mean birth weight was 3404 grams (SD = 801). No vision problems were reported. Table 2 provides demographic statistics for all infants included in data analyses and Table 3 provides information on gender and age composition of the final sample.

Apparatus

Visual stimuli were generated using Dazzle* Digital Photo Maker software and presented on a 45 X 65 cm Gateway 2000 Destination monitor. Throughout the test period, infants sat in an adult's lap in a 2.3 X 1.3 m area enclosed by a black curtain. Infants were seated at a distance of approximately 52 cm from the monitor. A Panasonic Color Video Camera (manufacturing # CT-20864) was mounted on top of the monitor to record direction of infant gaze. A second video camera was mounted on a tripod and placed behind the right shoulder of the parent in order to record the stimuli presented on the monitor. A Videonics Digital Video Mixer (Model # MX-1 NTSC) was used to generate picture-in-picture input from the two stimulus cameras throughout the test session. The test room was lit by the stimulus monitor and a lamp. Infant heart rate was recorded using silver/silver chloride electrodes; these data will not be reported in the current paper.

After the session, infant looking behaviors were coded off-line by trained coders to indicate direction of gaze and shift in gaze. This was done using a computer time code generator/reader card and custom software made to generate a time-code on each frame of the videotape. The time code generator recorded at 1/100 s intervals onto a VHS video tape by a JVC Professional Series Super VHS VCR (manufacturing # SR-TS1U).

Table 2
Demographic Data (n = 46)

Variable	9-month-olds M	9-month-olds SD	10-month-olds M	10-month-olds SD	11-month-olds M	11-month-olds SD	12-month-olds M	12-month-olds SD
Infant Birth Weight (Gr)	3574.9	642.4	3589.4	607.5	3178.0	927.0	3417.8	834.0
Maternal Age (Years)	29.4	6.31	31.0	5.0	31.4	4.3	30.0	4.5
Paternal Age (Years)	33.2	11.2	31.1	6.0	32.3	4.6	34.1	7.7

Variables	9-month-olds	10-month-olds	11-month-olds	12-month-olds
Ethnicity				
Caucasian	9	9	11	11
African-American	1	0	1	1
Asian	0	0	0	1
Other	0	1	1	0
Maternal Education, Highest Level				
Some High School	1	0	0	0
High School Graduate	1	0	0	1
Some College	1	6	8	6
College Graduate or More	7	4	5	6

Paternal Education, Highest Level				
Some High School	2	0	0	0
High School Graduate	1	2	2	2
Some College	1	3	4	5
College Graduate or More	6	5	6	6

Table 3

Age and Gender Sample Composition

Age	Male N	Female N
9-month-olds	4	6
10-month-olds	5	5
11-month-olds	6	7
12-month-olds	7	6

Because sampling rate for a VCR resolution is limited to 30 frames/s (33 ms/frame), each behavior was assigned to the nearest 33 ms bin.

Stimuli

An initial stimulus of a smiling Caucasian female was presented for 20 s to measure baseline look duration. The stimulus was presented against a black background and subtended approximately 16 degrees of visual angle.

The VExP stimuli consisted of eight brightly colored images that were randomly presented. The stimuli included a pinwheel, an apple, a puppy dog, a doll face, a field of stripes, a lamb, a star, a bear, and rings. The stimuli were static; however, they were programmed to move on the vertical plane approximately 4.5 cm subtending 4.95 degrees in order to give a dynamic appearance and maintain the infant's attention. In addition, an auditory component was added in order to further enhance infant attention. A total of 3 beeps were emitted during the presentation of each stimulus to coincide with the down-up-down cycle of the stimulus. Each stimulus was presented for 750 ms against a black background; the entire screen was black during a 750 ms ISI. Each stimulus was approximately 15.5 cm wide and subtended approximately 16.5 degrees of visual angle. The distance between inner edges of the stimuli was 25.5 cm; thus, stimuli were separated by approximately 27.55 degrees.

Coding

The stimulus sequence and the infants' looking responses were coded separately, off-line. The "picture in picture" feature of the digital video mixer allowed for a large recording of the infants' face with a smaller recording of the stimulus monitor in the corner of the large frame. In order to code the stimuli, a coder viewed each session frame-by-frame and recorded the precise frame when a stimulus appeared on the left or right side and when the screen was blank.

Behavioral measures such as direction of gaze, shifts in gaze, and inattentiveness were coded by highly trained coders using a combination of real-time and frame-by-frame analysis. In order to code accurately, the coders viewed each infant at full speed in their initial viewing of the session to learn an individual infant's gaze behaviors. On the second and subsequent passes, coders viewed each infant's test session in a frame-by-frame fashion.

Coders classified a look away from the previous stimulus location and toward the other side of the monitor as a "shift." A shift was determined by speed of saccade, direction of saccade, and final location at the end of the shift. An overt eye movement was necessary to be classified as a saccade. Head movements were not considered in the current coding scheme. Reactions and anticipations were determined on the basis of saccade latency.

A code of "looking away" was given when the infant was distracted, looked at a location other than the monitor, or did not shift his or her gaze within the period of time that the stimulus was presented (750 ms). Common off-task behavior included fussiness, social referencing to the mother, and covering the eyes with a hand or arm. Finally, a code of "cannot observe" indicated when the eyes could not be viewed due to the infant moving off camera, the camera coming out of focus, or the mother's head blocking observation of the test stimuli. The complete coding scheme can be found on Table 4.

Table 4

Coding Scheme

Stimulus

TV is blank
Center Stimulus is on
Right Stimulus is on (coder’s right)
Left Stimulus is on (coder’s left)
Break between sets of trials
TV cannot be seen (head blocking, etc.)
End of Experiment

Infant
Cannot observe baby’s eyes
Baby is looking toward center of TV
Baby is looking toward left side of TV (coder's left)
Baby is looking toward right side of TV (coder's right)
Baby is shifting from one side of TV to the other
Baby is looking away from TV

Reliability

Coding reliability was assessed by examining eight infants (two at each age) who were coded first by the author and then by a team of two observers. Reliability was measured by correlating the RT and anticipation latencies calculated by each coder; the reliability correlation was .88.

Procedure

Upon arrival at the laboratory, investigators explained the nature of the experiment, answered any parent questions, and obtained informed consent (see Appendix A). Infants were seated in the adult's lap and heart rate electrodes were applied. Infants were positioned so that they were seated approximately 52 cm from the monitor. Parents were asked to keep their infant centered throughout the procedure. Parents were further asked to refrain from directing their infant's looking and to remain quiet throughout the session except to calm their infant if he or she became fussy. When the infant was positioned, the camera was adjusted to focus closely on the eyes. So as to minimize glare off of the monitor, one set of overhead lights was extinguished and the standing lamp was lit. When the infant was judged to be calm and alert, the VCR was set to record and the parent was told the session would begin. The computers were then set to run the stimulus sequence. The entire session lasted approximately 3.75 minutes. A total of 58 stimuli were presented. A baseline trial of 12 pictures was presented in an irregular (left-right-right-left-right) fashion followed by two series blocks of 28 alternating (left-right) stimuli each. Figure 1 shows an example of the spatial and temporal arrangement of the presentation.

