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RELATIVE HABITUATION AND RECOVERY OF VISUAL ATTENTION TO ORIENTATION-MOVEMENT COMPOUNDS BY NEWBORN INFANTS.

by

David P. Laplante

B.A. Hon. McGill University

A Thesis
Submitted to the Faculty of Graduate Studies
through the Department of Psychology
in Partial Fulfilment of the
Requirements of the Degree
of Master of Arts at the
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ABSTRACT

Previous research has demonstrated that newborns infants are capable of discriminating stationary objects based on one stimulus dimension. The present study asked the following questions: can newborns process spatial orientation changes?; does stimulus movement influence spatial orientation processing?; can stimulus movement changes be processed?; and can changes to two dimensions of a stimulus be detected? Forty-eight, 2-day-old newborns were administered successive presentations of either stationary or moving, high contrast, black-and-white square wave gratings (stripes) and their level of visual fixation was recorded. The results indicated that newborns are capable of detecting spatial orientation changes in stationary and moving stimuli. Moreover, the findings indicated that newborn infants were capable of detecting direction of movement changes. It was demonstrated that newborn infants could detect changes to two dimensions of a stimulus concurrently. It was concluded that newborns are capable of processing more than one stimulus dimension simultaneously, demonstrating that their information processing capabilities are more sophisticated than previously thought. Finally, it was hypothesized that newborns encode stimulus dimension information separately, but can integrate these memories during object discrimination tasks.

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CHAPTER I

INTRODUCTION

Previous research on newborn visual processing abilities (Friedman, 1972; Slater & Sykes, 1977; Weiss, Zelazo, Laplante, & Papageorgiou, 1991) has indicated that newborn infants are capable of discriminating between single components of visual arrays. However, by focusing on the newborn infants' ability to process changes in single dimensions of static visual arrays these studies have only been able to establish that information processing abilities are available at birth. These studies have not addressed the extent of the newborn infants' information processing capabilities. The present study is an attempt to increase our knowledge of the magnitude of the newborn infants' information processing abilities by attempting to determine whether newborn infants are capable of processing two independent, but visually salient features of an object, simultaneously and be able to use this information to discriminate between various visual compounds. Specifically, it is designed to determine whether newborns are able to distinguish between both the spatial orientation of high contrast black and white stripes and the direction of movement of a visual array.

In order to further investigate the processing potential of newborn infants, the present study asks whether they can encode, retain, and retrieve information about two dimensions of an object. Thus, the major question of concern is whether newborns can simultaneously extract information pertaining to both the spatial orientation (i.e., horizontal versus vertical orientation) and the direction of movement (i.e., lateral versus vertical travel) of a visual compound.

For the purpose of the present study, the dimensions of the visual stimulus are defined as separate and non-interacting components of a stimulus that provide uniqueness to it. Each characteristic is separate and independent from the other in that modification to one (i.e., changing the spatial orientation of high contrast stripes) does not result in changes in the other characteristic (i.e., the stimulus' movement). If newborn infants are capable of extracting both dimensions of an orientation-movement compound, and are able to utilize this information to distinguish between various orientation-movement compounds, an argument can be made that their processing abilities are more advanced than previously believed.

The stimulus dimensions of spatial orientation of square wave gratings and stimulus movement were chosen to form the basis of the visual compound because prior research has shown that newborn infants are able to distinguish between these elements (Slater, Morison, Town, & Rose, 1985; Slater & Sykes, 1977; Weiss et al., 1991). Yet, there exists no published accounts of research attempting to determine whether newborns are able to discriminate objects along both of these dimensions simultaneously. The research indicating the newborn infants' ability to discriminate between various aspects of these dimensions will be reviewed in turn.

Processing of Spatial Orientation Information by Newborns

Slater and Sykes (1977) and Weiss et al. (1991) have both demonstrated that newborns are capable of distinguishing between the spatial orientation of stationary square wave grating stimuli. Slater and Sykes (1977) reported that when horizontal and vertical square wave gratings were simultaneously presented to newborn infants in a paired comparison procedure, the newborns preferred to fixate the horizontal more than the vertical gratings. Such preference for horizontal over vertical orientation can only occur if the newborn infants' are able to differentiate between the two stimulus orientations. If the newborns were unable to discriminate between the two orientations they would have demonstrated equivalent attention towards both of the stimulus orientations.

Weiss et al (1991), in a study concerned with discriminating between newborns born at varying levels of risk for subsequent cognitive delays demonstrated that normal and moderate risk newborns were capable of detecting and processing spatial orientation changes of square wave gratings. In this study, newborn infants from three risk conditions were habituated to a stationary, 15 X 15 centimetre, square wave grating stimulus in either a horizontal or vertical orientation. Following habituation of visual fixation the newborns were presented with the same stimulus rotated 90 degrees. All newborns, regardless of their risk status habituated to the initial presentation of the square wave grating. However, recovery to the changed orientation occurred only for normal and moderate risk newborns; high risk newborns remained habituated. The results indicate that spatial orientation changes can be detected by normal and moderate risk newborns. Moreover, the results suggest that these stimuli are sensitive enough to discriminate between newborns born with varying degrees of risk for subsequent cognitive delays.

Furthermore, Maurer and Martello (1980) suggest that the ability to detect changes in the spatial orientation of a square wave grating occurs at the level of the visual cortex and is not a reflexive, non-cortical act. Their conclusions are based on evidence from neurophysiological research conducted on cats (Hubel & Wiesel, 1962), monkeys (Hubel & Wiesel, 1977), and humans (Campbell & Kulikowski, 1966) that indicated neuronal activity specific to spatial orientation occurs only at the level of the visual striate cortex. Likewise, evidence from monkeys with severe lesions in the visual cortex indicate that discrimination of spatial orientation is not possible (Weiskrantz, 1963). Moreover, Maurer and Martello were able to determine that 5 to 6 week old infants processed orientation change rather than detect changes in a specific region of a stimulus. Because it had been suggested that orientation discrimination might be affected by the infants' preference for horizontal scanning of visual stimulus (Salapatek, 1968), Maurer and Martello habituated their subjects to square wave gratings presented on the diagonal and tested them with the same square wave grating stimulus presented on the reverse diagonal.

Discrimination of the two orientations could not occur because of changes in the region specific contours because horizontal (or for that matter vertical) scanning of both orientations would detect the same physical properties in both orientations. The behavioral information obtained in Maurer and Martello's study indicates that newborn infants' ability to detect changes in the stimulus was the result of their processing the spatial orientation information at a more central level of the visual system since specific contrast effect differences were controlled for by using oblique orientations.

The newborn data presented above, coupled with the results obtained from Maurer and Martello (1980), suggest that the spatial orientation of square wave grating stimuli is an acceptable measure to use in determining whether newborn infants are capable of forming and utilizing memories of complex, two feature compounds. Moreover, because the ability to detect spatial orientation exists only at the level of the visual cortex, the discrimination of this stimulus dimension may be said to involve processing at higher cognitive centres. As such, a cognitive explanation is possible.

Processing of Stimulus Movement by Newborns

Stimulus movement was chosen as the second dimension of the visual compound because research indicates that newborn infants can perceive changes in the movement of stimuli (Burnham, 1987). Slater, et al. (1985) have demonstrated that newborn infants are capable of distinguishing between static and moving stimuli and between two rates of stimulus rotation. In a visual preference procedure, newborn infants were simultaneously presented pairs of identical stimuli undergoing one of three motions: i) maltese crosses rotating in the fronto-parallel plane around their midpoints; ii) a rotating maltese cross or triangle paired with an identical stationary stimulus; or iii) a maltese cross or triangle travelling the circumference of an imaginary circle paired with an identical stationary stimulus. Each pair of stimuli were presented until a total of twenty seconds of visual fixation were accumulated on each two trial. The stimulus' position were reversed on each trial.

The results indicated that the newborn infants preferred to fixate the moving stimuli. When the newborns were presented with identical stimuli, one rotating or travelling in a circle and the other stationary, they looked significantly longer at the moving stimuli. Approximately 71 percent of their total looking time was directed at the moving stimuli. Therefore, it appears that newborn infants are capable of perceiving differences between static and moving visual arrays, and prefer the moving one. This finding suggests that movement might elicit the attention of newborn infants. Furthermore, the likelihood of the moving stimulus attracting the newborns visual attention appears independent of whether the motion results in changes in spatial orientation or whether the spatial orientation remains the same. Therefore, Aslin and Shea's (1990) claim that stimulus movement is one of the most effective means of attracting and sustaining the visual attention of young infants appears accurate. It appears that even newborns are attracted more strongly to moving objects.

Furthermore, Slater et al. (1985) have demonstrated that newborns are able to differentiate between different rates of stimulus rotation. They presented newborns with pairs of identical maltese crosses rotating at three different speeds (i.e., 45 degrees per second; 90 degrees per second; 180 degrees per second) and their visual preference was recorded. When the low and intermediate rates of rotation were paired, newborns showed no differential preference. However, when the intermediate and fast rates were paired, newborn infants preferred [fixated] the stimulus rotating at the intermediate rate (90 degrees per second). These results indicate that newborns are capable of detecting differences in rates of rotation for objects moving in the same direction.

Slater et al. (1985) then attempted to determine whether newborn infants could detect changes in the direction of rotation of moving stimuli. Using an infant-controlled habituation procedure, Slater et al. habituated newborns to a maltese cross rotating in either a clockwise or counterclockwise direction. Following habituation, the newborns were presented with two identical crosses, one rotating in the familiar direction and the other rotating in the opposite, or novel, direction. It was hypothesized that if newborns could detect changes in the direction of rotation, they would fixate the cross rotating in the novel direction more during the post-habituation test trials. These hypothesized results were not obtained. While 53 percent of the newborn infants' attention was directed at the cross rotating in the novel direction, this difference did not reach statistical differences. This result suggests that motion direction changes of stimuli whose physical properties are undergoing constant spatial orientation transformations are not perceived by newborns.

The failure by Slater et al. (1985) to determine that newborn infants are capable of processing changes in direction of the movement of stimuli may have occurred for two reasons. First, it is possible that their procedure was not sensitive enough to detect potential differences in the newborn infants' visual fixation patterns. It is possible that Slater et al.'s reliance on overall fixation scores (i.e., the accumulation of twenty seconds of looking time for each trial) during the post-habituation test trials may have concealed potential preference differences. It is possible that during the initial phase of each trial, the newborns may have directed their attention at the cross undergoing the novel motion direction more frequently then they did at the cross undergoing the familiar motion. But because the newborns were forced to fixate the stimuli for twenty seconds, it is possible that subsequent fixations during these post-habituation trials could have become more evenly distributed as the newborn became aware that the two stimuli were identical.

Since Slater et al (1985) did not report the location of the newborns' initial fixation it cannot be conclusively stated that newborns cannot detect changes in a stimulus' direction of movement. Differences in looking behavior may be restricted to the newborns' early fixations. Slater et al.'s (1985) design did not allow for this comparison.

Second, it is possible that an interactive effect between the continuous changes in the spatial orientation of the two maltese crosses and the newborns' relatively slow location of stimuli within their visual field may have further hindered their ability to process the direction of rotation. Because the maltese cross is symmetrical in composition, the relative position of the arms during the post-habituation test trials were frequently identical, regardless of the direction of rotation. Whenever the forward edge of any arm of the maltese cross (forward in terms of direction of rotation) was at multiples of 45 degrees, the spatial orientation of the two crosses was the same. Therefore, it is possible that because the two stimuli shared the same spatial orientation every second (the stimuli were rotated at 45 degrees per second), the newborns ability to detect changes in the direction of the stimuli's rotation was impeded.

Aslin (1987) has reported that 1-month-old infants are able to relocate displaced objects, but that this ability is not performed extremely rapidly. When attempting to relocate an object, young infants (1-month and older) use a series of saccades that move at approximately 5-7 degrees of visual field per second. This is well below the fastest (900 degrees per second) or average (15 degrees per second) duration of saccades for normal adults (Aslin, 1987).

Therefore, an object displacement of 30 degrees would require approximately 5 saccades by the infants before the object came into sharp focus. This process would be completed in about 1.7 seconds. Unfortunately, there exists no literature that details the time it takes infants to shift their attention between the two stimuli within the preferential looking paradigm. Aslin's (1987) data suggests that the farther apart the two stimuli are the longer it would take the infants to shift their attention. While duration of relocation of stimuli is not problematic when static stimuli are used, it does become a problem when the stimuli are moving. Since the minimal distance between the two stimuli used by Slater et al. (1985) was nine centimetres (corresponding to 16.67 degrees of visual field) the shortest duration of relocation of the second stimulus would be approximately one second. Therefore, because the stimuli are rotating at 45 degrees per second, it is possible that the newborns viewed the stimuli in identical orientations.

Slater et al. (1985) may have obtained negative results concerning the newborn infants' ability to process direction of movement because the continuous changes in spatial orientation coupled with the newborns relatively long period of stimulus relocation may have resulted in the two stimuli being perceived as identical. As such, the perceptual similarities of the two crosses may have overridden any movement information. While this argument is only speculative, it provides a possible explanation as to why newborn infants were not capable of processing changes in the stimulus' direction of movement.

Therefore, if an alternative form of motion had been used to assess the newborns' ability to process and detect changes in a stimulus direction of movement, Slater et al (1985) might have obtained more positive results. For example, if they had habituated the newborns to a stimulus travelling the circumference of an imaginary circle in a clockwise direction and then tested their preference for the familiar and novel directions, it is possible different preference measures may have been obtained. Because motions that travel the circumference of an imaginary circle do not result in displacements of the spatial orientation of the stimulus' other physical properties, this form of motion is not confounded by spatial orientation changes. Thus, it is possible that this form of motion may be easier to process by young infants. Consequently, it is possible that changes in the direction of any motion that does not result in the displacement of an object's physical properties could be detected by newborns. However, this remains to be studied empirically.

Also, the above argument is only valid if the pre- and post-habituation stimuli are presented simultaneously during the post-habituation test phase. This widely used assessment technique (called paired comparison or preferential looking), which was utilized by Slater et al. (1985), may have further enhanced the perceptual similarities of the two maltese crosses through their simultaneous presentation. Because this procedure only requires the newborns to recognize differences between two presented stimuli, perceptual similarities between them may make the task of object discrimination difficult for them. It is possible that the paired comparison technique may not be sophisticated enough to ascertain whether newborn infants are capable of detecting minor stimulus changes, such as direction of rotation.

However, if the post-habituation test stimuli were presented alone, it is possible that newborns might be able to effectively process and detect changes in stimuli that are perceptually similar to that of the original stimulus. Even though this form of recall memory task is cognitively more difficult for newborns to perform (Crowder, 1976), it may that when the to be discriminated visual stimuli are perceptually similar this form of cognitive effort may be more effortless. Therefore, for perceptually similar stimuli, successive rather than simultaneous presentation of the test stimuli may be more effective in determining the newborn infants' information processing abilities.

It is expected that if the above methodological considerations are accounted for, newborn infants' ability to process movement direction changes can be better studied. The present study will attempt to answer this question. At the same time, the newborn infants' ability to process two dimensions of a visual compound will also be assessed. At present, no research has been conducted to determine whether newborns are capable of processing both movement and spatial orientation simultaneously. This lack of empirical verification probably stems from the Slater et al. (1985) finding that newborn could not detect changes in the direction of rotating objects.

Processing of Two Dimensions of A Visual Compound: Results from Older Infants and a Possible Explanation

Research using older infants has demonstrated that the processing of more than one dimension of a visual stimulus is possible. Burnham & Kyriacus (1982) indicates that stimulus movement may play a prominent role in object discrimination. After being habituated to a standard motion-shape compound, four- and six-month-old infants were tested with either a same shaped or novel shaped object moving in either a familiar or novel direction. The results indicated that four- and six-month-old infants used both shape and motion information when differentiating between the various shape-motion compounds. While all the infants preferred the novel over familiar shape, infants fixated the novel shape undergoing a novel motion more than any other compound, including the novel shape undergoing a familiar motion. Moreover, when presented with two familiar shapes moving in either a novel or familiar motion, infants looked longer at the familiar object undergoing the novel motion. Both of these findings suggests that as early as four months infants are capable of using two dimensions of an object for discriminatory purposes.

Also, Burnham and Day (1979) have indicated that 12- and 17-week-old infants were capable of detecting color changes in rotating cylinders. Moreover, the data indicated that response recovery was greatest when the novel color was paired with the faster of the two rotation velocities. Therefore, these infants were attending to both rotation and color information since recovery to the novel color would have been equivalent across the two rotations if the infants were not attending to the motion.