A smiling female face was presented as a warm-up slide to acclimate the infant. After the initial stimulus presentation, VExP stimuli were presented in three blocks to measure RT and anticipations. The first block consisted of the baseline trials and the second and third blocks consisted of the predictable series trials. There was a break between blocks one and two and again between blocks two and three in order to reengage or calm the infant, if necessary. The break was experimenter-controlled such that the session could continue with a keyboard press as soon as the mother-infant pair were ready. The mother-infant pair were given an unlimited amount of time during the breaks; however, no break ever lasted more than 1 min. The test session continued until the infant became fussy, which occurred in 5% of all sessions, or the entire session was completed. After data collection, a health form (see Appendix B) was completed by the parent. Upon completion of the health form, a certificate of appreciation was given to the family and they were thanked for their participation.

CHAPTER 3

RESULTS

Determining a Cutpoint for Anticipations Based on Saccade Latencies

In order to determine which saccades should be classified as RTs and which should be classified as anticipations, the RT distributions for each age group were examined. A cutpoint distinguished an RT from an anticipation such that the determined time (e.g., 167 ms and anything below it) was defined as an anticipation and anything greater was an RT. Figures 2 through 5 show the frequency of saccade latencies in the series (left-right) trials at each age tested. In order to clearly present the data, saccades are distributed in 50-ms bins. On the x-axis, zero indicates the point of stimulus onset. The y-axis indicates the frequency of elicited saccades with an individual infant contributing as many saccades as were scorable.

Reactive saccades are elicited by input from the environment. As such, a distribution of reactive saccades should appear positively skewed with the minimum value corresponding to the fastest possible RT (Canfield et al., 1997; Luce, 1986). Furthermore, anticipations are thought to consist of a pre-planned cognitive process rather than a reaction to a stimulus. Therefore, anticipations should appear more uniformly distributed while the maximum anticipation latency corresponds to the bin just before the minimum RT. As a result, in determining minimum RT, it is expected that a discontinuity in the latency bins separating elicited saccades from reactive saccades will

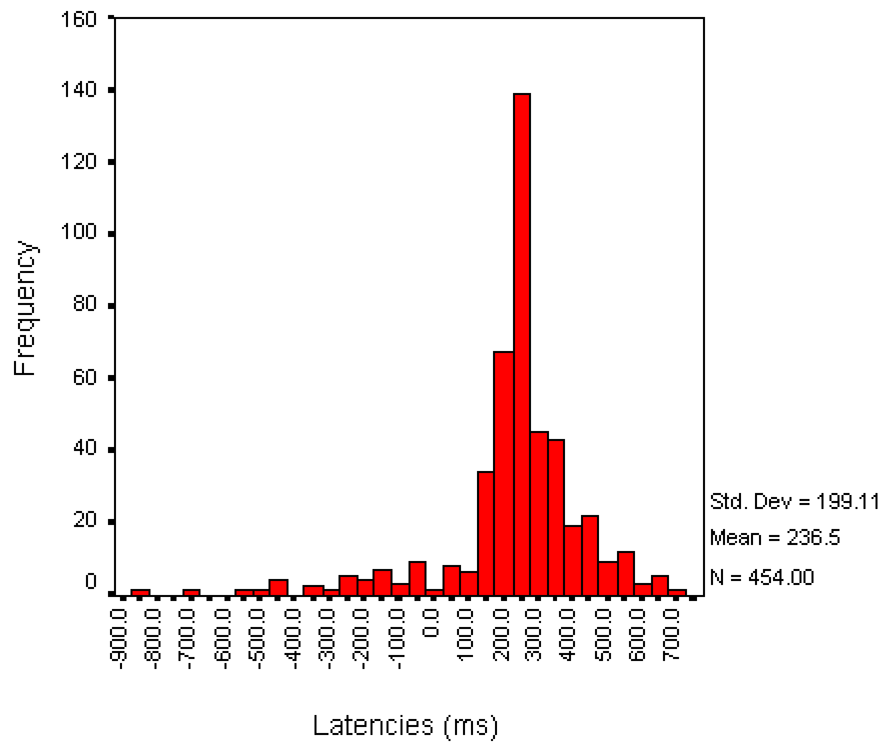


Figure 2. Distribution of Saccade Latencies for 9-Month-Olds

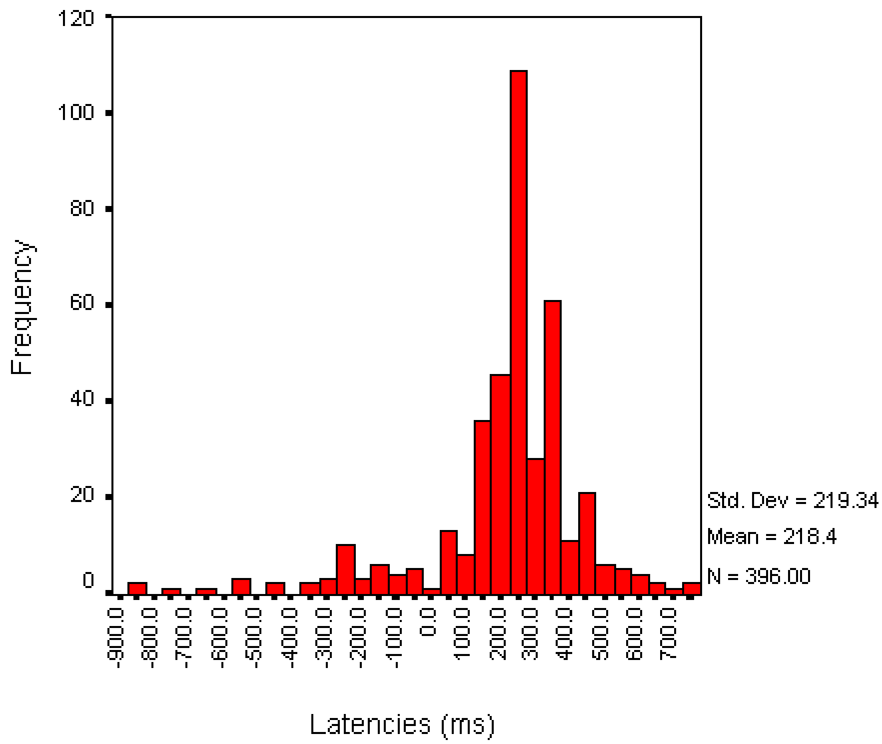


Figure 3. <u>Distribution of Saccade Latencies for 10-Month-Olds</u>

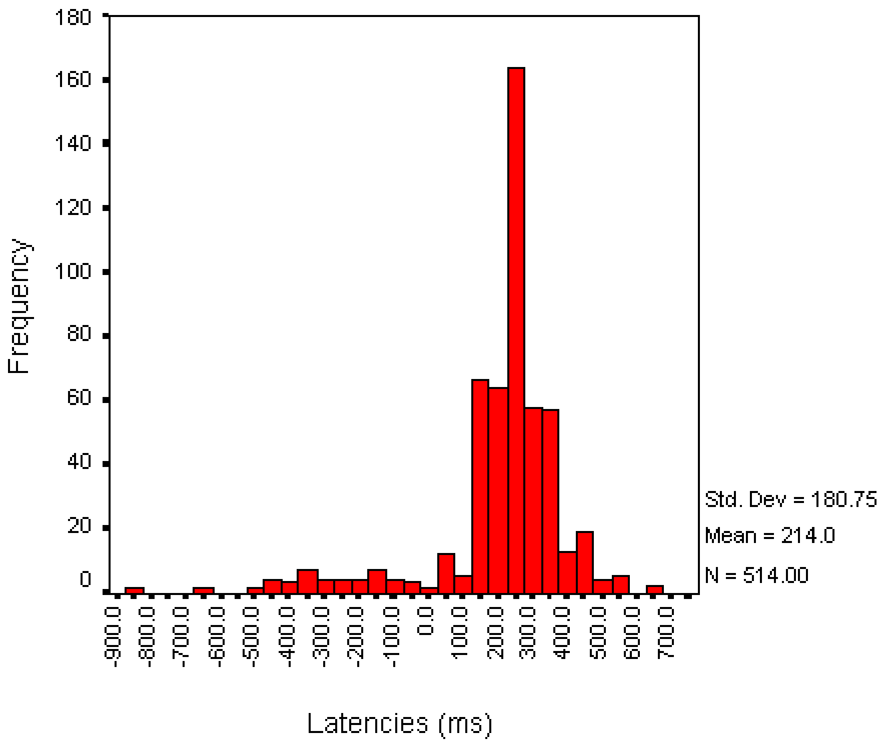


Figure 4. Distribution of Saccade Latencies for 11-Month-Olds

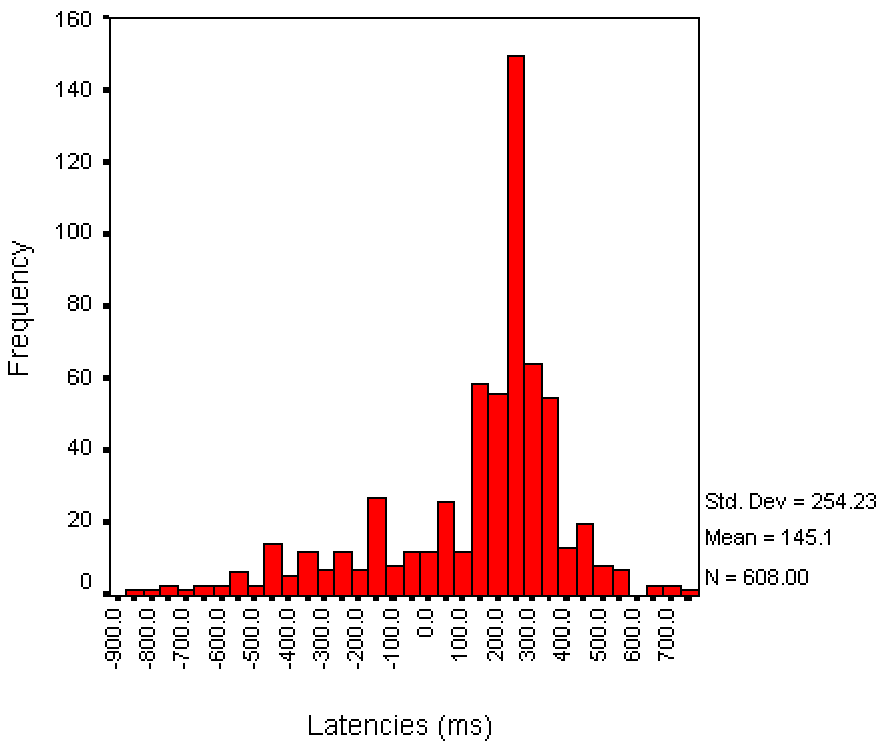


Figure 5. <u>Distribution of Saccade Latencies for 12-Month-Olds</u>

be apparent. Of particular importance to the current study is the relative similarity of saccade latencies across all age groups. Note that each distribution consists of a flat, relatively shallow left tail marked by a discontinuity with subsequent gradual decreases in frequency of elicited saccades. Examination of the distributions of saccade latencies for each age group revealed a discontinuity between the 150 ms and 200 ms bins with 200 ms being the mode for each age group. Thus, based on the data, the cutpoint for anticipations was placed between 150 ms and 200 ms, such that 167 (the nearest saccade based on VCR resolution) would be classified as an anticipation and 200 ms would be classified as an RT.

The cutpoint for determining anticipatory from reactive saccades has been controversial. Intially, Haith et al. (1988) placed the cutpoint at 200 ms after stimulus onset. Thus, saccades made up to 200 ms were considered anticipations. Canfield et al. (1997) argued that a 200 ms cutpoint may be too conservative and true RTs were probably being classified as anticipations. As a result, the current data were examined using various cutpoints to assure that the 167 cutpoint was most accurate (see Table 5). When the cutpoint was moved to 133 ms, 5.5% fewer anticipations were noted. When the cutpoint was moved to 200 ms such that 233 ms would be classified as a RT and 200 ms would be classified as an anticipation, there were 12.2% more anticipations. Rose et al. (2002) noted that the selection of a cutpoint is somewhat arbitrary and any chosen point will often be too stringent for some infants and too liberal for others. However, based on the current data, because a large discontinuity exists between classifying 167 ms and 200 ms as anticipations, it is logical to place the cutpoint at 167 ms to capture true

Table 5

Percentage of Anticipations

	Percentage of Anticipations		
	133 ms	167 ms	200 ms
Age			
9-month-olds	10.7	14.7	28.2
10-month-olds	21.8	25.7	35.1
11-month-olds	18.4	27.5	38.5
12-month-olds	30.9	37.6	46.6

anticipations and RTs and avoid classifying an actual RT as an anticipation. As such, the following data were analyzed using the 167 ms cutpoint to determine anticipations from RTs.