Cohen (1973) has developed a theoretical model which can be used to help explain how young infants are capable of processing more than one dimension of a visual stimulus. Cohen believes that the information processing system that is required to detect changes in external stimuli is comprised of two independent, yet equally essential components: Attention-Getting and Attention-Holding. The Attention-Getting component determines whether an infant will visually engage an object. The Attention-Holding component determines how long the infants will remain attentive once they have fixated the stimulus. Moreover, Cohen believes that the two components are influenced by different aspects of a stimulus. The Attention-Getting component is more affected by the size and/or movement of a stimulus. The Attention-Holding component is influenced by the complexity and familiarity of the visual stimulus. Processing is the result of a combination of these two components. Habituation of either process will result in a lowering of the infants attention. However, it appears that the Attention-Getting component initially plays a more prominent role in the processing system as this component determines whether or not the infant will attend to the stimulus. Once attention is established, the Attention-Holding component becomes more influential. Therefore, the Attention-Getting component works to direct the infants attention towards objects while the Attention-Holding component works to sustain their attention so that stimulus encoding can occur.

The above research suggests that changes in two dimensions of an object can be processed by young infants. This ability appears to be available to the infant by 12-weeks. However, this does not mean that this ability is not available to younger infants. Since that data suggest that even newborn infants are capable of processing each dimension separately, it is possible that when combined they will be able to process both simultaneously.

To recapitulate. It has been demonstrated that newborn infants are capable of detecting differences between horizontal and vertical spatial orientations of high contrast, black and white stripes (Slater and Sykes, 1977). Likewise, Weiss et al. (1991) have reported that normal and moderate risk newborn infants who have been habituated to one spatial orientation of black and white stripes (i.e., horizontal) display a recovery of their visual attention to the stimulus when it has been rotated 90 degrees (i.e., vertical). Also, Slater et al. (1985) have demonstrated that newborn infants are capable of differentiating between static and moving stimuli, and between two rates of stimulus rotation. However, these same researchers failed to demonstrate that newborns are capable of detecting changes in the direction of rotation of the stimuli. As such, it appears that newborn infants are capable of detecting and processing information concerning the spatial orientation of high contrast, black and white stripes and certain motions of symmetrical maltese crosses and triangles. Moreover, the failure of the newborns to detect direction of movement changes may have been the result of methodological limitations. As Cohen (1973) has suggested, changes in stimulus motion may effect only initial periods of looking behavior. Therefore, a procedure that captures this form of looking behavior may discover that newborn infants are capable of processing movement changes.

An Information Processing Approach

Before outlining the hypotheses of the present study a theoretical account of the utilization of visual fixation as a means of assessing cognitive functioning in newborns is required. Likewise, a brief review of the how visual fixations are used to infer cognitive functioning will be presented. This approach used habituation and subsequent recovery of visual fixation toward a visual stimuli to infer cognitive functioning. This section will be followed by Dannemiller and Banks' (1983, 1986) critical review of the information processing position of suggesting that habituation and recovery infer cognitive functioning in the young infant. In turn, this will be followed behavioral and neurophysiological evidence that weakens some of the main tenets of the selective receptor model, as well as Ackles and Karrer's (1991) review of the evidence on which this model is based.

The present study uses visual fixation directed at a orientation-movement compound as an indices of information processing, as previous reviews (Bornstein, 1985, 1989; Werner & Perlmutter, 1979) have suggested that attention towards visual stimuli can be used as a valid measure of cognitive functioning in young infants. This approach to the study of cognitive functioning assumes that young infants' visual fixations are representative of the underlying processes necessary for cognition. By drawing from adult and child models of information processing (c.f., Atkinson & Shiffrin, 1968; Flavell, 1985), infant researchers are attempting to explain the phenomena of response decrement (habituation) to repeated presentations of visual stimuli and subsequent recovery (dishabituation) to discrepancy or novelty within a cognitive context. Although the field of infant cognition is in an early phase of building a theory of cognitive development beyond the stage model of Piaget (1954), the current information processing model of infant cognition has offered some useful theoretical focus.

Aronson and Tronick (1971) have argued that differences in information processing abilities observed across pre-linguistic infants reflect quantitative differences in the infants ability to utilize their underlying cognitive processes, rather than reflecting qualitative shifts in cognitive functioning as proposed by Piaget (1954). Aronson and Tronick suggest that while the cognitive processes of stimulus encoding, storage, and retrieval are the same for all pre-linguistic infants, differences typically observed between infants below and above four-to-five months of age, can be used to indicate the younger infants' more inefficient utilization of their underlying processes. Processing differences, according to Aronson and Tronick, do not indicate that the required cognitive structures are functionally different between the young and old infants, as proposed by Piaget (1954). Rather they reflect the degree to which the pre-linguistic infants utilize the underlying cognitive processes.

For example, Aronson and Tronick (1971) suggest that the differences in visual tracking of rapidly moving objects reported by Bower, Broughton, and Moore (1971) for infants below and above 20-weeks of age occurred because the younger infants were unable to sufficiently encode the object displacement information fast enough, and not because they did not possess the necessary underlying cognitive processes. Therefore, rapidly moving objects were likely perceived as being stationary lines by the young infants because of their poorer information processing capabilities.

The present study provides a logical extension of the argument put forth by Aronson and Tronick (1971) by assuming that the cognitive processes required to adequately process external information, namely stimulus encoding, storage, and retrieval, are available at birth. This argument suggests that the underlying cognitive processes are similar between newborn infants and older pre-linguistic infants. As before, newborns differ from older pre-linguistic infants only in terms of their ability to utilize their underlying cognitive processes. This quantitative difference in processing ability is best seen in two ways. First, newborns require more time to encode stimulus information. Second, they possess a more limited storage capacity, which is of shorter duration. Also, newborn infants have fewer means by which to express their cognitive capabilities. Unlike older pre-linguistic infants who are capable of indicating recognition of external stimuli through a variety of ways (i.e., pointing, directed gaze, stimulus directed vocalizations), newborns have a more limited expressive repertoire. As such, information processing in newborns is usually inferred through changes in their visual fixations, headturning towards a sound source, or non-nutritive sucking. These variables represent a much more limited means of cognitive expression. Yet, it has been demonstrated that newborn infants appear to possess and utilize similar underlying processes to guide their cognitive actions as those of older infants.

As mentioned above, previous research has demonstrated that newborn infants are able to detect changes in single dimensions of visual stimuli. For example, Friedman (1972) has demonstrated that newborn infants are capable of detecting differences in the number of squares in checkerboard displays. Likewise, Slater and Sykes (1977) demonstrated the newborn infants are capable of discriminating between horizontal and vertical orientations of square wave gratings (i.e., high contrast, black and white stripes). While this research has demonstrated that newborns are equipped to process information in their environment, it says nothing about the newborn infants' full processing potential. By focusing on the newborns' ability to process single dimension information, infant researchers have only been able to identify the lower limits of the newborn infants processing abilities. The present study is designed to determine whether newborns can encode, retain, and retrieve information concerning two dimensions of a stimulus.

If newborn and older pre-linguistic infants have the same underlying cognitive processes necessary to encode, store, and retrieve information, it is likely that when placed in the right situations newborn infants will be able to process similar forms of information as their older counterparts. Therefore, it is theoretically acceptable to expect that newborns are capable of processing both stimulus movement and a change in another property of a stimulus, much in the same manner as the older infants do (i.e., Burnham and Day, 1979, Burnham and Kyriacus, 1982). As such, it is expected that newborns will be able to simultaneously process information from two dimension, much in the same manner as that observed in older infants.

The issue faced by the researcher should not be whether newborns have the necessary underlying processes, but whether they (the researchers) are capable of designing conditions in which the newborns true information processing abilities can be assessed. Therefore, researchers interested in understanding the nature of newborn development should attempt to create situations which are perceptually more salient to newborns so that their processing capabilities are not limited by design limitations. The present study attempts to provide the newborns with a visual compound and an experimental procedure that is expected to enhance and not hinder the newborns information processing abilities.

Habituation and Recovery of Visual Attention as a Measure of Information Processing in Young Infants

Habituation of visual attention towards a visual display is thought to reflect the reciprocal mental processes of memory construction and comparison (Bornstein, 1988), thus indicating information processing. Mental construction is believed to consist of the infants' active encoding and storing of the visual stimulus. The end product of stimulus encoding and storing is the development of a mental representation of the visual array. The process of mental comparison consists of the infants' continuous need to contrast incoming information about the visual stimulus with their developing mental representation of the stimulus. Thus, the reduction of visual attention, which defines habituation, reflects the development of the infants' memories for the repeatedly presented stimulus. Therefore, habituation of visual attention is thought to indicate central processing abilities in newborns and older infants since the reduction of visual fixations is believed to be correlated with memory development.

However, according to Sophian (1980), habituation of visual attention alone is not a valid measure of information processing. The reliance on habituation of visual attention is problematic because infants may display a response decrement for a variety of reasons. For example, a reduction of visual attention might arise as a result of stimulus encoding (true cognitive habituation) or from an increase in negative affect (i.e., crying and/or drowsiness). If habituation alone was used as the indicator of information processing, infants who reach criterion for habituation for different reasons (i.e., encoding or fatigue) could not be differentiated. As such, Sophian argues that a measure of response recovery is necessary to determine the infants true processing abilities. A measure of recovery would provide a more accurate account of the infants' information processing abilities as it requires that the infants first habituate to a repeatedly presented stimulus and then dishabituate to a novel stimulus.

Hence, measures of information processing in newborns and older infants are best obtained when measures of recovery of visual attention to novelty following habituation are recorded.

Bornstein (1989) argues that measures of recovery of visual attention to a novel object provide the clearest demonstration of central processing because attention will only recover if the infants' perceive differences between the familiar and novel objects. This ability to discriminate between familiar and novel objects indicates that infants are capable of remembering salient properties of the familiar object. Moreover, this ability indicates that infants are able to use this memory of the familiar object as a base from which to compare incoming information. If the incoming information matches what is already in memory, no further attention is required. On the other hand, if the incoming information does not match the existing memory, further attention is required and the infants display a recovery in their overall level of attention. Thus, the infants differential attention towards the novel stimulus during post-habituation trials can be used as a valid measure of their information processing capabilities.

In general, habituation of visual attention is believed to reflect the formation of a mental representation of the external visual array. Infants reduce their amount of visual attention as their mental representation becomes more developed. Therefore, low levels of attention after several repeated presentations of the visual array is assumed to indicate that the infants have formed a memory of the object. As such, the reduction in attention is associated with the development of a memory, which according to the information processing approach is essential to cognitive functioning (Bornstein, 1988). More importantly, a renewal of attention to a novel visual array indicates that infants are capable of using their mental representations of familiar objects as a means of comparing new information. When the novel incoming information does not match their existing mental representations their attention is heightened. Thus, habituation and recovery reflect the internal processes of memory formation and mental comparison. Both of these processes are important within a model of information processing.

An Alternative Explanation: Selective Receptor Adaptation Model

However, the information processing explanation of habituation and recovery of visual attention is not universally supported. Dannemiller and Banks (1983, 1986) have argued that habituation of visual fixation (and the ensuing recovery to novelty) in infants below 3 to 4 months of age is the result of selective receptor adaptation at the level of the visual cortex. Thus, response decrement to a repeated visual stimulus is believed to result from the fatigue of feature specific neurons in the visual cortex. Recovery of visual attention to novelty occurs because the novel array excites a different set of non-fatigued feature specific neurons in the visual cortex. Their position suggests that cognitive processes are not required for stimulus discrimination by infants below three to four months.

Dannemiller and Banks have based their position on their interpretation of the neurophysiological findings that the visual cortices of cats (Hubel and Wiesel, 1962) and monkeys (Albrecht, DeValois, & Thorell, 1980) separate visual stimuli into their component features. This research has demonstrated that the visual cortex is designed to respond selectively to bars and edges of various sizes and orientations and to differing spatial frequencies and orientations. More importantly, they argue that it has been shown that the repeated presentation of the same stimulus result in the feature specific neurons loosing their ability to transmit this information to the rest of the cortex. Therefore, the perceiver becomes functionally blind for that specific type of visual stimulation during the refractory period. Finally, they cite evidence reported by Pettigrew (1974) indicating that this effect was greater in young kittens when compared to mature cats. For Dannemiller and Banks (1983) this information provided sufficient evidence to conclude that early perceptual discriminatory abilities were the result of neurological fatigue and not resulting from cognitive functioning. Moreover, they used Pettigrew's (1974) data to suggest that this effect was greater in the infant below 3 to 4 months of age.

To demonstrate the power of their model, Dannemiller and Banks (1983) reinterpreted Friedman's (1972) newborn data within a selective receptor adaptation model. In this study Friedman habituated newborn infants to either a 2 X 2 or 12 X 12 checkerboard pattern and then tested their recognition memory abilities using the non-habituated pattern. Friedman's results indicated that the newborns visual attention habituated to repeated presentations of the familiar checkerboard pattern and then showed subsequent recovery to a novel pattern during the test period. Friedman attributed this effect to the newborn infants' ability to form and retain a memory of the initial stimulus and to use this memory to detect differences between the familiar and novel checkerboard patterns. Therefore, newborn infants, according to Friedman, are capable of cognitive functioning.

Dannemiller and Banks (1983) suggest that a cognitive explanation of this pattern of visual attention was not required. They suggest that the newborns habituation to the checkerboard pattern was the result of selective receptor adaptation of feature specific neurons. For the 12 X 12 checkerboard pattern, they suggest that the newborns' set of receptors designed to respond to and process short-line, thin-bar, and high spatial frequency information became fatigued with the repeated presentation of the initial stimulus. Furthermore, the subsequent introduction of the 2 X 2 pattern resulted in increased visual attention because this pattern excited a set of feature detectors responsible for long-line, wide-bar, and low spatial frequency information. They suggest that habituation was the result of receptor fatigue and recovery was the result of the novel stimulus exciting a set of non-fatigued neurons. They concluded that what Friedman obtained was a indication of selective receptor adaptation and not a demonstration of cognitive functioning in newborn infants.

Critique of the Selective Receptor Adaption Model

Dannemiller and Banks (1983, 1986) position has been criticized from both behavioral and neurophysiological perspectives. Zelazo, Weiss, and Tarquinio (1991) have summarized the behavioral evidence that contradicts the main tenets of the selective receptor adaptation model. While the review centres on data obtained from auditory perception studies, these authors feel that the central processing requirements of the two perceptual modalities are similar enough to justify using the results to place doubt on Dannemiller and Banks' position. However, until studies using the visual modality are performed, the arguments against the selective receptor adaptation model are theoretical. Perhaps the most compelling behavioral data used to counter Dannemiller and Banks claim comes from the long-term retention studies of Zelazo and his colleagues (Swain and Zelazo, 1987; Zelazo, Weiss, Randolph, Swain, & Moore, 1987). In both studies it was demonstrated that newborn infants remained habituated to a familiar word (i.e., tinder or beagle) after delays of 10 and 55 seconds, but demonstrated response recovery (recovery of headturning directed at the sound source) after delays of 100 and 145 seconds. Furthermore, Swain and Zelazo (1987) demonstrated a 24 hour savings effect. This study tested the effect that previous experience with the same sound had on the newborns' retention abilities. These authors repeated the procedures of Zelazo et al. (1987) on two consecutive days. The findings for the first day matched those obtained by Zelazo et al. (1987). However, different results were obtained for the Day II testings. While all infants oriented to the sound (same sound as used on Day I) on Day II, they habituated at much faster rates. In addition, the newborns remained habituated to the familiar word after delays of up to 145 seconds were introduced. These findings appear to indicate that newborn infants are capable of retaining some information about repeatedly presented words for a period of 24 hours. The more rapid rate of habituation and the longer period of retention of the information during the testing (145 seconds on Day II versus 55 seconds on Day I) suggest a savings effect. It is unlikely that neural feature detectors would remain habituated for this length of time.

The second piece of behavioral data that weakens Dannemiller and Banks (1983) position comes from the work of Tarquinio, Zelazo, and Weiss (1990). These authors demonstrated that newborn infants' attention recovered to an auditory stimulus of weaker intensity following habituation at a standard intensity. This evidence provides a direct challenged to selective receptor adaptation model since the model suggests that recovery to a stimulus of lower intensity would not be possible. This is because changes in a stimulus' intensity do not result in different neurons being fired (intensity only determines the number of neurons within a specific set which will be fired). Therefore, if the selective receptor adaptation model was correct, stimuli of lesser intensity should not be able to excite the fatigued neurons. Because newborns are capable of responding to the same sound at a decreased level of intensity, an explanation other than the one proposed by Dannemiller and Banks must be used.

Ackles and Karrer (1991) argue that the evidence Dannemiller and Banks (1983, 1986) claimed supported the selective receptor adaptation model of habituation and recovery of visual attention was not valid. The primary area of concern was Dannemiller and Banks' (1983) claim that receptor refractory periods could last as long as several hours. Ackles and Karrer (1991) suggest that the neurophysiological data indicates that refractory periods last on the order of milliseconds (Bullock, Orkland, & Grinnell, 1977), not the hours claimed by Dannemiller and Banks. Also, they point out that Hubel and Wiesel (1962) reported that receptor fatigue occurred only for specific areas of the visual field of each receptor; the entire receptor never fatigued. As well, receptor fatigue occurs only if the eye has been totally immobilizing thereby permitting the stimulus to fall on exactly the same receptors trial after trial. They argue that this is difficult to obtain in anesthetized cats and probably impossible to obtain in an infant.

Moreover, Ackles and Karrer (1991) suggest that the evidence cited by Dannemiller and Banks (1983) to justify their claim that the selective receptor adaptation effect is greater in less mature organisms is inaccurate. They argue that the data presented by Pettigrew (1974) cannot be used as evidence of a developmental shift in receptor adaptation as Pettigrew did not directly compare adult and infant cats. In general, Ackles and Karrer suggest that the phenomenon of habituation and recovery of visual attention cannot be adequately explained using the selective receptor adaptation model.

In conclusion, the literature suggests that habituation and recovery (dishabituation) of visual attention to visual stimuli is the result of cognitive activity and does not occur as a result of neuronal fatigue. The behavioral data suggests that neurons in the auditory area of the cortex do not remain fatigued for as long as the selective receptor adaptation model suggests. Using the auditory system to refute Dannemiller and Banks' claim regarding the functioning of the visual system may not be best means of contradicting selective receptor adaptation model, but it would seem unlikely that differences in the neural functioning of the two modalities could justify Dannemiller and Banks' position. As such, using measures of visual attention directed at a complex visual compound can be seen as a valid attempt to assess the information processing capabilities of newborn infants. Therefore, subsequent results obtained in the present study will be expressed in terms of cognitive activity.

Newborn Visual Processing of Two Dimensions of a Visual Compound: The Present Study

The present study has been designed to answer three separate questions. The first part of the present study is designed to replicate Weiss et al.'s (1991) findings that newborn infants are capable of detecting changes in the spatial orientation of high contrast, black and white square wave grating (striped lines). In addition, two empirical questions related to the effect of movement on spatial orientation discrimination will be examined. As such the second questions asks whether spatial orientation changes can be processed by newborns when the stimulus is moving. Consequently, movement will be added to the gratings, and the spatial orientation processing abilities of newborn infants will be assessed. The third question focuses on whether newborn infants are capable of processing both spatial orientation and movement dimensions of a visual compound simultaneously.

Question I: Can newborn infants process changes in the spatial orientation of a stationary stimulus?

The first question has been designed to replicate the findings of Weiss et al. (1991). As such, the study seeks to determine whether newborn infants are capable of detecting changes in the spatial orientation of stationary high contrast, black and white square wave gratings. As with the Weiss et al. study, it is expected that newborns who have been habituated to the repeated presentations of a visual stimulus containing either a vertical or horizontal spatial orientation, and then presented with a visual stimulus containing the opposite spatial orientation, will display a recovery of their visual attention.

Specifically, it is expected that all newborn infants will initially attend to a visual stimulus of either vertical or horizontal spatial orientation. Moreover, the initial spatial orientation of the stimulus' square wave gratings will not influence the newborns overall level of visual attention. After several presentations of the same visual stimulus it is expected that all newborns will display a reduction of their visual attention, thus indicating that they have processed and retained information concerning the spatial orientation of the stimulus' square wave grating. Finally, it is expected that only the newborns who are presented with a visual stimulus that contains a novel spatial orientation [Movement (None) - Orientation (Change) (M(N) - O(C)) condition] will display a recovery of the level of visual attention. The level of visual attention of newborns in the Movement (None) - Orientation (Same) [M(N) -O(S)] condition, who will receive the same stimulus during the post-habituation test trials, will remain at the habituation level.

Therefore, it is anticipated that the present study will demonstrate that newborn infants are capable of processing spatial orientation information of stationary stimuli. As such, the present study is expected to replicate the findings of prior research (Weiss et al., 1991). By replicating the findings of

Weiss et al. it is hoped that subsequent findings concerning the effect of stimulus movement may be more easily addressed.

Question II: What is the effect of stimulus movement on the newborn infants' ability to process spatial orientation changes?

This question asks whether stimulus movement has any effect on the newborn infants' ability to process spatial orientation changes. Using the same high contrast, black and white square wave grating stimulus as used to answer the first question of the present study, newborn infants will be presented with either a stationary stimulus or with a stimulus moving vertically or horizontally across their visual fields. This design permits study of the potential effects that stimulus movement might have on spatial orientation processing.

It is believed that the newborns will be able to detect spatial orientation changes when the visual stimulus is moving [Movement (Same) - Orientation (Change) (M(S) -O(C)) condition] and when the stimulus is stationary [M(N) - O(C) condition]. Moreover, it is expected that the recovery of attention for the newborns in the spatial orientation change conditions will be greater than that for the newborn infants in the no change control conditions. Newborns in the M(N) - O(S) and Movement (Same) - Orientation (Same) [M(S) - O(S)] conditions will not display dishabituation during the post-habituation phase.

The visual attention of the newborns, regardless of whether they are presented stationary or moving stimuli is expected to habituate to the repeated presentations of the original visual stimulus during the habituation phase. It is anticipated that the newborns' attention will gradually decrease over the habituation period.

However, two measures of visual attention during the habituation phase are expected to differentiate the M(N) - O(C) and M(S) - O(C) conditions. First, because moving stimuli are believed to be preferred by newborns over identical stationary ones (Slater et al., 1985), it is expected that the mean latency to fixate the stimulus will be shorter for the M(S) - O(C) condition. This is because it is believed that the movement of the stimulus will attract the newborns' attention more so than the static stimulus. Therefore, it is postulated that movement may function as an attention getting mechanism for newborns. Consequently, it is expected that newborns in the M(S) - O(C) condition will require more trials to habituate to the original stimulus This is because the stimulus' movement is expected heighten the newborns' awareness of their visual surroundings. Thus, the stimulus' movement should increase the total amount of attention directed at the stimulus throughout the entire experiment.

Following habituation of their visual attention, it is anticipated that the newborns in the change conditions, regardless of movement condition, will demonstrate response recovery of their visual attention to a change in the spatial orientation of the stimulus. The newborns' overall attention is expected to increase to pre-habituation levels. Recovery of visual attention will be used to indicate that the newborns perceived the two spatial orientations as being different.

Similar to the habituation phase, it is expected that differences in the speed in which the newborns in the two condition become cognizant of the spatial orientation change will differ. It is hypothesized that newborns in the M(S) - O(C) condition will notice and therefore process the spatial orientation change faster than the newborns from the M(N) - O(C) condition. The stimulus' movement is expected to quicken the discriminative abilities of newborns because of its attention attracting ability. By attracting the newborns attention to the stimulus faster, movement will increase the speed at which newborn infants detect spatial orientation changes. No changes are expected for the two control conditions.

Therefore, stimulus movement is expected to increase the speed in which newborns attend to and therefore process changes in their environment. By directing the newborns' attention to stimuli in their environment, movement may facilitate their information processing abilities.

Question III: Can newborn infants process two dimensions of a visual compound simultaneously?

The final question asks whether newborn infants are capable of processing two dimensions of a compound visual stimulus simultaneously. In other words, can newborns process both spatial orientation and movement direction dimensions of a compound visual stimulus concurrently, or must they focus on one dimension to the exclusion of the other. The former suggests that the information processing capabilities of newborn infants is more sophisticated than presently believed. As previously mentioned, research has focused on single dimension processing and has examined multiple dimension processing.

In order to assess whether newborns are capable of processing spatial orientation and movement components, a visual compound was developed such that each dimension could be independently manipulated. As a result, the visual compound that will be used in the present study is a high contrast, black and white square wave grating that can be positioned in either a vertical or horizontal orientation. In addition, the stimulus has been designed to travel either vertically or horizontally across the newborns' visual fields. The stimulus will move in such a manner that its spatial orientation is not altered. Therefore, four spatial orientation-movement compounds are possible. They are: Vertical Orientation-Vertical Movement; Vertical Orientation-Horizontal Movement; Horizontal Orientation-Vertical Movement; and Horizontal Orientation-Horizontal Movement.

It is hypothesized that newborns repeatedly presented with any one of the four visual compounds will exhibit habituation of their visual attention directed at the stimulus during the habituation phase of the experiment. Regardless of the specific spatial orientation-movement composite, the newborns' visual attention will decrease with increased exposure to the visual compound. Moreover, neither visual compound is expected to attract the newborns attention faster than the others. As a result, the newborns' mean latency to fixate the visual compounds will be equivalent across the four spatial orientation-movement combinations. However, it is hypothesized that the newborns' mean latency to fixate the visual compound will increase as their overall level of visual attention decreases. With repeated presentations of the visual compound, they newborns will take longer to fixate the stimulus.

To assess whether newborns are capable of processing and detecting changes in both dimensions of the visual compound four post-habituation experimental conditions will be required. Three of the experimental conditions will involve a change in one or both of the compounds' dimensions. The remaining condition will function as a no change control. In the first condition, Movement (Change) - Orientation (Change) [M(C) - O(C)], both dimensions of the visual compound are modified. In the second condition, Movement (Same) - Orientation (Change) [M(S) - O(C)], only the spatial orientation of the visual compound is changed, the stimulus' direction of movement remains unchanged. In the third condition, Movement (Change) - Orientation (Same) [M(C) - O(S)], the spatial orientation of the compound remains the same while the stimulus' direction of movement changes. In the final condition, M(S) - O(S), no changes to the stimulus' dimensions occur.

Changes to the visual compounds' two dimensions are expected to differentially influence the manifestation and overall degree of recovery of the newborns' visual attention. In general, it is expected that changes in the stimulus' direction of movement will result in rapid recovery of visual attention during the initial period of the first post-habituation test trial. However, for movement only changes it is expected that the duration of recovery will be short-lived. In order for sustained recovery of the newborns' attention, it is hypothesized that changes in the compound spatial orientation will be necessary. In other words, movement changes are expected to attract the newborns' attention quickly, but spatial orientation changes are expected to maintain their attention.

Specifically, it is expected that newborns presented with a visual compound undergoing movement direction changes (i.e., M(C) - O(C) and M(C) - O(S) conditions) will display higher levels of attention recovery during the initial period of the first post-habituation test trial than newborns in two experimental conditions that do not involve movement direction changes. The change in the direction of movement is expected to redirect the newborns' attention back towards the visual compound faster than either changes in the spatial orientation alone or when no change to the compound occurs. As such, the newborns' mean latency to fixate the compound will be shorter for the M(C) - O(C) and M(C) - O(S) conditions. Therefore, initial levels of recovery are expected to be under the control of the movement dimension.

However, the spatial orientation dimension of the visual compound is predicted to influence the overall level of visual attention recovery more than movement changes. Therefore, newborns in the M(C) - O(C) and M(S) - O(C) conditions are expected to display a greater degree of recovery of their overall visual attention than the remaining two conditions. This finding is anticipated because it is believed that spatial orientation changes will be able to maintain the newborns attention in much same manner as it did for the static stimuli presented to the newborns by Weiss et al. (1991).

It is believed that newborn infants will be able to process both dimensions of the visual compound. However, their expression of discrimination, as determined by their level of visual attention during the post-habituation phase of the experiment, will vary depending upon which dimension is altered. Thus, it is anticipated that the newborns degree of recovery will correspond to the specific dimension modification. Movement changes will result in rapid, but brief recovery. On the other hand, spatial orientation changes will result in a much higher degree of recovery.

Because it is expected that recovery of the newborns' attention will be effected by changes in both dimensions of the visual compound, four levels of visual attention recovery are expected. First, it is expected that the newborns in the M(C) - O(C) condition will display the highest level of visual attention recovery. Newborns in this condition will benefit from changes in both dimensions. The changed direction of movement will initially attract their attention, while the changed spatial orientation will hold their attention. Second, newborns in the M(S) - O(C) condition are expected to display significant levels of recovery, but their recovery will be lower than that of the M(C) - O(C) condition. The changed spatial orientation is expected to recapture their attention in much the same manner as a stationary stimulus would. Their level of recovery is not expected to match that of the M(C) - O(C) condition because these newborns will not be aided by a change in the compounds' direction of movement. Therefore, their attention will be directed towards the changed spatial orientation at much slower rates compared to the M(C) - O(C) condition. Third, it is expected that newborns in the M(C) - O(S) condition will display some initial visual attention recovery as a result of the changed direction of the stimulus' movement. However, it is not anticipated that their overall level of recovery will be sufficient to indicate object discrimination. Therefore, overall attention measures may mask potential movement discrimination abilities in newborn infants. Finally, newborns in the M(S) - O(S) control condition are not expected to show any signs of visual attention recovery. Their visual attention during the post-habituation test trials should remain stable or decrease even more.

Summary of Hypotheses

The fist question asks whether newborn infants are capable of processing spatial orientation changes of a stationary black and white striped stimulus. This question was included to provide empirical support for the findings reported by Weiss et al. (1991). As with the previous study, it is expected that newborns will be able to detect spatial orientation changes of the stationary stimulus.

The second question asks whether the introduction of motion has any effect (either positive or negative) on the newborn infants ability to process spatial orientation changes of the same black and white striped stimulus used to answer question one. It is expected that the introduction of movement will attract the newborns' attention faster than the stationary stimulus, yet will result in the infants requiring relative more trials to reach criterion of habituation. Finally, it is expected that movement will increase the speed in which the newborns detect the spatial orientation changes. In general, the introduction of movement is expected to aid the newborns in processing spatial orientation changes by increasing the speed at which they will initially visually engage the stimulus.

The final question asks whether newborn infants will be able to simultaneously detect changes in both movement and spatial orientation changes. It is hypothesized that newborns will be able to process both dimensions simultaneously. Moreover, it is expected that movement changes will lead to faster processing of spatial orientation changes by orienting the newborns toward the stimuli quicker than newborns who are presented with a stimulus containing a novel spatial orientation but undergoing the familiar movement. Therefore, it is hypothesized that newborns presented with stimuli containing changes to both dimensions of the visual compound will display the greatest level of recovery.

CHAPTER II

METHOD

Subjects

The subjects for this study were forty-eight, 2-day-old newborns (mean age: 54.7 hours; males: 22; females; 26) were recruited from the Well Baby Nursery of the Salvation Army Grace Hospital. Only full-term (38-42 weeks gestational age) newborns who experienced uneventful deliveries (i.e., no indication of meconium staining) and peri-natal histories, and whose one and five minute Apgar scores were 7 or greater were recruited. Also, newborns who were suspected of having visual dysfunctions were excluded from the potential recruitment population. By restricting the sample population to healthy full-term newborns with no known visual abnormalities, it was hoped that any subsequent differences in measures of visual attention would be the result of the newborns' information processing abilities and not the result of any medical complications.

Conditions

The newborns were divided into one of six experimental conditions of eight newborns. Two conditions involved a stationary stimulus while the other four conditions involved the use of a moving visual compound. See Table 1 for a detailed description of each condition.

Table 1. Description of the six experimental conditions. Spatial orientation of the square wave grating and direction of movement (if any) are provided for the Habituation and Post-Habituation phases of the experiment.

CONDITIONS		TEST PHASES			
		HABITUATION		POST-HABITUATION	
		MOVEMENT	ORIENTATION	MOVEMENT	ORIENTATION
MOVEMENT	01	None	Vertical	None	Horizontal
(NONE) -	02	None	Vertical	None	Horizontal
ORIENTATION	03	None	Vertical	None	Horizontal
(CHANGE)	04	None	Vertical	None	Horizontal
	05	None	Horizontal	None	Vertical
(Grp 1)	06	None	Horizontal	None	Vertical
	07	None	Horizontal	None	Vertical
	08	None	Horizontal	None	Vertical
MOVEMENT	09	None	Vertical	None	Vertical
(NONE) -	10	None	Vertical	None	Vertical
ORIENTATION	11	None	Vertical	None	Vertical
(SAME)	12	None	Vertical	None	Vertical
	13	None	Horizontal	None	Horizontal
(Grp 2)	14	None	Horizontal	None	Horizontal
	15	None	Horizontal	None	Horizontal
	16	None	Horizontal	None	Horizontal
MOVEMENT	17	Vertical	Vertical	Vertical	Horizontal
(SAME) -	18	Vertical	Vertical	Vertical	Horizontal
ORIENTATION	19	Horizontal	Vertical	Horizontal	Horizontal
(CHANGE)	20	Horizontal	Vertical	Horizontal	Horizontal
	21	Vertical	Horizontal	Vertical	Vertical
(Grp 3)	22	Vertical	Horizontal	Vertical	Vertical
	23	Horizontal	Horizontal	Horizontal	Vertical
	24	Horizontal	Horizontal	Horizontal	Vertical
MOVEMENT	25	Vertical	Vertical	Horizontal	Vertical
(CHANGE) -	26	Vertical	Vertical	Horizontal	Vertical
ORIENTATION	27	Horizontal	Vertical	Vertical	Vertical
(SAME)	28	Horizontal	Vertical	Vertical	Vertical
	29	Vertical	Horizontal	Horizontal	Horizontal
(Grp 4)	30	Vertical	Horizontal	Horizontal	Horizontal
	31	Horizontal	Horizontal	Vertical	Horizontal
	32	Horizontal	Horizontal	Vertical	Horizontal
MOVEMENT	33	Vertical	Vertical	Horizontal	Horizontal
(CHANGE) -	34	Vertical	Vertical	Horizontal	Horizontal
ORIENTATION	35	Horizontal	Vertical	Vertical	Horizontal
(CHANGE)	36	Horizontal	Vertical	Vertical	Horizontal
	37	Vertical	Horizontal	Horizontal	Vertical
(Grp 5)	38	Vertical	Horizontal	Horizontal	Vertical
	39	Horizontal	Horizontal	Vertical	Vertical
	40	Horizontal	Horizontal	Vertical	Vertical
MOVEMENT	41	Vertical	Vertical	Vertical	Vertical
(SAME)-	42	Vertical	Vertical	Vertical	Vertical
ORIENTATION	43	Horizontal	Vertical	Horizontal	Vertical
(SAME)	44	Horizontal	Vertical	Horizontal	Vertical
	45	Vertical	Horizontal	Vertical	Horizontal
(Grp 6)	46	Vertical	Horizontal	Vertical	Horizontal
	47	Horizontal	Horizontal	Horizontal	Horizontal
	48	Horizontal	Horizontal	Horizontal	Horizontal

In the Movement (None) - Orientation (Change) condition, the newborns were habituated to a stationary visual stimulus possessing one of two spatial orientations (vertical or horizontal). During the post-habituation test phase, the spatial orientation of the stimulus was rotated 90 degrees (vertical to horizontal or horizontal to vertical).