Off-task Behavior

Off-task behavior is defined as the percent of trials to which infants did not attend. Results showed that 9-month-olds' (M= 38.04, SD = 14.39), 10-month-olds' (M= 38.21, SD = 16.71), 11-month-olds' (M= 39.29, SD = 21.39), and 12-month-olds' (M= 29.26, SD = 19.07) off-task behavior was very similar. A 2 X 4 (trial X age) between subjects ANOVA revealed no significant differences in off-task behavior during series trials between ages, $F(3, 45) = .808$, $p = .497$.

Reaction Time

Results showed there were no differences in RT across series blocks 1 and 2, $t(45) = .208$, ns, (block 1 M = 300.6 ms, SD = 56.0; block 2 M = 297.7 ms, SD = 56.9) indicating no change in

these variables across the session. Since no significant differences in RT were found, data were collapsed across the two blocks.

Figure 6 illustrates baseline RT and series RT across age; results were not significant for either baseline, F (3, 45) = 1.69, p = .185 or series, F (3, 45) = 0.78, p = .512. Thus, as expected, RT remained stable.

Facilitation. Rose et al. (2002) suggested that examining the difference between mean baseline RT and mean series RT is a possible way of measuring anticipation formation. As an infant learns a rule, she should exhibit facilitation, or a decrease in RT

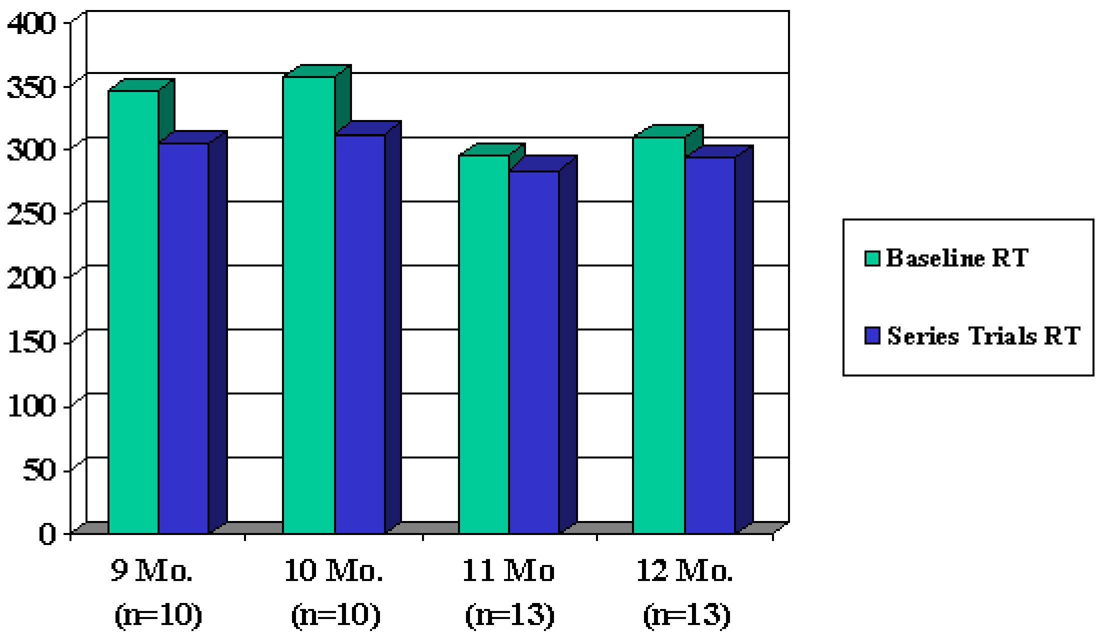


Figure 6. RT by Age for Baseline and Series Trials

across trials. Thus, it was expected that facilitation of RT would occur in the series trials when infants could learn the rule and not in the baseline when trials were unpredictable. A paired samples t-test revealed a significant difference between mean baseline RT ($\underline{M}$ = 324.1 ms, $\underline{SD}$ = 76.8) and mean series RT ($\underline{M}$ = 298.1 ms, $\underline{SD}$ = 45.8), $\underline{t}(45) = 3.579$, $\underline{p} < .01$, indicating facilitation of RT.

SDRT. A 2 X 4 (trial X age) repeated measures ANOVA revealed that the SDRTs showed no significant change from 9 to 12 months in either baseline trials, $\underline{F}\ (3, 45) = 1.189$, $\underline{p} = .326$, or series trials, $\underline{F}\ (3, 45) = 1.872$, $\underline{p} = .149$, as shown in Table 6. Results indicate a stability in SDRT across 9 to 12 months.

Anticipations

As expected, %ANT increased significantly from 9 to 12 months. A 2 X 4 (trial X age) between subjects ANOVA revealed a significant increase in anticipations across age for series trials, $\underline{F}\ (3, 45) = 3.76$, $\underline{p} < .05$. Figure 7 illustrates the increase in anticipations.

Correlations

Correlational analyses revealed that infants who showed faster baseline RTs also showed faster RTs to series trials, $\underline{r}(45) = .80$, $\underline{p} < .05$ and had less variable RTs, $\underline{r}(45) = .50$, $\underline{p} < .05$. Also, infants who had a faster baseline showed more anticipations during the series trials, $\underline{r}(45) = -.38$, $\underline{p} < .05$ and spent less time off task, $\underline{r}(45) = -.30$, $\underline{p} < .05$.

Table 6

Means and SDs of All Measures

	9-month-olds		10-month-olds		11-month-olds		12-month-olds	
	M	SD	M	SD	M	SD	M	SD
RT (ms)								
Baseline	345.8	125.4	357.0	44.0	295.7	61.5	310.3	52.4
Series	305.8	59.6	311.7	47.9	285.5	50.5	293.4	46.8
SDRT (ms)								
Baseline	73.9	36.0	73.8	53.1	50.9	25.3	73.5	33.6
Series	84.6	32.4	100.2	29.8	68.8	24.2	86.9	39.4
Anticipations (%)	14.7		25.7		27.5		37.6	
Off-task trials (%)	38.0		38.2		39.3		29.3	