In the Movement (None) - Orientation (None) condition, the newborns were presented with the same stationary visual stimulus during both experimental phases.

For the remaining four experimental conditions the newborns were habituated to one of four spatial orientation-movement visual compounds during the habituation phase. The four compounds are: Vertical Orientation-Vertical Movement; Vertical Orientation-Horizontal Movement; Horizontal Orientation-Vertical Movement; and Horizontal Orientation-Horizontal Movement. For each condition, all four spatial orientation compounds were utilized twice.

During the post-habituation test phase, the compound which the newborns are presented depended upon the specific experimental condition. In the Movement (Same) - Orientation (Change) condition, the newborns were presented with a visual compound in which the spatial orientation was rotated 90 degrees (vertical to horizontal or horizontal to vertical) while the direction of movement remained unchanged (vertical to vertical or horizontal to horizontal).

In the Movement (Change) - Orientation (Same) condition the newborn infants were presented with a visual compound possessing the same spatial orientation (vertical to vertical or horizontal to horizontal) while its direction of movement was changed (vertical to horizontal or horizontal to vertical) during the post-habituation test phase.

In the Movement (Change) - Orientation (Change) condition, the newborns were presented with a visual compound in which both its spatial orientation (vertical to horizontal or horizontal) and direction of movement (vertical to horizontal or horizontal to vertical) were altered during the post-habituation test phase.

In the Movement (Same) - Orientation (Same) condition, the newborns were presented with the same visual compound during both the habituation and post-habituation test phases. Hence, the visual compound had the same spatial orientation (vertical to vertical or horizontal to horizontal) and direction of movement (vertical to vertical or horizontal to horizontal) during both phases.

In order to complete the data collection in a balanced manner, the following group assignment strategy was utilized. Eight recruitment blocks of six subjects (one subject per experimental condition) were created using random number tables. Within each recruitment block, the order in which the experimental conditions would be filled was randomized once again. Thus, eight randomly formed recruitment blocks, in which the order of recruitment across the six experimental conditions was also randomized, were obtained. This method of subject recruitment ensured even completion of the conditions, as one condition cannot be filled at a faster pace than the other four.

Apparatus

The apparatus used in the present study was a three-sided viewing chamber containing a roof, floor, and an interior partition. The viewing chamber was constructed in two parts. The front end of the chamber was constructed in wood and provided the necessary depth and viewing angles. The back end of the chamber was constructed in metal and housed the machinery responsible for moving the visual compound. The viewing chamber can be seen in Figures 1 and 2. Figure 1 is a view of the front of the chamber (as seen by the newborns). Figure 2 is a picture of the lights and blackout screen as seen from the back of the chamber.

The exterior of the chamber (excluding the motor housing) is 71.12 centimetres wide X 71.12 centimetres high X 60 centimetres deep. A 43.18 X 43.18 centimetre opening is located in the centre of the rear wall of the viewing chamber so that the visual compound can be presented to the newborns. The exterior of the chamber is painted a flat white.

As mentioned above, an opening is located in the centre of the rear wall of the viewing chamber. A second opening is located 20 centimetres from the rear wall and has the following dimensions: 24.13 centimetres wide X 39.05 centimetres high. The dimensions of the interior partition that form the second opening

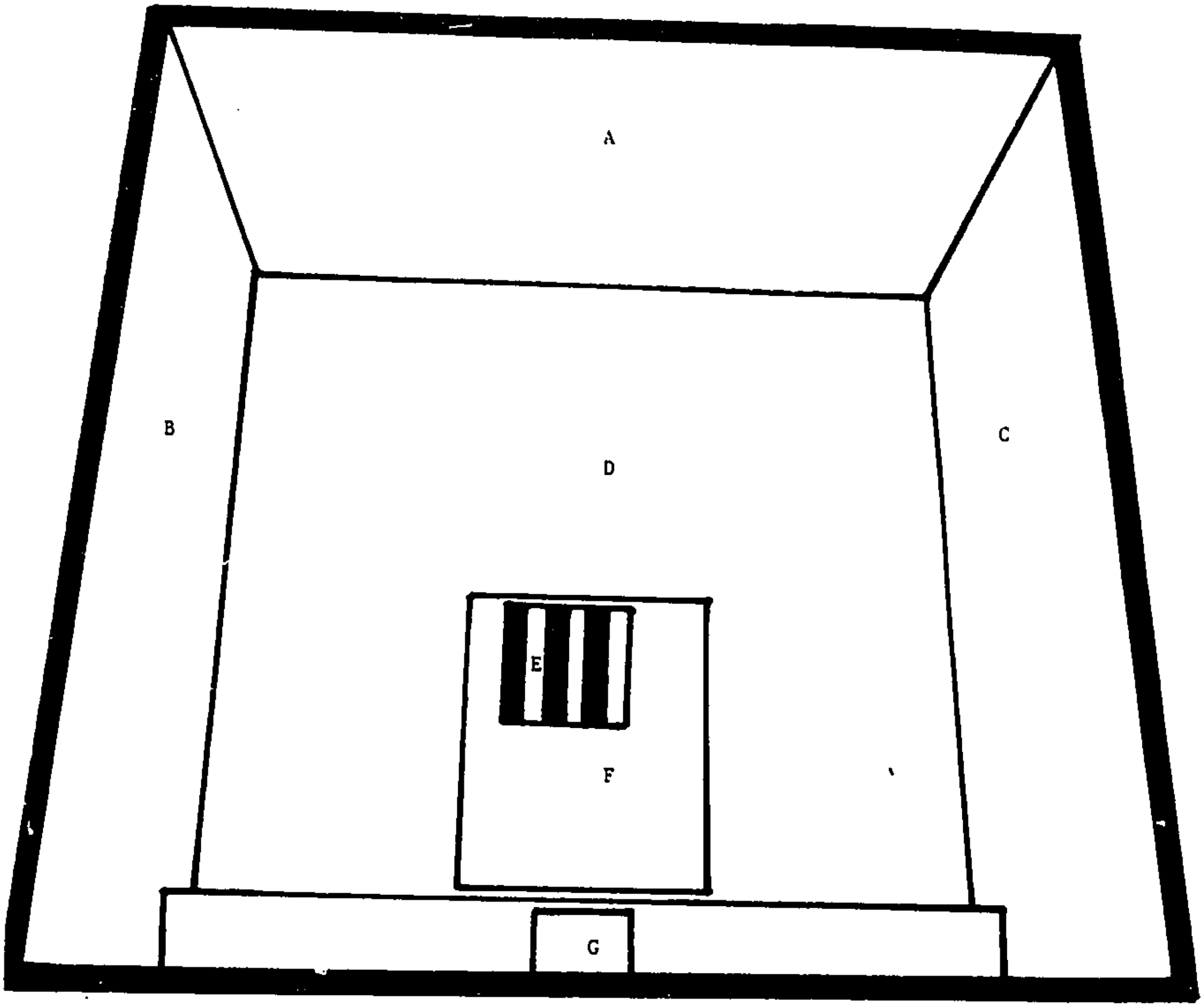

Figure 1. Front view of the viewing chamber. The main structures of the chamber are :'A': Chamber roof; 'B': Left sidewall; 'C': Right sidewall; 'D': Front of the interior partition; 'E': Visual stimulus; 'F': Rear wall (movable); and 'G': Mirror assemble.

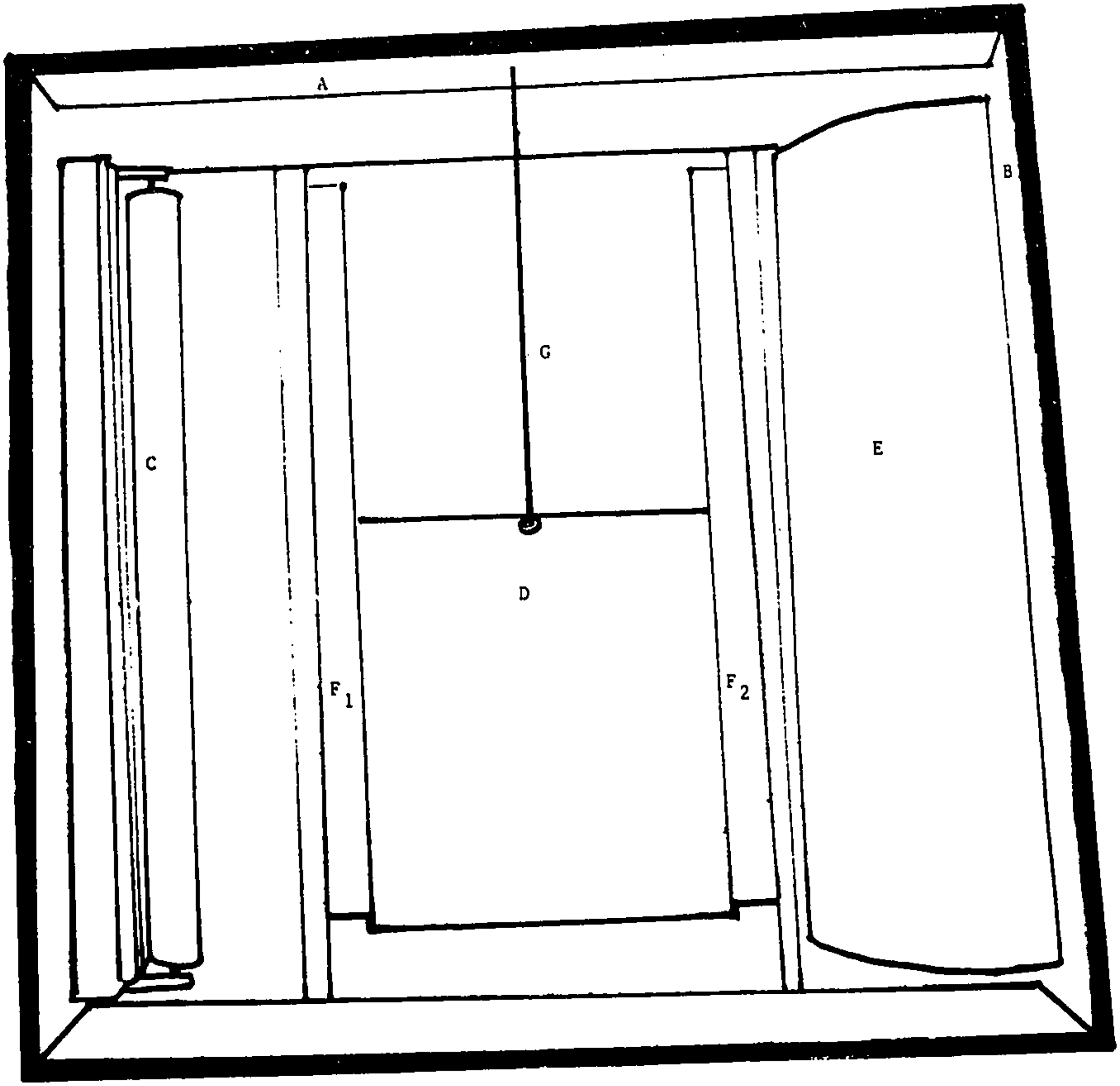

Figure 2. Back view of the viewing chamber. The main structures of the chamber are: 'A': Chamber roof; 'B': Left sidewall; 'C': 20 watt, fluorescent tubing (located of each sidewall); 'D': Back of the blackout screen; 'E': Light Baffle (located over each fluorescent tube); 'F_1' and 'F_2': Blackout screen guides; and 'G': Back of the interior partition. are: side-wall= 23.5

centimetres; top= 26.35 centimetres; and bottom= 5.72 centimetres. This opening enables the newborns to see approximately 2.54 centimetres on each side of the opening on the rear wall. This allows the newborns to clearly observe the entire travel area of the visual compound without seeing any potentially distracting properties of the viewing chamber (i.e., lights). The floor of the viewing chamber extends 45 centimetres from the rear wall to the front edge. This distance results in the newborns being 50 centimetres from the visual compound. All interior wall, ceiling and, floor surface is painted a flat grey in order to absorb as much of the non-stimulus directed lighting as possible and provide a uniform background.

Located in the centre of the bottom panel of the interior partition is a small rectangular mirror. The mirror is positioned at a 45 degree angle from the newborns such that its midpoint is 35.56 centimetres from the left side-wall of the viewing chamber. The mirror is angled 4 degrees from its vertical axis (away from the newborns) so that the entire face of the newborns is captured on the video monitor. In order to minimize the distractibility of the mirror, it is entirely enclosed. The roof of the baffle runs the entire width of the interior of the viewing chamber (71.12 cm) at a width of 10.16 centimetres. The front side of the baffle also runs the entire width of the chamber, however, a 10.16 centimetre opening is located equidistant from both side-walls (30.48 centimetres from each wall) permitting the face of the newborns to be viewed from the mirror. A circular opening of 7.62

centimetres in diameter was made in the left side-wall just before the front of the interior partition. A 100 centimetre long tubing extends from the opening to the camera. This tubing ensures that no exterior light enters into the viewing chamber. Aimed at the mirror, from a distance of 135.56 centimetres is a videocamera. The videocamera recorded the faces of the newborns during the testing. The camera was also connected to a black and white monitor that will permit on-line recording of the three dependent measures by the coder. The construction of the baffle around the mirror ensures that a clear image of the newborns face.

The visual compound is lit by two 20 watt fluorescent tubes located directly behind interior partition. Light diffusers ensure even lighting across the entire viewing area. Vents are provided so that no excessive heat from the tubes is allowed to build up.

Located behind the upper panel of the interior partition is a sliding blackout screen. The screen is opened and closed using a series of pulleys attached to a lever. When the lever is lowered the screen is raised, allowing the newborns to view the visual compound. When the lever is raised the screen is lowered, obstructing the newborns' vision of the compound.

The visual compound is connected to a motor that controls its movement. The motor is entirely enclosed so that no extraneous light is permitted to enter the viewing chamber.

The visual compound is mounted so that it can be rotated 90 degrees, permitting the direction of travel can be changed. The rotation is controlled by a reversible motor that positions the structure in three positions: horizontal, vertical and a neutral position in between the two experimental positions. The spatial orientation of the compound is changed by a second reversible motor. The researchers were able to position the visual compound into three spatial orientations: horizontal, vertical, and a neutral position in between the two experimental positions.

The computer and videotape monitor were located to the right of the viewing chamber. Both monitors were positioned so that the researchers have unobstructed views.

Visual Compound

The visual compound is shown in Figure 3. The compound was a 12.7 X 12.7 centimetres, high-contrast, black and white, square wave grating. The stimulus contained a series of six stripes, alternating between black and white. When viewed at a distance of 50 centimetres, the visual compound subtended a visual angle of approximately 14.33 degrees of the newborns' visual field. At the same distance, each stripe subtended a visual angle of approximately 2.4 degrees of the newborns' visual field. The visual compound had either a vertical or horizontal spatial orientation (see Figure 3) depending upon the experimental condition.

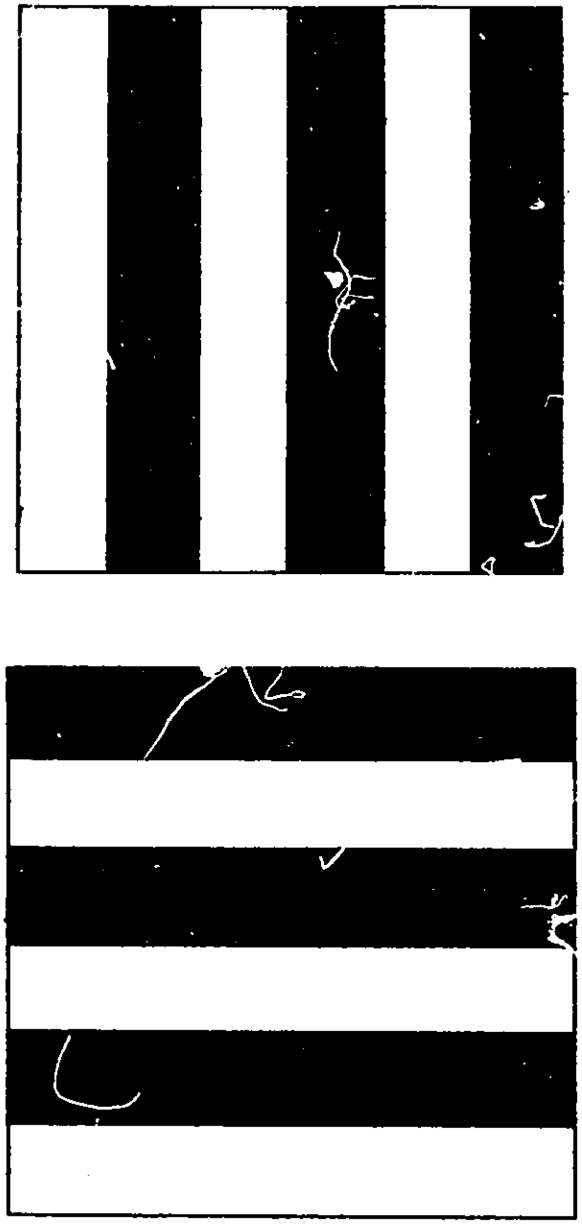

Figure 3. The Visual Compound

Direction of Movement

Because the make-up of the two movements were identical in all aspects expect for their direction of travel, only the horizontal movement is described in detail. At the beginning of each trial the visual compound was at rest in the centre of the rear wall of the viewing chamber. The compound then travelled 12.7 centimetres to the right, reversed its direction of travel and moved 25.4 centimetres to the left, where it once again reverse its direction of travel and moved 12.7 centimetres to the right, coming to rest at the starting point. See Figure 4 for a schematic representation of the compound's direction of movement.

The visual compound travelled a total distance of 50.8 centimetres during each trial. The range of travel (from the extreme left to the extreme right) was 38.1 centimetres. At a viewing distance of 50 centimetres, the full range of travel subtended a visual angle of approximately 37.33 degrees of the newborn infants' visual field.

The compound travelled at a rate of 1.69 centimetres per second or 1.24 degrees of visual angle per second. This velocity of travel was chosen as research by Roucoux, Culee, and Roucoux (1983) has indicated that newborns are capable of sustaining relatively long periods of smooth visual pursuit when the velocity of travel is slow.

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                              X--------->--------->---------X

X---------<---------<---------<---------<---------<---------X

X--------->--------->---------X
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Figure 4. Schematic representation of the direction of movement of the visual compound

Dependant Measures

Three major classes of dependent measures were recorded during each trial: visual fixation, fretting, and eyes closed. Each measure was further divided into two components: overall duration of visual fixation (fret, eyes closed) and latency to first visual fixations (fret, eyes closed).

Visual fixation was defined as any instance of stimulus directed gaze that was not associated with negative affect. In order for instances of visual fixation to be recorded, the corneal reflection of at least one of the newborn's eyes must have minimally covered 50 percent the visual compound. Instances of visual fixation were recorded by depressing the designated button on the mouse attached to a Phillips personal computer. The "visual fixation" button was released when the corneal reflection covers less than the required 50 percent of the newborns' pupil.

Overall duration of visual fixation was defined as the total of all instances of visual fixation during each trial. This measure was calculated by summing the length (in seconds) of all fixations. Latency to the first fixation was defined as the time it takes (in seconds) the newborn to first fixate the compound during each trial.

Fretting was defined as any instance of negative affective vocalization coupled with the pursing of the mouth and squinting of the eyes. As with visual fixation, instances of fretting were recorded by depressing the designated button on the mouse. The "fret button" was depressed for as long as the newborn was fretting. When the newborn terminated this behavior, the button was released. As with visual fixation measure, fretting was divided into two components: overall duration of fret and latency to first fret.

Eyes closed was defined as any instance in which both of the newborn's eyes are fully closed. As above, all instances of eyes closed were recorded by depressing the designated "eyes closed" button on the mouse as long as the behavior persisted. Likewise, measures of overall amount of eyes closed and latency to first instance of eyes closed were calculated for each trial.

The above three dependent measures have been designed to be mutually exclusive measures of the newborn's behavior. As such, only one of the three dependent measures was recorded at any given time. In order to guard against erroneously elevating the newborn's level of visual fixation, measures of fretting and eyes closed took precedence over the visual fixation measure. It was believed that this conservative approach to recording the newborn's visual fixation behavior protected against false incidents of dishabituation during the post-habituation test phase trials.

While the distinction between eyes closed and visual fixation is straightforward - one cannot fixate a visual compound when one's eyes are closed - the distinction between fretting and visual fixation is more complex. Fretting usually indicates that the newborn is in a state of general discomfort. However, it is not always possible to discern the immediate cause for the discomfort. The discomfort might be compound related (i.e., a result of boredom with the compound) or non-compound related (i.e., a result of fatigue, hunger, or a bowel movement). Moreover, it is not possible to determine whether or not the newborn is actively fixating the compound during bouts of fretting. Therefore, all instances of visual fixation during periods of fretting were not recorded. Instead the duration of the fret was recorded.

A second coder was familiarized with the coding scheme and recoded six randomly chosen testings to determine the reliability level of each dependent measure. The reliabilities were based on information obtained for 58 trials. A correlation of r= .72 was obtained for overall visual fixation and a correlation of r= .78 was obtained for latency to first fixation. For the two negative state measures, correlations of r= .96 and r= .80 were obtained for fretting and eyes closed.

Computer Program

A computer program had been written to perform three main functions. First, the program determined the length of each trial. At the beginning of each trial the computer was activated, permitting the mutually exclusive recording of the three main variables. However, after 30 seconds had elapsed (the length of each trial) the program terminated, suspending the observer's ability to record further behaviors. Moreover, at the completion of the 30 second trial, the computer program signalled the experimenters that the trial had come to an end.

The second main purpose of the computer program was to calculate the newborns' overall fixation levels. The program was designed to calculate the mean length of visual fixation for three consecutive trials. By using the first three trials as a baseline measure, the program determined when the newborns had reached criterion of habituation. At such time, the program had been designed to indicate to the experimenter holding the newborns that a change in the compound was required.

The third purpose that the computer program was designed to perform was that of a behavioral data collector. The program kept an account of all behavioral instances that were keyed into it by the observer. When one of designated buttons was depressed the program indicated (in tenths of a second) the onset and offset points of the behavior. This permitted the creation of all of the aforementioned dependent measures.

Procedure

A newborn-controlled habituation-dishabituation procedure was used in the present study. During the habituation phase the visual compound were presented to the newborns for a varied number of 30 second trials. In this procedure, the length of the habituation phase is determined by the visual fixation levels of each individual newborn. The procedure was divided into two phases.

In the Habituation Phase, the mean visual fixation scores of the first three trials served as the baseline measure. Criterion of habituation was defined as an average reduction of visual fixation to 40 percent of the initial baseline measure during three consecutive habituation trials. During this phase the newborns were repeatedly presented with one of the following six stimuli: vertical spatial orientation-no movement; horizontal spatial orientation-no movement; vertical spatial orientation-vertical movement; vertical spatial orientation-horizontal movement; horizontal spatial orientation-vertical movement; and horizontal spatial orientation-horizontal movement. Measures of visual fixation, fretting, and eyes closed were recorded.

During the Post-Habituation Test Phase, the stimulus was modified according to the experimental condition in which the newborn was assigned. Measures of visual fixation, fretting, and eyes closed were recorded during three trials. These three post-habituation test trials were used to assess whether the newborns' visual attention recovered or remained at habituation levels.

The individual testing procedure for each trial of the study was consistent across experimental conditions and phases. The newborn infants were brought into a conference room adjacent to the day nursery, either from the parent's room or directly from the day nursery. Attempts were made to dim the lights within the conference room (the curtains were drawn and the lights turned off) in order to reduce as many extraneous distracters as possible. To encourage an alert, inactive state for testing, attempts were made to assess the newborn infant after he/she has received a feeding and has had his/her diaper changed. Earlier experience (Weiss et al., 1991) has indicated that this procedure works well in establishing a testable state in newborns. Likewise, the newborn's nightshirt was loosened around the neck and the newborn was re-swaddled. Again, previous experience has shown that this was effective in promoting an alert, inactive state in newborn infants.

Once the newborn was in an alert state, one experimenter (holder) positioned the visual compound into its proper, habituation phase setting, and then positioned the newborn in the midline of the viewing chamber facing the rear wall at a viewing distance of approximately 50 centimetres. When the newborn was properly positioned, the second experimenter (observer) opened the blackout screen, and activated the motor and computer program. The opening of the screen was accompanied by an discernible clicking sound as the screen latched into position. The trial was continued until 30 seconds had elapsed. During the trial period, the observer recorded all instances of visual fixation, fretting, and eyes closed. After the 30 second period had elapsed, the computer program automatically terminated, the motor disengaged, and the observer closed the blackout screen. During the inter-trial interval, the holder moved the visual compound to its neutral settings for both dimensions and then reset the compound to for the next trial according to the experimental phase. Once this was accomplished the above steps were repeated. The entire testing was videotaped for later reliability analyses.

CHAPTER III

RESULTS

Because the present study was designed to examine three different questions, each question will be analyzed and presented separately. Within each question, the analyses will be reported in two parts: those obtained during the habituation phase and those obtained during the post-habituation phase.

The habituation phase consisted of a minimum of six trials in which the first three trials were used to obtain a baseline measure of visual fixation for each newborn. This phase continued until the newborn's visual fixation drop below forty percent of their original baseline attention for three consecutive trials. The first Trial Block of the habituation phase is composed of the first three trials that were used to obtained the newborn's baseline visual attention. The second Trial Block is composed of the last three trials during which an average reduction of forty percent of their visual fixation occurred.

The post-habituation phase was made up of the three trials presented to the newborns after habituation was obtained. These trials either included a novel visual stimulus in terms of orientation and/or movement for the subjects in the change conditions or the same, familiar stimulus for the subjects in the control conditions. There were six conditions defined as follows: Movement (None) - Orientation (Change) [M(N) - O(C)] - spatial orientation change with no movement; Movement (None) - Orientation (Same) [M(N) - O(S)] - no spatial orientation change nor movement; Movement (Same) - Orientation (Change) [M(C) - O(C)] - spatial orientation cnange in with same movement throughout both phases; Movement (Change) - Orientation (Same) [M(C) - O(S)] - movement change for a stimulus containing same spatial orientation throughout both phases; Movement (Change) - Orientation (Change) [M(C) -O(C)] - changes to both movement and spatial orientation; and Movement (Same) - Orientation (Same) [M(S) - O(S)] - stimulus contained the same movement and spatial orientation throughout both phases.

For the habituation phase of each question the following variables will be examined: negative state, latency to first visual fixation per trial, total visual fixation per trial, and the number of trials to habituate. Negative state was defined as the total amount of fretting (seconds) plus the total amount of eyes closed (seconds) during each trial. Subsequently, the mean amount of negative state per trial was calculated for each newborn for the two Trial Blocks of the habituation phase by summing the total amount of negative state displayed during each three trial block and dividing by three. This procedure resulted in determining the average amount of negative state displayed by each newborn per trial during each of the two habituation phase Trial Blocks.

Latency to first fixation per trial was defined as the delay between trial onset and the first fixation to the stimulus during each trial. Mean latency to first fixation per trial was calculated for each newborn by averaging their latencies across the three trials of each Trial Block. This procedure yielded the average latency per trial that each newborn took to fixate the stimulus during each of the two Trial Blocks.

Total amount of visual fixation per trial was defined as the sum of the duration of all visual fixations per trial. The mean visual fixation was calculated by dividing the total amount of visual fixation obtained during each of the three trials that were used to form each trial blocks by the number of trials (3).

The number of trials to demonstrate habituation of the newborn's visual attention was calculated to determining the number of trials required for the newborns to decrease their attention to forty percent of their original level. This always included as a minimum the three baseline trials and the three trials that formed the second trial block. As such, the minimum number of trials that each newborn was exposed to during the habituation phase was six. There was no predetermined maximum for the number of habituation trials.

In the post-habituation phase each subject was presented with three trials. The following variables were calculated for each trial: total duration of negative state, latency to first fixation per trial, and total visual fixation per trial. Thus, during this phase trial was treated as a repeated measures.

Question I: Can newborn infants process changes in the spatial orientation of a stationary stimulus?

To determine whether a change in the spatial orientation of a stationary object can be detected by newborns the data obtained for the M(N)O(C) and M(N)O(S) conditions will be examined. During the habituation phase newborns from each condition were presented with either a vertically or horizontally oriented, stationary black-and-white striped pattern. During the post-habituation phase the newborns in the M(N)O(C) conditions were presented with a stimulus that differed in its spatial orientation (i.e., vertical rather than horizontal) while the M(N)O(S) newborns were presented with the stimulus in the same orientation during both phases.

Habituation Phase

It was hypothesized that newborns from both conditions should display similar levels of negative affect, latency times, and total amount of visual attention throughout the habituation phase. Moreover, it was hypothesized that the initial spatial orientation of the stimulus would not influence the values of the dependent measures.

Means and standard deviations for mean amount of negative state, mean latency to first fixation per trial, mean total visual fixation, and mean number of trials to habituate for each of the Condition X Orientation categories are presented in Table 2.

Orientation. A 2(Orientation) X 2(Trial Block) analysis of variance (ANOVA) was performed on each dependent measure to determine if the initial orientation of the stimulus had any effect. For each measure, negative state, latency to first fixation, visual fixation, and trials to habituate, no effect of orientation was found. Therefore, for the remainder of the analyses for this question orientation was not included as a factor.

Negative State. The 2(Condition) X 2(Trial Block) analysis of variance (ANOVA) revealed only one significant effect, a Trial main effect, F(1,12)= 9.151, p< .01, indicating that for both conditions negative state increased across the two Trial Blocks (Figure 5). No Condition main-effect or interactions were obtained.

Latency to First Fixation. The 2(Condition) X 2(Trial Block) ANOVA revealed a Condition main-effect, F(1,14)= 6.978, p< .02, indicating that the newborns in the M(N)O(C) condition required significantly more time to fixate the stimulus during the habituation phase than the newborns in the M(N)O(S) condition. As indicated in Figure 6, a Trial Block main-effect (F(1,12)= 5.052, p< .045) was also obtained and suggests that newborns took longer

Table 2. Means and (Standard Deviations) for negative state, latency to first fixation, and total visual fixation for each initial spatial orientation for newborns in the Movement (None) - Orientation (Change) and Movement (None) - Orientation (Same) conditions during the two Trial Blocks of the habituation phase (HAB1 and HAB2) and the three trials of the post-habituation phase (POST1, POST2, and POST3).