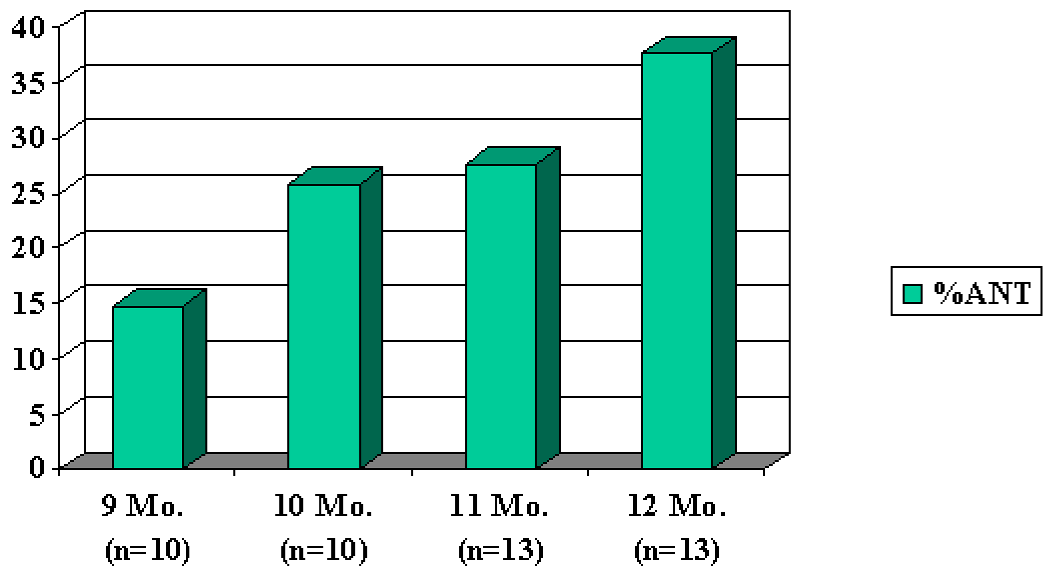


Figure 7. Percentage of Anticipations by Age

CHAPTER 4

DISCUSSION

The present study assessed developmental changes in visual expectations and RTs in 9- to 12-month-old infants using the VExP. This is the first study to examine 10- and 11-month-olds in the task and one of only a few to study the period of 9 to 12 months. This study builds on the research of Canfield et al. (1997), Reznick et al. (2000), and Rose et al. (2002) to replicate and clarify conflicting results.

Anticipation Criterion

The present results suggest that anticipations occur before 200 ms in 9- to 12-month-old infants. The selection of the 167 ms anticipation criterion in this study is supported by the finding of similar saccade latency distributions across these ages. Previous results manipulating anticipation criterion illustrate the need to address it in the current study. For example, Canfield et al. (1997) used a 100 ms anticipation criterion and found between a 5% and 16% difference in RT classification from the traditional 200 ms anticipation criterion. They also found that the difference overestimating minimum RT (i.e., considering 233 ms a minimum amount of time required to react to presentation of a stimulus as compared to 133 ms) was very small and concluded that individual differences for RT would not have been altered had the more generous 200 ms cutpoint been used. However, when examining %ANT with both cutpoints, Canfield et al. (1997) came to a very different conclusion. Based on growth curves for %ANT, they found that when the 200 ms criterion was used, anticipations are overestimated particularly from 9 to 12 months. Further, they found that when the 200 ms cutpoint was used with the 12 month data, results more than doubled their 12 month %ANT estimate. Obviously, this overestimate can have a significant impact on conclusions drawn about the development of anticipations and possibly underlying mechanisms at the end of the first year of life. In order to determine if overestimates of %ANT could be found in previous research, Canfield et al. subsequently reexamined studies from their lab that had implemented the 200 ms cutpoint. In both Canfield et al. (1995) and Canfield and Smith (1996), infants between four and six months were tested and no significant differences were found when the cutpoint was lowered to 100 ms. However, Canfield et al. (1997) argue that a anticipation criterion shorter than 200 ms should be selected for older infants based on their most recent growth model indicating that %ANT overestimates are likely to be occurring at the end of the first year, but not before.

Rose et al. (2002) followed the suggestion of Canfield et al. (1997) and examined their results using the traditional 200 ms cutpoint and a 150 ms cutpoint (indicating a 133 ms anticipation). Their results indicated that when a 200 ms cutpoint was used, a significant difference was found in both %ANT and RT between the ages of 5, 7, and 12 months. Further, consistent with Canfield et al. (1997), Rose et al. found that adjustment of anticipation latency made no difference in their results except when determining %ANT. Thus, when the cutpoint was changed to 150 ms, the age increases in %ANT disappeared. However, further analyses revealed that 12-month-olds showed 14.7% shifts in gaze in the 150 ms to 200 ms range, which is over 2.5 times more shifts in gaze than 7-month-olds showed in the 150 ms to 200 ms range. Based on this marked increase in shifts in gaze over the 150 ms to 200 ms range, the Rose et al. results lend support to Canfield et al.'s (1997) conclusion that RT latency may shift in the latter part of the first year of life. As such, it is likely that the selection of 167 ms cutpoint for the present study is accurate.

Haith, Wass, and Adler (1997) conducted analyses on a cross-sectional study of 2-, 3-, 5-, and 8-month-olds to determine if frequency of eye movements at 133, 167, and 200 ms were correlated with overall percentage of anticipations or overall percentage of fast RT saccades (occurring between 233 ms and 300 ms). They found that the number of eye movements that occurred at 133 ms was highly correlated with overall percentage of anticipations, and the number of eye movements that occurred at 200 ms was highly correlated with percentage of fast saccades. Saccades that occurred at 167 ms were found to correlate with percentage of fast saccades, but not as highly as those at 200 ms. As a result, Haith et al. suggest that eye movements falling in the 167 ms bin are a mixture of RTs and anticipations, with individual differences determining the type of saccade. The results of Haith et al. lend support for the determination of the current anticipation criterion. As 133 ms clearly indicates an anticipatory saccade and 200 ms clearly indicates a reactive saccade, it is logical to place to cutpoint at 167 ms to reflect those saccade latencies. Further, though 167 ms may represent both anticipatory and reactive saccades, the current sample displays the largest discontinuity between the 167 ms and 200 ms bins, lending further support for the 167 ms criterion selection.

Because recent literature has addressed the selection of anticipation criterion, it is not surprising that a degree of debate has surrounded the topic. The traditional 200 ms anticipation latency (Haith et al. 1988) has been adjusted to 100 ms (Canfield et a. 1997; Reznick 2000), 133 ms (Rose et al. 2002), and 167 ms in the current study all with differing results. It is clear that researchers cannot agree upon an absolute criterion based on the results to the present. Though it is apparent that an elicited saccade can occur before 233 ms, as was originally suggested, it is uncertain exactly how soon an elicited saccade can occur in older infants. It is possible that stimulus and ISI differences across studies may be important to consider in the definition of anticipation criterion. Properties inherent to a specific stimulus, such as whether it is dynamic, animated, or more salient may affect infants' saccade latencies. In addition, the presentation time and ISI may also affect infants' saccade latencies such that with longer presentations, an infant may become bored or may not find the task challenging, or conversely, very short presentations may interfere with the infant's ability to learn the stimulus sequence or become overwhelming to the infant. As such, close attention should be paid to consistency across labs so that in the future, a definitive decision may be reached on anticipation latency criterion.