	Test Phases				
	Habituation		Post-Habituation		
Orientation	HAB1 (seconds)	HAB2 (seconds)	POST1 (seconds)	POST2 (seconds)	POST3 (seconds)
			Movement (None) - Oreintation (Change)		
Vertical					
State	0.8 (1.4)	3.7 (2.7)	3.0 (4.4)	1.2 (1.6)	7.5 (11.0)
Latency	3.8 (3.7)	6.1 (2.5)	4.0 (3.3)	1.4 (1.5)	9.4 (14.0)
Fixation	18.9 (7.7)	9.1 (3.6)	15.8 (8.1)	19.8 (7.1)	14.8 (11.2)
Horizontal					
State	1.7 (1.8)	3.1 (3.2)	4.0 (2.9)	1.3 (2.4)	0.8 (1.0)
Latency	1.2 (1.0)	7.8 (8.3)	12.0 (12.0)	1.7 (1.0)	3.0 (5.2)
Fixation	17.7 (3.1)	8.0 (3.1)	8.5 (4.7)	18.2 (5.9)	20.8 (7.6)
			Movement (None) - Oreintation (Same)		
Vertical					
State	0.7 (1.3)	2.8 (5.0)	2.3 (4.3)	2.3 (4.0)	3.6 (5.0)
Latency	1.2 (0.5)	1.9 (1.4)	6.5 (7.5)	12.6 (7.0)	2.8 (1.7)
Fixation	20.1 (7.1)	11.1 (4.2)	4.8 (4.4)	5.5 (4.0)	7.6 (1.9)
Horizontal					
State	0.1 (0.2)	3.1 (4.1)	4.6 (5.1)	4.4 (4.9)	8.6 (8.8)
Latency	1.2 (0.7)	2.9 (2.7)	5.1 (3.0)	3.1 (3.0)	5.9 (6.0)
Fixation	24.6 (1.2)	11.3 (3.8)	7.5 (7.8)	10.8 (3.6)	6.4 (9.1)

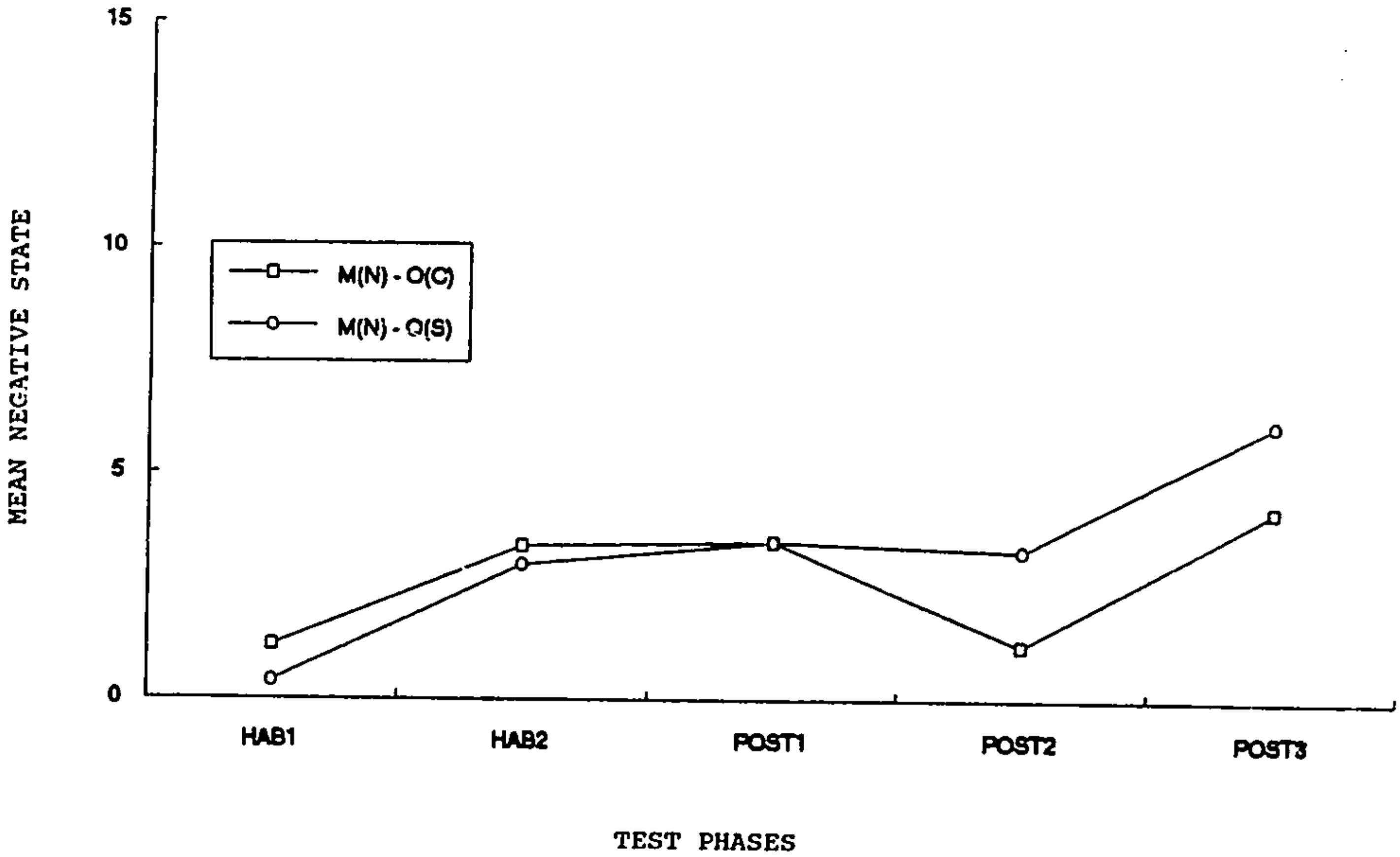

Figure 5. Mean negative state (seconds) for newborns in the Movement (None) - Orientation (Change) [M(N) - O(C)] and Movement (None) - Orientation (Same) [M(N) - O(S)] conditions during the two Trial Blocks of the habituation phase (HAB1 and HAB2) and the three trials of the post-habituation phase (POST1, POST2, and POST3).

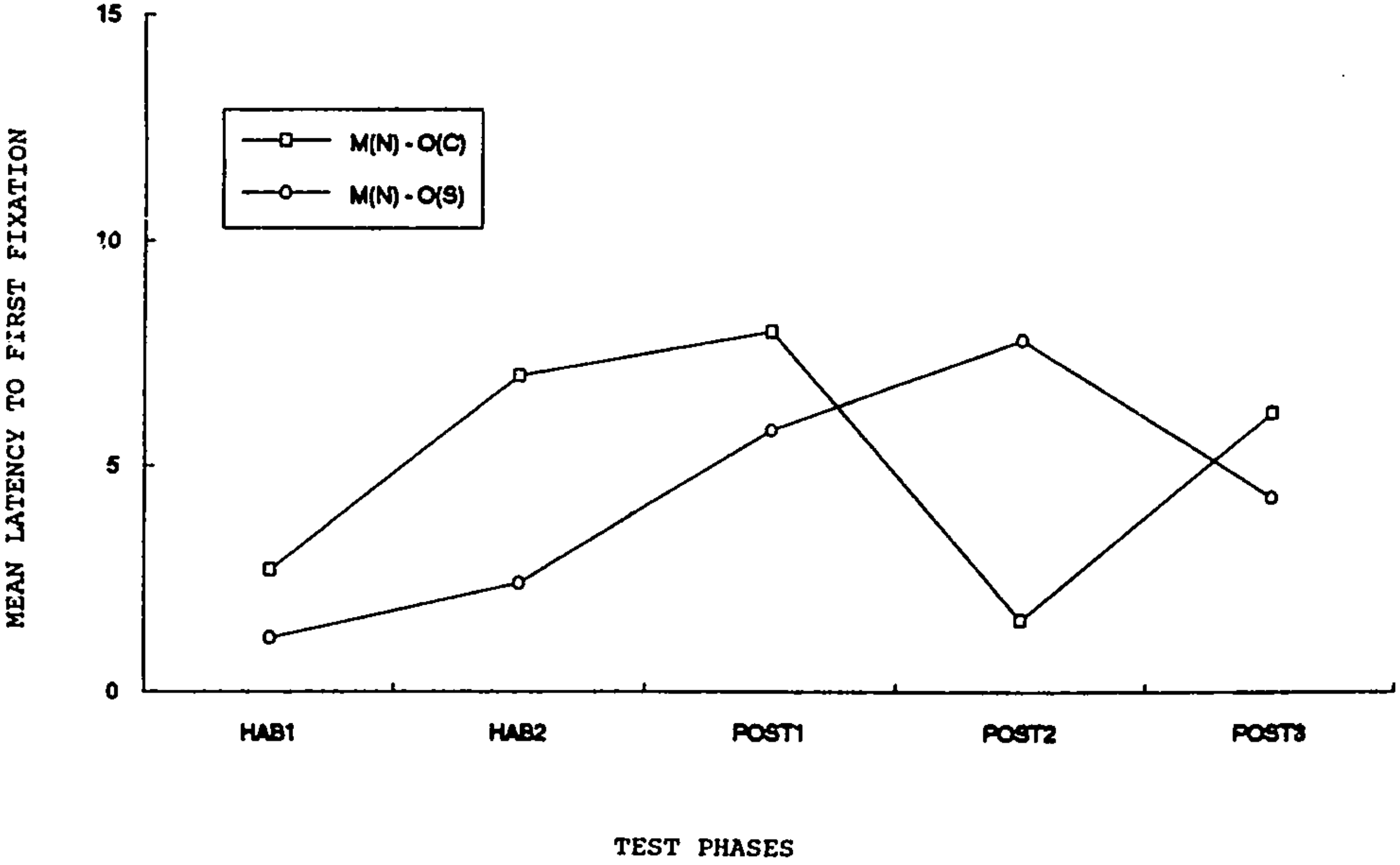

Figure 6. Mean latency to first fixation per trial (seconds) for newborns in the Movement (None) - Orientation (Change) [M(N) - O(C)] and Movement (None) - Orientation (Same) [M(N) - O(S)] conditions during the two Trial Blocks of the habituation phase (HAB1 and HAB2) and the three trials of the post-habituation phase (POST1, POST2, and POST3).

to fixate the stimulus during the second Trial Block than during the initial Trial Block. No additional effects were obtained.

Visual Fixation. A 2(Condition) X 2(Trial Block) ANOVA revealed a significant Trial Block main-effect, F(1,14)= 148. 961, *p*< .0001. As shown in Figure 7, newborns decreased their level of visual fixation across the two Trial Blocks, however, this decrease was created by the design of the experiment. Neither a Condition main-effect nor a Condition X Trial Block interaction were obtained. Thus, differences in post-habituation visual fixation should be attributable to the experimental manipulation.

Trials to Habituate. A one-way ANOVA for condition for the number of trials to habituate revealed no significant effects. Newborns in the M(N)O(C) condition required on average 8.6 trials (sd: 4.7; Range: 6 - 20 trials) to reach criterion of habituation. Newborns in the M(N)O(S) condition required on average 7.1 trials (sd: 1.5; Range: 6 - 10 trials) to reach criterion of habituation.

Data Summary. The analyses of this phase reveal that no condition differences existed in terms of negative state, total visual fixation, and number of trials to habituate differences were obtained. However, an unexpected difference in mean latency to fixate the stimulus was obtained, and indicated that the

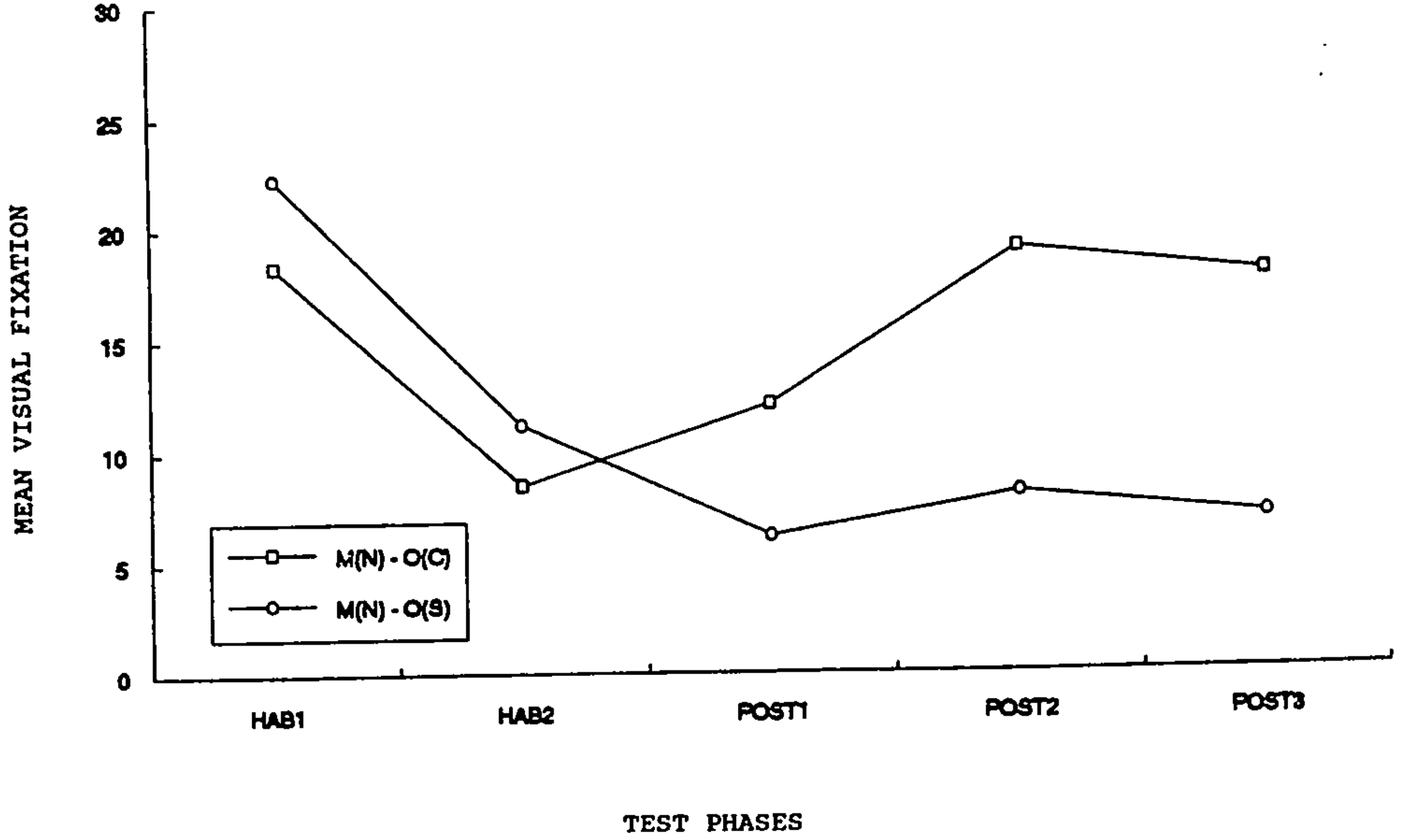

Figure 7. Mean visual fixation (seconds) for newborns in the Movement (None) - Orientation (Change) [M(N) - O(C)] and Movement (None) - Orientation (Same) [M(N) - O(S)] conditions during the two Trial Blocks of the habituation phase (HAB1 and HAB2) and the three trials of the post-habituation phase (POST1, POST2, and POST3).

newborns in the M(N)O(S) condition fixated the stimulus faster throughout the habituation phase than did the newborns in the M(N)O(C) condition. Also, the initial spatial orientation did not result in any significant effects for any of the four dependent measures.

Post-Habituation Phase

It was hypothesized that newborns who were presented a stimulus with a different spatial orientation would increase their level of visual fixation. Because no orientation main-effects were obtained for the habituation phase, all subsequent analyses were collapsed over this variable. Means and standard deviations for negative state, latency to first fixation, and overall visual fixation levels for the two Condition X Orientation categories during the three trials of the post-habituation phase are shown in Table 2.

Negative State. A 2(Condition) X 3(Trial) ANOVA indicated no Condition or Trial main-effects or interactions (Figure 5). Negative state for the two conditions did not differ significantly during the post-habituation phase. Therefore, potential differences pertaining to visual fixation were not likely attributed to differences in negative state.

Latency to First Fixation. This analysis was performed to determine whether the change in the spatial orientation of the black-and-white stripes had an effect on the mean latency time to first fixation per trial. A 2(Condition) X 3(Trial) ANOVA was performed on the latency times for each condition during the three post-habituation trials and revealed no significant effects.

Because latency differences in the habituation phase might have masked subsequent latency differences in the post-habituation phase a Multivariate Analysis of Covariance (MANCOVA) was performed on the post-habituation latency times using the latency time for the trial block of the habituation phase as the covariate. The analysis revealed no significant differences, but a near significant trend was found for the latency times for the second post-habituation trial, $F(1,13)=4.215$, $p< .065$. As indicated in Figure 6, newborns who saw the stimulus containing the novel spatial orientation [M(N)-O(C)] fixated the stimulus faster than the newborns who continued to see the same stimulus [M(N)-O(S)].

Visual Fixation. As expected, the 2(Condition) X 3(Trial) ANOVA revealed a significant Condition main-effect, $F(1,14)= 13.086$, $p< .003$, indicating that newborns in the M(N)O(C) condition displayed a higher level of visual fixation to a changed stimulus during the post-habituation trials than the newborns in the M(N)O(S) condition who continued to be presented with the same stimulus (Figure 7).

Data Summary. The analyses revealed that newborns who were presented with a stimulus containing a novel spatial orientation during the post-habituation trials displayed a higher level of visual fixation relative to newborns who were presented with a stimulus containing the same spatial orientation during both phases. Likewise, a near significant trend indicated that newborns who were presented with a novel spatial orientation fixated the stimulus faster during the second post-habituation trial. No state differences were obtained for this phase, thereby eliminating a possible explanation for the obtained visual fixation and latency time differences.

Question II: What is the effect of stimulus movement on the newborn infants' ability to process spatial orientation changes?

To determine whether the introduction of stimulus movement has an effect on the newborn's ability to process spatial orientation changes, all subsequent analyses will be performed on the data from the following conditions: M(N)O(C), M(N)O(S), M(S)O(C), and M(S)O(S). The procedures for this question are exactly the same as those for the previous question, except that the newborns in the two movement conditions saw the stimulus moving in either a vertical or horizontal direction of motion. Thus, the M(N)O(S) conditioned mirrored the M(S)O(S) condition in term of spatial orientation. The same was true for the two orientation change conditions. The direction of travel remained the same across both phases and was counterbalanced for direction of travel.

Habituation Phase

It was hypothesized that the introduction of movement would increase the speed at which the newborns first fixated the stimulus during each trial and their overall visual fixation level during the habituation phase. Therefore, it was expected that newborns from the two movement conditions would display shorter mean latency times and higher mean visual fixation levels relative to the newborns in the two stationary conditions. Moreover, it was expected that the newborns in the two movement conditions would require more trials to habituate. It is hypothesized that the introduction of movement will not result in any negative state differences. Again it was expected that neither the initial spatial orientation of the stimulus nor the movement would have any effect on the newborns initial state and visual fixation behaviors.

Means and standard deviations for average duration of negative state, average latency to first fixation per trial, and average total visual fixation per trial for the four Condition X Orientation categories during the two Trial Blocks of the habituation phase are presented in Tables 2 and 3.

Table 3. Means and (Standard Deviations) for negative state, latency to first fixation, and total visual fixation for each initial spatial orientation for newborns in the Movement (Same) - Orientation (Change) and Movement (Same) - Orientation (Same) conditions during the two Trial Blocks of the habituation phase (HAB1 and HAB2) and the three trials of the post-habituation phase (POST1, POST2, and POST3).

	Test Phases									
	Habituation				Post-Habituation					
Orientation	HAB1 (seconds)		HAB2 (seconds)		POST1 (seconds)		POST2 (seconds)		POST3 (seconds)	
	Movement (Same) - Oreintation (Change)									
Vertical										
State	0.9	(1.9)	1.6	(1.7)	3.4	(3.9)	4.5	(6.9)	2.7	(5.4)
Latency	1.5	(0.7)	2.7	(1.5)	1.2	(0.4)	3.2	(3.0)	3.4	(4.9)
Fixation	20.4	(5.1)	9.0	(4.1)	17.5	(5.5)	10.4	(7.9)	18.3	(7.9)
Horizontal										
State	1.1	(1.6)	5.6	(1.6)	0.6	(0.6)	5.1	(6.4)	10.9	(9.4)
Latency	1.6	(1.1)	6.9	(2.7)	2.1	(0.4)	3.9	(4.4)	9.7	(13.4)
Fixation	20.2	(1.9)	7.7	(2.1)	19.9	(6.4)	13.7	(6.7)	5.8	(4.0)
	Movement (Same) - Oreintation (Same)									
Vertical										
State	1.1	(1.3)	6.5	(6.0)	11.6	(8.0)	7.2	(6.9)	6.8	(7.8)
Latency	1.6	(1.1)	6.0	(5.4)	14.4	(14.0)	3.4	(3.9)	4.8	(6.3)
Fixation	17.1	(6.0)	7.9	(4.2)	4.2	(3.9)	7.6	(5.1)	8.1	(4.2)
Horizontal										
State	0.2	(0.2)	5.1	(2.4)	16.3	(6.5)	15.8	(13.8)	20.0	(6.5)
Latency	2.0	(1.5)	5.3	(5.4)	15.6	(14.6)	14.4	(14.2)	15.0	(14.3)
Fixation	19.6	(7.1)	10.0	(6.1)	2.0	(2.4)	1.3	(1.2)	2.9	(2.6)

Orientation. A 2(Orientation) X 2(Trial Block) ANOVA was performed on each of the four dependent measures. No significant orientation differences were obtained for any of the measures. Therefore, the remainder of the analyses will be collapsed over this factor.

Direction of Movement. To determine if the direction of movement had any differential effects on the four dependent measures, separate 2(Movement) X 2(Trial Block) ANOVAs were performed on the newborns from the M(S)O(C) and M(S)O(S) conditions. No significant effects were obtained for any of the dependent measures.

Negative State. A 4(Condition) X 2(Trial Block) ANOVA revealed no Condition main-effect. A Trial Block main-effect was obtained, $F(1,28)= 27.159$, $p< .0001$, indicating that newborns, regardless of experimental condition displayed an increase in negative affect over the two Trial Blocks (Figure 8).

Latency to First Fixation. A 4(Condition) X 2(Trial Block) ANOVA revealed no Condition main-effect or Condition X Trial interaction. The Trial Blocks main-effect was significant, $F(1,28)= 16.896$, $p< .0004$ As indicated in Figure 9, newborns across all conditions displayed a consistent increase in their mean latency to fixate the stimulus across the two habituation.

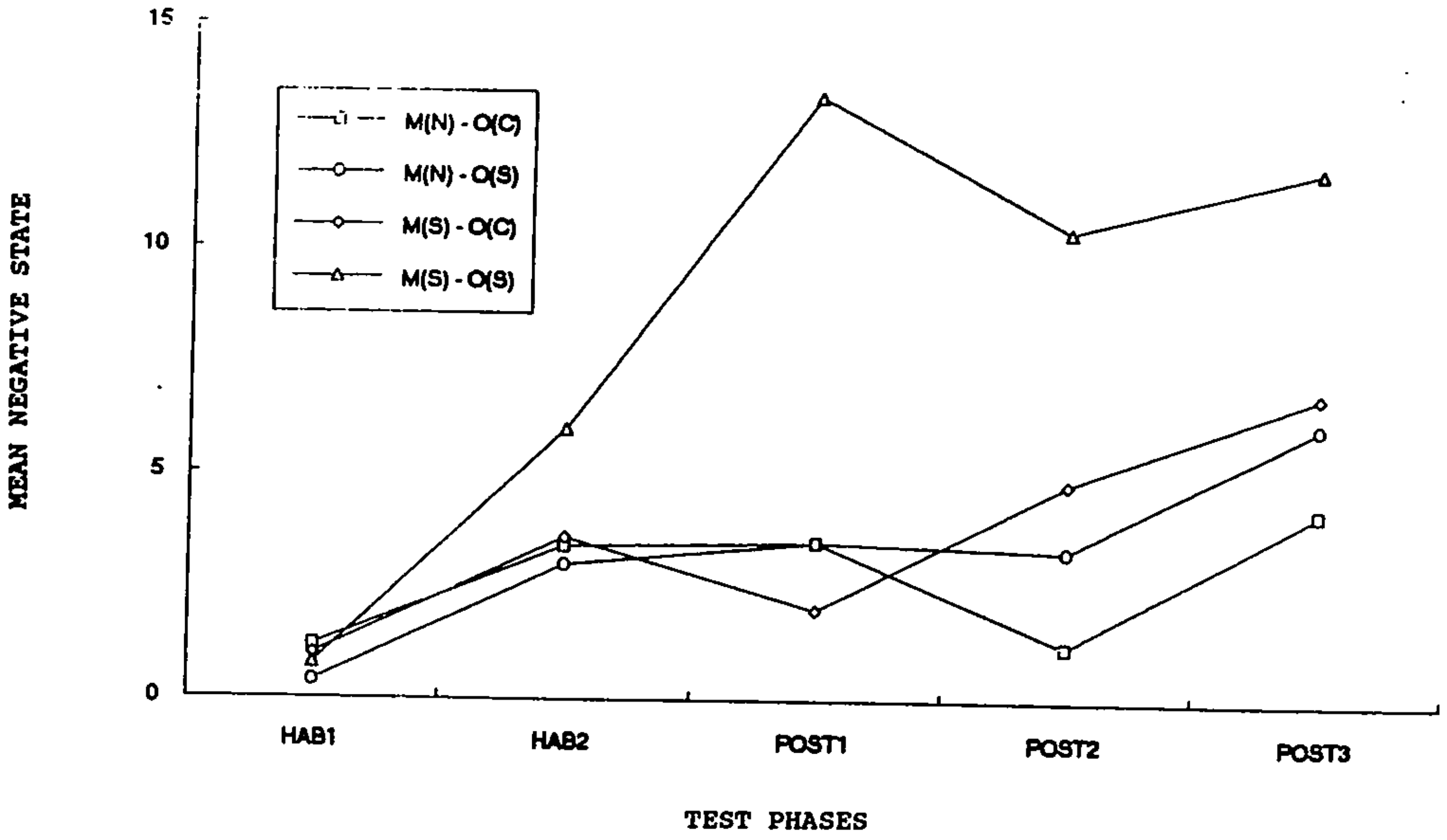

Figure 8. Mean negative state (seconds) for newborns in the Movement (None) - Orientation (Change) [M(N)-O(C)], Movement (None) - Orientation (Same) [M(N)-O(S)], Movement (Same) - Orientation (Change) [M(S)-O(C)], and Movement (Same) - Orientation (Same) [M(S)-O(S)] conditions during the two Trial Blocks of the habituation phase (HAB1 and HAB2) and the three trials of the post-habituation phase (POST1, POST2, and POST3).

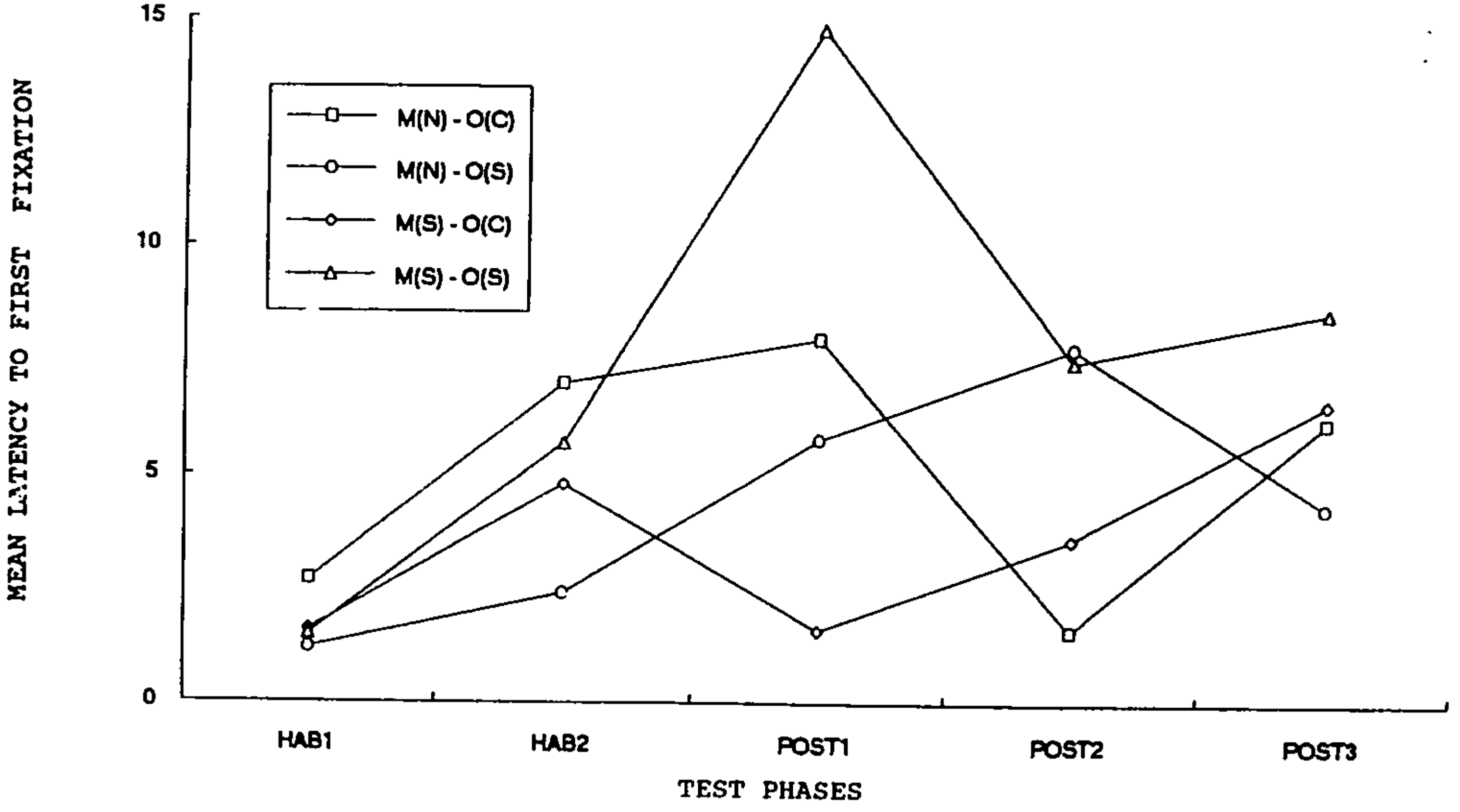

Figure 9. Mean latency to first fixation per trial (seconds) for newborns in the Movement (None) - Orientation (Change) [M(N)-O(C)], Movement (None) - Orientation (Same) [M(N)-O(S)], Movement (Same) - Orientation (Change) [M(S)-O(C)], and Movement (Same) - Orientation (Same) [M(S)-O(S)] conditions during the two Trial Blocks of the habituation phase (HAB1 and HAB2) and the three trials of the post-habituation phase (POST1, POST2, and POST3).

Since it was possible that movement would only influence the newborns latency times during the first baseline trials of the habituation phase, separate one-way ANOVAs for Condition were performed for the mean latency times during the first trial and Trial Block. Neither of these analyses revealed a significant Condition main-effect.

Visual Fixation. As with the previous latency to first fixation analysis, a 4(Condition) X 2(Trial Block) ANOVA revealed no Condition main-effect. However, all newborns, regardless of experimental condition, displayed a decrease of the visual attention across the Trial Block periods of the habituation phase, $F(1,24)= 441.806$, $p< .0001$ (Figure 10). No interactions were obtained.

As with the latency to first fixation data, separate one-way ANOVAs for Condition were performed for the first trial and Trial Block of the habituation phase to determine if movement had only an initial effect on the newborns' overall visual attention. As with the latency to first fixation results, no Condition main-effects were obtained.

Trials to Habituate. A one-way ANOVA for four conditions based on the number of trials to habituate revealed no significant effect. Newborns in the M(N)O(C) condition required on average 8.6 trials (sd: 4.7; Range: 6 - 20 trials) to reach the criterion of habituation. Newborns in the M(N)O(S) condition

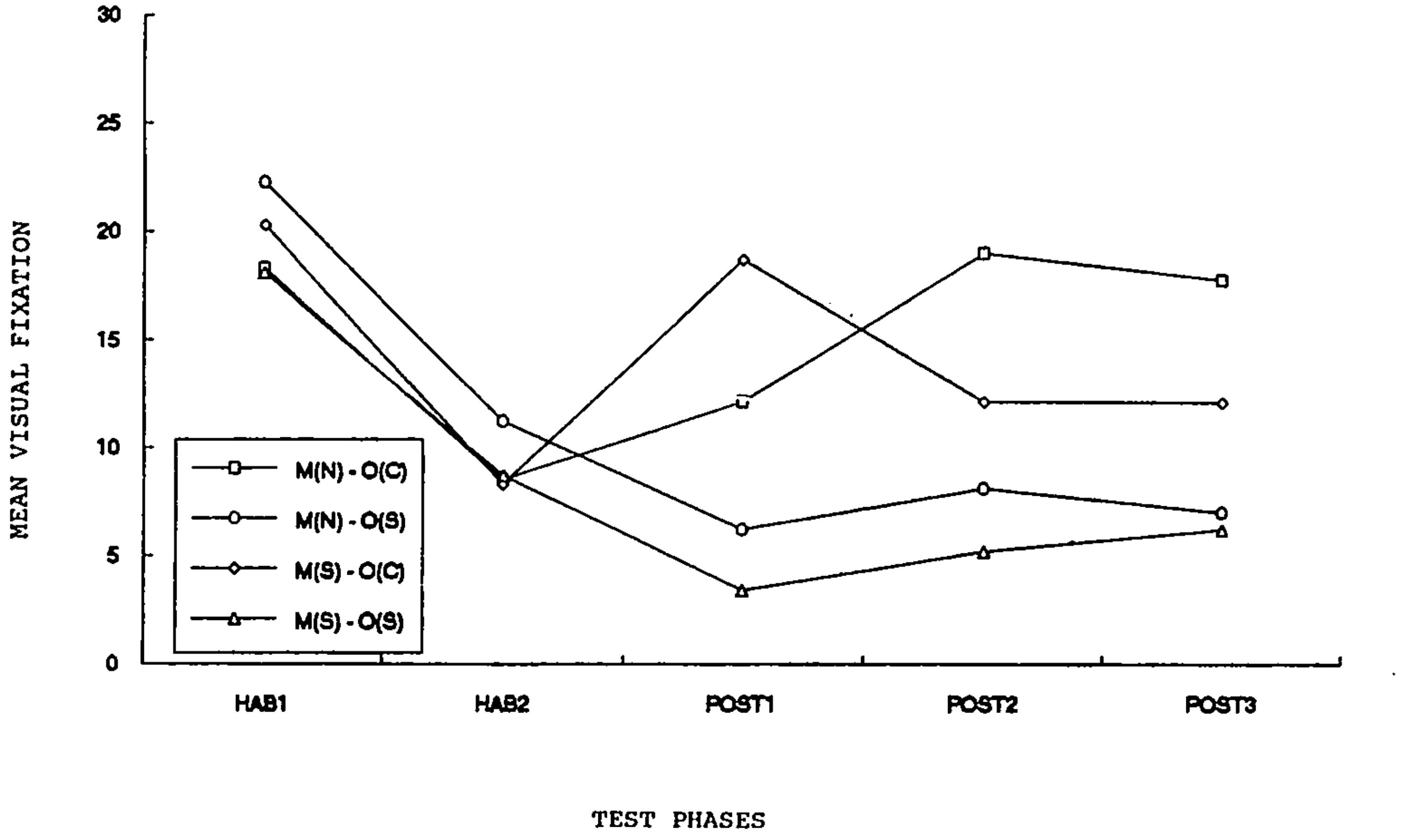

Figure 10. Mean visual fixation (seconds) for newborns in the Movement (None) - Orientation (Change) [M(S) - O(C)], Movement (None) - Orientation (Same) [M(N) - O(S)], Movement (Same) - Orientation (Change) [M(S) - O(C)], and Moment (Same) - Orientation (Same) [M(S) - O(S)] conditions during the two Trial Blocks of the habituation phase (HAB1 and HAB2) and the three trials of the post-habituation phase (POST1, POST2, and POST3).

required on average 7.1 trials (sd: 1.5; Range: 6 - 10 trials) to reach the criterion of habituation. Newborns in the M(S)O(C) condition required on average 7.1 trials (sd: 1.9; Range: 6-11) to reach the criterion of habituation. Newborns in the M(S)O(S) condition required a mean of 7.3 trials (sd: 1.3; Range: 6-10) to reach the criterion of habituation.