Off-task behavior was measured in the present study to verify that the task was not too difficult or simple and confirm consistency with previous studies. Off-task behavior remained fairly stable over age with 9-, 10-, and 11-month-olds attending to approximately 60% of the trials and 12-month-olds attending to approximately 70% of the trials. These means reflect similar or only slightly higher off-task percentages compared to recent studies with infants of comparable age. For example, Rose et al. (2002) reported off-task behavior of 30.2% in 12-month-olds. More off task behavior with 9- to 11-month-olds in the present study could possibly be a result of less engaging stimuli or length of stimulus presentation or ISI. However, because the 12-month-olds' off-task behavior is most reflective of previous studies and it can be argued that the oldest infants should become "bored" most easily with a simple series such as the present paradigm, off-task behavior in the current sample is likely acceptable. Also, because previous studies have used up to a 1000 ms stimulus presentation and 1100 ms ISI, the present off-task behavior probably is not due to these factors.

Reaction Time

The hypothesis that RT would remain stable across 9 to12 months was supported. The RT results are consistent with previous findings (Canfield, 1997; Reznick 2000). Kail (1988; 1993) found a developmental decrease in RT with periods of more rapid decrease and periods when RT would plateau across childhood. Furthermore, Canfield et al. (1997) found a developmental decrease in RT in the first 9 months with no change at then end of the first year. Both Kail and Canfield et al.'s data show that a decrease in RT forms an asymptote during periods of development. As such, it is possible that the age period of 9 to 12 months marks a stabilizing of processing speed in infancy where the developmental curve asymptotes, but later in childhood, decreases in RT will occur again. The stabilizing of RT at then end of the first year may indicate temporary constancy of processing speed, perhaps due to the transition period occurring in the first and second attentional systems. After the transition is complete and the second attentional system is fully functional, processing speed will show further decreases.

Facilitation of RT. It was expected that facilitation of RT would occur in the series trials when infants could learn the rule and not in the baseline when trials were unpredictable. Results indicate that facilitation of RT does indeed occur in the series trials. This provides evidence for expectation formation when a predictable series is presented. The current results are the first to show facilitation of RT with older infants. Both Rose et al. (2002) and Canfield et al. (1997) found no evidence for facilitation. Further, Rose et al. (2002) actually found that baseline and series RTs were more similar at 12 months than at any other age, contradictory to what would be hypothesized on the basis that older infants form more expectations. The conflicting findings between the present study and previous studies can be resolved by examining methodological differences. First, both Canfield et al. and Rose et al. used a more complex (left-left-right) series presentation. In the present study, a simple (left-right) series presentation was employed, enabling infants to show more rapid saccades during the series trials. Thus, the opportunity to measure infants' facilitation was greater. Also, both of the previous studies were longitudinal. Following the same infants over a period of time enabled the examination of individual differences, but might not be optimal at capturing facilitation across the various ages. Finally, with the inclusion of 10- and 11-month-olds in the present sample, the argument is strengthened that facilitation occurs during a series presentation.

Standard Deviation of RT. The hypothesis that SDRT, thought to measure the underlying mechanism of sustained attention or "on-task" behavior, would decrease across the period of 9 to 12 months was not supported. The recent interest in SDRT is due to studies showing that adult SDRT correlates independently and more strongly than adult RT to IQ (Jenson, 1992; Larson & Alderton, 1990). Rose et al. (2002) suggest that SDRT and RT may be tapping two different cognitive processes. Whereas RT reflects speed of processing a particular cognitive event, SDRT may reflect the infant's ability to persevere, or stay on task (Haith et al., 1997). Given that the current findings show no change in SDRT across the 9 to 12 month period, this may indicate SDRTs have become stable by the end of the first year, enabling infants to stay on-task for longer periods of time. By contrast, the lack of change may indicate that SDRT is more a measure of individual differences. Thus, following the same infant across this period may show that those with more variable RTs at 9 months also have more variable RTs at 12 months. This is a plausible explanation as it has been shown that infants' SDRT at 3.5 months predicts IQ at 4 years
(Dougherty & Haith, 1997). Though the present study did not find developmental decreases in SDRT, it is likely the case that SDRT is a measure of infants' ability to sustain attention.

Anticipations

The hypothesis that %ANT would increase across 9 to 12 months was supported. The inclusion of 10- and 11-month-olds in this study further strengthens the argument that anticipations do indeed increase through the end of the first year. The current study is the first to show an increase in anticipations in the 9 to 12 month period. It has been suggested that the anticipation criterion should be lowered below 200 ms with increasing age because failing to do so may artificially inflate %ANT by assuming that infants do not show developmental increases in RT. However, as Rose et al. (2002) correctly mention, dropping the cutpoint across age would systematically diminish developmental increases in anticipations, which is not desirable. As an alternative, it is necessary to examine the anticipatory saccades to determine if the type of anticipation changes across development.

Reznick et al. (2000) made a distinction between different types of anticipations the infant might be exhibiting in the VExP. It is possible that the infant generates an anticipation based on specific expectations about what is occurring in the series, such as anticipations made in which the infant shifts on the basis of a specific expectation about timing, or identity of an upcoming stimulus. By contrast, an anticipation could also indicate a general goal-oriented expectation such that the infant will shift her gaze because she expects to see a stimulus appear in a specific location. Although this is a feasible hypothesis, goal-oriented anticipations are likely not formed until the latter part of the first year of life, when the second attentional system is active (Ruff & Rothbart, 1996). The argument that goal-directed anticipations are not present until the end of the first year is strengthened by the study conducted by Reznick and colleagues (Reznick et al., 2000). In the first experiment 6-, 9-, and 12-month-olds sat in front of 4 monitors arranged in a cross-pattern and were presented with a simple (left-right) series or complex series that included a "wing" location (i.e. top-left-bottom-left). In the second experiment, 4-, 8-, and 12-month-olds were presented with a simple (left-right) or simple (top-bottom) series. The experiments were designed to inspect whether infants make incorrect anticipations, such that they exhibit an anticipatory saccade toward an incorrect location. Results showed that younger infants make between 19% and 25% anticipations; however, only 8%-9% were correct anticipations. Older infants showed more anticipations overall and showed between 33% and 40% correct anticipations. The results suggest that older infants are more skilled at forming anticipations based on a specific expectation for location, whereas younger infants form expectations with no explicit underlying rule driving their behavior.

Based on the work of Reznick and colleagues, the current results suggest that goal-oriented expectations are being formed and a developmental increase in goal-oriented expectations occurs across the period of 9 to12 months. Further, much of the VExP literature suggests that %ANT is a measure of memory (e.g., Benson, Cherny, Haith, & Fulker, 1993; Canfield et al., 1997; DiLilla et al., 1990; Rose et al., 2002). The current results suggest that %ANT in the VExP may be good measure of memory by showing a developmental improvement in memory for goal-directed behavior across 9 to 12 months.

Individual Differences in RT

Correlational analyses replicated the findings of Rose et al. (2002) such that infants who showed faster baseline RTs showed faster RTs to series trials and had less variable RTs. One explanation for the current findings is that infants with faster RTs show them because they process information more effectively and sustain attention for longer periods of time. Correlational analyses also revealed that infants who showed faster baseline RTs showed more anticipations during the series trials and spent less time off task. Because infants with faster RTs have a more efficient speed of processing mechanism, it is logical that they learn a series and form expectations more often than infants with slower RTs. Furthermore, because SDRT is thought to measure attentional maintenance and SDRT was found to correlate with baseline RT, it is not surprising that infants with faster RTs in the baseline spent more time on-task during the series trials.

Attentional Development and Underlying Mechanisms in Older Infants

The current results provide support for Ruff and Rothbart's (1996) two-system model of attentional development. Recall that the first attentional system develops within the first nine months and is responsible for disengagement of attention and novelty preference. The second attentional system begins to develop at nine months, and is responsible for goal-oriented attention and control of complex activity. With infants exhibiting anticipatory saccades as early as two months, it can be argued that the mechanisms of the first attentional system drive the activity. To be sure, the first attentional system enables the infant to disengage attention from one location and shift fixation based on the timing or location of a stimulus. As infants reach nine months and the second attentional system emerges, infants develop the ability to form specific goal-oriented expectations about an event. As such, in the VExP, the older infant views the series, encodes it, and forms a specific expectation about what will occur in the series based on a comparison of the event to what is encoded. The infant subsequently makes a goal-oriented shift in fixation to foveate the anticipated stimulus.

Ruff and Rothbart argue that the second attentional system develops through the preschool years but that the period from 9 to 12 months is a transition period when the first attentional system is reorganizing in order to interact with the second attentional system. The current data support this claim as it seems that goal-oriented cognitive processing must still be developing at 12 months because infants show anticipatory shifts in less than 38% of all attended to trials. If the 12-month-old infant had a fully developed attentional system, anticipations should be much higher.

Rose and Tamis-LeMonda (1999) outlined five underlying mechanisms of visual information processing in infancy. They include speed of basic processes, memory, deployment of attention, perceptual organization, and development of a knowledge base. Three of these underlying mechanisms (speed of processing, memory, and deployment of attention) can be measured directly with the VExP. Speed of basic processes is measured by RT in the VExP. The current data show that RT is stable across the ages tested, thus the development of processing speed seems to plateau across this period. Similarly, SDRT, a measure of deployment of attention (on-task behavior) shows no changes in 9- to 12-month-olds. Thus, it too may plateau across this period of development. By contrast, memory as measured by anticipations, increases indicating improvement in this underlying mechanism during the period of 9 to 12 months. Hence, the current results suggest that the underlying mechanisms speed of processing, deployment of attention, and memory, most effectively measured by the VExP, follow different developmental trajectories at the end of the first year.

Future directions

Further research should be conducted longitudinally with 9-, 10-, 11-, and 12-month-olds to follow individual differences in improvement and to determine the extent to which there is stability shown across these ages. Because the current study is the first to explore the 10 to 11 month age range, it is important replicate the present results. Furthermore, long-term longitudinal studies will help strengthen the previous findings that individual differences in RT predict childhood IQ (DiLalla et al.,1990; Dougherty & Haith, 1997). Colombo (1993) found that infants with faster RTs have faster underlying mechanisms such as speed of processing and greater attention. Conducting longitudinal studies on older infants then continuing into childhood will aid in determining stability of RT and will aid in developing arguments for underlying mechanisms of cognition.

In addition, converging evidence from imaging techniques such as event related potential (ERP) studies is vital to propose theoretical models of expectation formation and the development of underlying attentional mechanisms in the older infant. Nelson (1995) suggests that the temporal lobe, which is not active until late in the first year, is essential in making a prediction, or being aware of an explicit rule. Assessing brain activity while engaged in the VExP will aid in understanding the development of goal-directed expectation formation and strengthen behavioral results. Future researchers may also find it worthwhile to assess heart rate. Physiological measures such as heart rate have not yet been reported in the VExP; however, heart rate has been shown to be related to infant attentional responses (Porges, Arnold, & Forbes, 1973; Richards, 1987; 1997). According to Berg and Donohue (1992), heart rate is a good physiological measure for studying anticipatory processes. They argue that infants display heart rate decelerations in response to stimuli and are even capable of showing heart rate decelerations in anticipation of an auditory stimulus. Based on this evidence, future research should examine whether heart rate shows decelerations prior to anticipations and if it is a correlate to underlying attentional mechanisms such as speed of processing, as measured by RT in the VExP.

Finally, future research should continue to address the criterion for anticipation latency, particularly in older infants. It is evident that no matter what the criterion selected, it will be too fast for some infants and too slow for others. However, determining the most appropriate cutpoint at each age is necessary in order to draw conclusions across studies. Currently, each lab determines a cutpoint most accurate for their data which makes it difficult to replicate findings and have conversations about what develops.

Conclusions

The present study using the VExP found that whereas RT remains stable across the period of 9 to 12 months, anticipatory saccades increased with the selection of a 167 ms anticipation criterion. These findings have significant implications for underlying attentional mechanisms driving older infants' behavior in forming expectations and demonstrating those expectations through anticipatory saccades.

The stability of RT found in the present study strengthens the argument that RT plateaus between the period of 9 to 12 months, but might show further decreases over subsequent development. RT has been thought to index the underlying mechanism speed of processing. As such, RT in the VExP can be seen as a predictor of present and future information processing abilities. Facilitation of RT is exhibited as an enhanced RT across trials and has been thought to index the infants' ability to detect the regularity of a sequence without forming an anticipation. The data show that 9- to 12-month-old infants do show facilitation of RT from baseline to series trials. Thus, it is likely that older infants do have an understanding of the temporal characteristics of the paradigm. Standard deviation of RT has become a recent measure of interest in the VExP literature. It has been suggested that SDRT is a measure of sustained attention and contributes independently of RT to cognitive processes. The data showed no changes in SDRT across the ages tested, thus it is possible SDRT follows a similar trajectory as RT and shows stability in the 9 to 12 month range, to be followed by later developmental changes. The present study is the first to show an increase in anticipatory saccades across 9 to 12 months. Percentage of anticipations is thought to be a measure of underlying memory processes. Based on the development of the second attentional system, if older infants are indeed forming goal-oriented expectations, then %ANT can be seen as a measure of the infant's learning and storage of the expectation in memory.

Weaknesses in methodology and coding of the present study could have possibly affected the outcome. First, a lack of diversity in the sample may have skewed results, as the sample may not accurately reflect the true population. Caucasians made up nearly 90% of the sample and almost 90% of parents had completed at least some college. A more diverse sample of ethnicity and parents' educational level would aid in the generalizability of the current sample to the population.

Second, the stimulus duration and ISI could have affected the degree to which the infants attended to the task. Off-task behavior was somewhat higher, but still consist with previous research. A decrease in stimulus presentation (less than 750 ms) and ISI could enhance infants' attentiveness. Rose et al. (2002) used a 500 ms presentation (while maintaining a 720 ms ISI) with the 12-month-olds in their longitudinal study and found it to be effective in sustaining attention across the task. Decreasing the presentation and the ISI below the current 750 ms, therefore, could possibly reduce off-task behavior.

Finally, the coding scheme, although consistent throughout the duration of the study, could have affected the RT and anticipation results. The coding scheme devised for the current study was a modification of Haith and colleagues coding scheme. More recently (Canfield et al. 1997; Reznick et al. 2000), however, descriptions of coding schemes indicate a coding scheme that deviates somewhat from Haith et al. (1988). Canfield et al. (1997) indicated the beginning of a saccade as an anticipation when the infant began to shift, even if the infant had to make large, corrective saccades upon stimulus appearance. Reznick et al. (2000) indicated anticipatory shifts even if they were shifts to the incorrect location. The current study only indicated shifts that fixated on the correct location and went directly from one location to the next, with no corrective shifts. Excluding incorrect anticipations and corrective saccades in the current study could have affected the percentage of anticipations by coding them as RTs or off-task behavior. A universal coding scheme should be adopted in order to avoid such inconsistencies across labs.

In conclusion, the current experiment provides evidence to support the notion that the VExP is useful paradigm for assessing infants' ability to sustain attention (as measured by SDRT), their processing speed (as measured by RT) and possibly memory (as measured by anticipations). However, this is the first study to show an increase in anticipations across the period of 9 to 12 months and the first to include 10- and 11-month-olds. Nonetheless, there is evidence that while the first attentional system is in place and functioning during the time period in question, it seems as though the second attention attentional system is beginning to develop and aid the infant in such tasks as forming goal-oriented expectations.

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APPENDIX A
INFORMED CONSENT FORM

Summer and Fall, 2001

I give my consent for my child, ______________________________, to participate in the research study titled "The Development of Visual Expectations in 9-12 Month Old Infants," which is being conducted by Dr. Janet E. Frick, Department of Psychology, University of Georgia, 542-5258. I understand that this participation is entirely voluntary. I can withdraw consent and terminate my child's session at any time without penalty, and have the results of the participation, to the extent that it can be identified as my child's, removed from the research records or destroyed.

The following points have been explained to me:

1. The reason for this research is to examine developmental changes in infant visual attention, and specifically, the relationship between behavioral measures of attention (such as looking) and physiological measures of infant attention (such as heart rate and breathing). The benefit that I may expect from participation in this study is helping provide important information on the early development of visual attention in very young children.

2. The procedures are as follows: my baby's heart rate and breathing will be measured while he or she engages in an attention task. Measurement of heart rate and breathing involves applying standard medical electrodes to the baby's chest, and attaching an elastic belt around the baby's waist to measure breathing. During the attention task, my baby will sit in my lap in front of a TV monitor, on which pictures will be presented. The baby will watch pictures on the TV for approximately 5 minutes; breaks can be taken during this procedure if the baby becomes fussy or fidgety. At the conclusion of the session, I will fill out a brief survey asking questions about the baby's health and general questions about our family. I am free to choose not to respond to any of these questions.

3. No lasting discomforts or stresses are foreseen as a standard part of this research; however, if my baby becomes fussy or sleepy, I am free to pause the session in order to comfort my child, or terminate the session without any penalty.

(over, please)

4. No risks from participating in this research are foreseen. The heart-rate electrodes are attached to the infant's chest with disposable, hypoallergenic adhesive collars, which are similar to small band-aids. While it is extremely unlikely, in the event that my infant should experience an allergic reaction to this adhesive, any expenses associated with this would be my responsibility. If my child has experienced past reactions to adhesives such as those found in band-aids, I have been asked to inform the researcher.

5. The results of this participation will be confidential, and will not be released in any individually identifiable form without my prior consent, unless otherwise required by law. In addition, all other information that may be observed concerning my child's health or welfare will be confidential, unless otherwise required by law. Sessions will be videotaped, but infants are issued an 8-digit ID number
which will be used on all testing materials, and thus infants cannot be identified by name on forms or videotapes of the testing session. Videotapes will be destroyed 10 years following completion of the study (approximately August, 2011).

6. The researcher will answer any further questions about the research, now or during the course of the project, and can be reached by telephone at 542-5258 (UGA Infant lab phone number) or through email at jfrick@egon.psy.uga.edu.

_______________________________________ _______________________________
Signature of Researcher Date Signature of Parent or Guardian Date

Please sign both copies of this form. Keep one and return the other to the investigator.

Research at the University of Georgia that involves human participants is overseen by the Institutional Review Board. Questions or problems regarding your rights as a participant should be addressed to Julia D. Alexander, M.A., Institutional Review Board, Office of the Vice President for Research, University of Georgia, 606A Boyd Graduate Studies Research Center, Athens, Georgia 30602-7411; Telephone (706) 542-6514; E-Mail Address JDA@ovpr.uga.edu.

APPENDIX B
HEALTH AND DEMOGRAPHICS FORM

I. Health Information

Baby's Date of Birth: _______ / _______ / _______ Birth Weight: _______ pounds
Baby was born:

- _____ Before the due date, by ___________ days (or, ______________ weeks)
- _____ On the due date
- _____ After the due date, by ___________ days (or, ______________ weeks)

Does your baby have any vision or eye problems? ____ yes _____ no

Has your baby had any serious illnesses or conditions? ____ yes _____ no

If yes to either, please explain.
____

How long has it been since your baby last woke up? ____________________________

How long has it been since your baby last ate? ____________________________

II. Demographic Information

Baby's gender: ____ female _____ male
Please choose the category which best describes your baby's ethnicity:

- _____ White (Non-Hispanic)
- _____ Hispanic
- _____ Black/African-American
- _____ Native American
- _____ Asian/Pacific Islander
- _____Other (please explain):____

(over, please)

Mother's Age: ________	Father's Age: _________
Mother's Education:	Father's Education:
_____ some high school	_____ some high school
_____ high school graduate	_____ high school graduate
_____ some college education	_____ some college education
_____ degree from 4-year college or more	_____ degree from 4-year college or more

Parent(s) Occupation:____

How many ***other*** children (brothers and sisters) under age 18 live at home? ___________