Data Summary. The findings of this phase did not support the hypothesis that movement would increase the attractiveness of a visual stimulus. The analyses revealed that no Conditions differences were obtained four any of the four dependent variables. Moreover, the analyses revealed that the initial spatial orientation did not result in any significant differences for any of the dependent measures.

Post-Habituation Phase

It was hypothesized that newborns who were presented a novel stimulus in terms of orientation or movement during the three post-habituation trials would demonstrate a higher level of visual fixation than newborns who saw the familiar stimulus throughout both phases. Also, it was expected that the newborns in the movement condition who saw a novel stimulus would display a higher level of visual fixation than the newborns in the stationary condition who saw a novel stimulus. Once again because no orientation main-effects were obtained during the habituation phase, all subsequent analyses were collapsed over this variable.

Means and standard deviations for negative affect, latency to first fixation per trial, and total visual fixation per trial for each Condition X Orientation category during the three trials of the post-habituation phase are shown in Tables 2 and 3.

Negative State. A 2(Change) X 2(Movement) X 3(Trial) ANOVA was conducted to determine if negative state differed across the four conditions. As shown in Figure 8, Change and Movement main-effects were obtained, F(1,28)= 5.298, $p< .025$ and F(1,28)= 3.28, $p< .02$. These analyses revealed that newborns in the Change conditions [M(N)-O(C) and M(S)-O(C)] exhibited a lower level of negative affect. Likewise, newborns in the Movement conditions [M(S)-O(C) and M(S)-O(S)] displayed more negative affect than the newborns in the two stationary conditions.

Latency to First Fixation. A 2(Change) X 2(Movement) X 3(Trial) ANOVA was performed on the latency times. The analysis revealed a Change main-effect, such that the newborns who saw the stimulus with a novel spatial orientation had shorter mean latency times (4.6 seconds) when compared to the newborns who saw the stimulus with the same spatial orientation (8.1 seconds) throughout the entire testing, F(1,28)= 4.432, $p< .045$. Neither Movement or Trial main-effects nor any interaction were obtained.

Visual Fixation. A 2(Change) X 2(Movement) X 3(Trial) ANOVA revealed a Change main-effect, $F(1,28) = 35.463$, $p < .0001$, indicating that newborns who saw the changed stimulus during the post-habituation phase fixated the stimulus longer (15.3 seconds) on average than the newborns who saw the same stimulus (6.0 seconds) throughout both phases of the experiment.

A Change X Movement X Trials interaction was obtained, $F(2,56) = 3.907$, $p < .03$. Individual one-way ANOVAs were performed for each factor during each post-habituation trial using level of visual fixation as the dependent measure to determine the effect of this three-way interaction. The ANOVAs for the three post-habituation trial using the Change factor revealed that this factor discriminated between the newborns who were presented a novel stimulus during the post-habituation trials and the control newborns. For each trial, newborns who saw the novel stimulus fixated it longer than newborns in the control conditions, $F(1,30) = 23.921$, $p < .0001$ for trial 1, $F(1,30) = 16.254$, $p < .0035$ for trial 2, and $F(1,30) = 9.769$, $p < .004$ for trial 3.

The one-way ANOVAs for the Movement factor failed to reach significance for each of the three post-habituation trials. Likewise, the one-way ANOVAs performed on Trials for each condition revealed no significant differences. Therefore, the interaction was the result of the two Change conditions differing from the two control conditions while the two movement conditions did not differ from the two stationary condition.

Data Summary. In general, it appears that while newborns from the Change conditions detected the change to the spatial orientation of the stimulus, the pattern of fixation across the three post-habituation trials differs. The analyses also revealed that the newborns in the change conditions displayed shorter mean latency times and longer mean visual fixations times than the newborns in the two control conditions. Also, it was found that the newborns in the M(S)O(S) condition displayed a higher level of negative affect than the remaining three conditions.

Question III: Can newborn infants process two dimensions of a visual compound simultaneously?

This question was designed to determine whether newborns could detect direction of movement changes and whether they could detect both spatial orientation and direction of travel changes simultaneously. In order to answer these questions the data from the four movement conditions was used during the analyses: M(S)O(C), M(C)O(S), M(C)O(C), and M(S)O(S). It is expected that newborns will be able to detect direction of movement changes, as well as being able to process spatial orientation and direction of movement information simultaneously.

Habituation Phase

It is anticipated that no Condition or Compound differences will be obtained. Compound was defined as the combination of the spatial orientation and direction of movement of a visual stimulus. Thus, there were four visual compounds: Vertical spatial orientation plus vertical direction of movement; vertical spatial orientation plus horizontal movement; horizontal spatial orientation plus vertical movement; and horizontal spatial orientation plus horizontal movement.

Newborns from the four relevant conditions are not expected to differ in the state and visual fixation behavior during the habituation phase. Moreover, it is expected that newborns will attend to the four different spatial orientation-movement compounds similarly during this phase. The means and standard deviations for negative state, latency to first fixation, overall visual attention, and trials to habituate for each Condition X Compound category during the two Trial Blocks of the habituation phase are presented in Tables 4, 5, 6, and 7.

Compound. Separate one-way ANOVAs were performed on each dependent measure to determine if differences existed between any of the initial spatial orientation-direction of movement combinations. The analyses revealed no effect for the Compound for any of the dependent measures. Therefore, the remaining analyses will be collapsed over this factor.

Table 4. Means and (Standard Deviations) for negative state, latency to first fixation, and total visual fixation for each initial spatial orientation for newborns in the Movement (Same) - Orientation (Change) condition during the two Trial Blocks of the habituation phase (HAB1 and HAB2) and the three trials of the post-habituation phase (POST1, POST2, and POST3).

	Test Phases				
	Habituation		Post-Habituation		
Compound	HAB1 (seconds)	HAB2 (seconds)	POST1 (seconds)	POST2 (seconds)	POST3 (seconds)
	Movement (Same) - Orientation (Change)				
Vertical - Vertical					
State	1.9 (2.6)	1.3 (1.8)	3.3 (4.6)	7.3 (10.3)	5.4 (7.6)
Latency	2.2 (1.8)	1.5 (0.4)	1.2 (0.0)	0.7 (0.3)	5.9 (6.8)
Fixation	18.1 (6.8)	7.7 (5.9)	17.0 (5.5)	10.0 (12.7)	15.2 (5.5)
Vertical - Horizontal					
State	0.0 (0.0)	1.9 (2.0)	3.6 (5.0)	1.8 (2.5)	0.0 (0.0)
Latency	0.8 (0.1)	4.0 (0.5)	1.2 (0.4)	5.6 (1.4)	0.9 (0.6)
Fixation	22.7 (3.3)	10.3 (3.1)	17.9 (7.6)	10.9 (5.3)	21.4 (10.9)
Horizontal - Vertical					
State	0.5 (0.7)	5.3 (1.5)	0.9 (0.6)	2.2 (0.5)	6.5 (0.6)
Latency	2.4 (1.1)	5.6 (2.5)	1.2 (0.4)	1.3 (1.0)	0.9 (0.2)
Fixation	20.0 (0.8)	6.2 (0.3)	19.5 (4.1)	17.0 (0.2)	6.9 (1.9)
Horizontal - Horizontal					
State	1.8 (2.3)	5.9 (2.3)	0.4 (0.6)	8.0 (9.4)	15.3 (13.8)
Latency	0.9 (0.0)	8.2 (3.0)	3.0 (2.6)	6.6 (5.4)	18.6 (14.5)
Fixation	20.4 (3.7)	9.3 (1.7)	20.3 (10.3)	10.5 (9.6)	4.8 (6.4)

Table 5. Means and (Standard Deviations) for negative state, latency to first fixation, and total visual fixation for each initial spatial orientation for newborns in the Movement (Change; - Orientation (Same) condition during the two Trial Blocks of the habituation phase (HAB1 and HAB2) and the three trials of the post-habituation phase (POST1, POST2, and POST3).

	Test Phases									
	Habituation				Post-Habituation					
Compound	HAB1 (seconds)		HAB2 (seconds)		POST1 (seconds)		POST2 (seconds)		POST3 (seconds)	
	Movement (Change) - Orientation (Same)									
Vertical - Vertical										
State	0.6	(1.1)	4.1	(5.7)	0.1	(0.2)	0.2	(0.3)	9.5	(7.1)
Latency	1.9	(1.3)	5.2	(7.4)	5.9	(8.6)	1.2	(0.9)	11.2	(16.3)
Fixation	21.4	(3.7)	10.0	(5.1)	17.5	(10.9)	13.3	(10.0)	1.7	(1.6)
Vertical - Horizontal										
State	3.7	(5.2)	7.7	(6.9)	7.5	(8.6)	14.7	(1.6)	8.9	(11.2)
Latency	0.9	(0.7)	10.0	(10.3)	2.0	(0.2)	6.3	(0.7)	7.6	(6.8)
Fixation	17.0	(4.9)	6.9	(1.3)	10.5	(2.3)	4.4	(0.4)	2.3	(1.8)
Horizontal - Vertical										
State	0.1	(0.0)	0.7	(0.0)	0.9	(0.0)	11.3	(0.0)	0.0	(0.0)
Latency	1.0	(0.0)	4.2	(0.0)	0.5	(0.0)	0.7	(0.0)	30.0	(0.0)
Fixation	23.6	(0.0)	13.6	(0.0)	23.7	(0.0)	10.3	(0.0)	0.0	(0.0)
Horizontal - Horizontal										
State	0.5	(0.5)	3.2	(3.3)	1.0	(0.4)	4.7	(5.5)	0.3	(0.4)
Latency	1.4	(0.3)	5.6	(6.9)	2.5	(0.1)	2.6	(1.2)	1.3	(0.3)
Fixation	18.4	(1.0)	9.9	(0.9)	15.3	(10.6)	9.1	(5.4)	14.2	(12.6)

Table 6. Means and (Standard Deviations) for negative state, latency to first fixation, and total visual fixation for each initial spatial orientation for newborns in the Movement (Change) - Orientation (Change) condition during the two Trial Blocks of the habituation phase (HAB1 and HAB2) and the three trials of the post-habituation phase (POST1, POST2, and POST3).

	Test Phases				
	Habituation		Post-Habituation		
Compound	HAB1 (seconds)	HAB2 (seconds)	POST1 (seconds)	POST2 (seconds)	POST3 (seconds)
	Movement (Change) - Orientation (Change)				
Vertical - Vertical					
State	0.0 (0.0)	0.0 (0.0)	0.4 (0.5)	0.8 (1.1)	0.0 (0.0)
Latency	0.6 (0.1)	9.2 (4.1)	2.2 (0.1)	3.2 (1.4)	3.0 (1.7)
Fixation	28.9 (0.7)	15.5 (2.2)	24.1 (1.1)	20.0 (4.0)	15.5 (1.9)
Vertical - Horizontal					
State	0.0 (0.0)	0.9 (0.1)	8.1 (11.5)	4.8 (4.5)	1.0 (0.2)
Latency	1.1 (1.0)	3.1 (0.9)	5.6 (6.3)	9.9 (13.2)	0.5 (0.2)
Fixation	27.0 (1.4)	14.8 (2.0)	13.1 (4.9)	11.0 (14.4)	25.3 (5.0)
Horizontal - Vertical					
State	0.6 (0.8)	0.7 (0.9)	0.0 (0.0)	12.4 (17.5)	0.2 (0.2)
Latency	2.1 (0.5)	3.1 (0.9)	1.5 (0.0)	1.5 (0.9)	0.5 (0.2)
Fixation	24.2 (0.4)	13.5 (0.1)	26.6 (3.0)	11.8 (11.5)	26.0 (5.0)
Horizontal - Horizontal					
State	0.7 (0.3)	0.3 (2.9)	2.0 (2.8)	0.7 (0.9)	0.3 (0.4)
Latency	1.3 (0.7)	2.3 (1.8)	2.0 (0.5)	4.0 (1.4)	6.7 (5.9)
Fixation	16.5 (5.7)	5.8 (4.4)	11.0 (5.4)	16.6 (1.0)	17.1 (7.9)

Table 7. Means and (Standard Deviations) for negative state, latency to first fixation, and total visual fixation for each initial spatial orientation for newborns in the Movement (Same) - Orientation (Same) condition during the two Trial Blocks of the habituation phase (HAB1 and HAB2) and the three trials of the post-habituation phase (POST1, POST2, and POST3).

	Test Phases				
	Habituation		Post-Habituation		
Compound	HAB1 (seconds)	HAB2 (seconds)	POST1 (seconds)	POST2 (seconds)	POST3 (seconds)
	Movement (Same) - Orientation (Same)				
Vertical - Vertical					
State	0.5 (0.7)	2.8 (2.9)	7.6 (6.8)	3.4 (5.9)	4.7 (8.1)
Latency	1.0 (0.1)	3.3 (1.6)	11.5 (15.3)	5.1 (4.4)	5.5 (8.8)
Fixation	20.1 (6.0)	10.6 (2.5)	5.7 (4.7)	11.1 (1.9)	9.5 (4.9)
Vertical - Horizontal					
State	1.9 (1.8)	12.1 (4.8)	17.8 (10.3)	12.8 (4.1)	10.1 (8.8)
Latency	1.7 (0.4)	10.0 (7.5)	18.7 (16.0)	0.9 (0.7)	3.6 (1.2)
Fixation	12.6 (1.0)	3.8 (0.8)	2.1 (3.0)	4.4 (1.6)	6.2 (3.0)
Horizontal - Vertical					
State	0.0 (0.0)	7.8 (0.0)	17.5 (0.0)	27.4 (0.0)	27.2 (0.0)
Latency	0.8 (0.0)	0.7 (0.0)	0.8 (0.0)	30.0 (0.0)	30.0 (0.0)
Fixation	27.3 (0.0)	16.9 (0.0)	1.2 (0.0)	30.0 (0.0)	0.0 (0.0)
Horizontal - Horizontal					
State	0.4 (0.2)	3.8 (0.9)	15.8 (9.1)	10.1 (13.5)	16.4 (2.6)
Latency	2.6 (1.5)	7.6 (5.1)	23.0 (9.9)	6.6 (6.4)	7.6 (8.5)
Fixation	15.8 (3.4)	6.6 (1.9)	2.4 (3.3)	2.0 (0.0)	4.2 (1.3)

Negative State. A 4(Condition) X 2(Trial Block) ANOVA revealed no Condition main-effect. As shown in Figure 11, a Trial Block main-effect was obtained, $F(1,28)= 27.077$, $p< .0001$, but is qualified by a Condition X Trial Block interaction, $F(3,28)= 3.950$, $p< .02$. Individual one-way ANOVAs for Condition revealed no significant Condition effects for the first Trial Block. However, a significant Condition main-effect was obtained for the seconds Trial Block, $F(3,28)= 3.356$, $p< .04$. Newman-Keuls post-hoc analyses revealed that the newborns in the M(S)O(S) condition displayed a higher level of negative state than newborns in the M(C)O(C) condition, $p< .05$. No other significant differences were obtained. Likewise, individual one-way ANOVAs for Trial Block performed on each condition revealed that newborns in the all conditions except M(C) - O(C) displayed a higher level of negative state during the second Trial Block (M(S) - O(C): $F(1,7)= 8.9$, $p< .025$; M(C) - O(S): $F(1,7)= 8.549$, $p< .025$; and M(S) - O(S): $F(1,7)= 10.583$, $p< .015$). Therefore, it appears that the interaction was the result of the newborns in the M(S)O(S) condition displaying a higher level of negative state during the second Trial Block than newborns in the M(C)O(C) condition, a difference that was not seen in the first Trial Block.

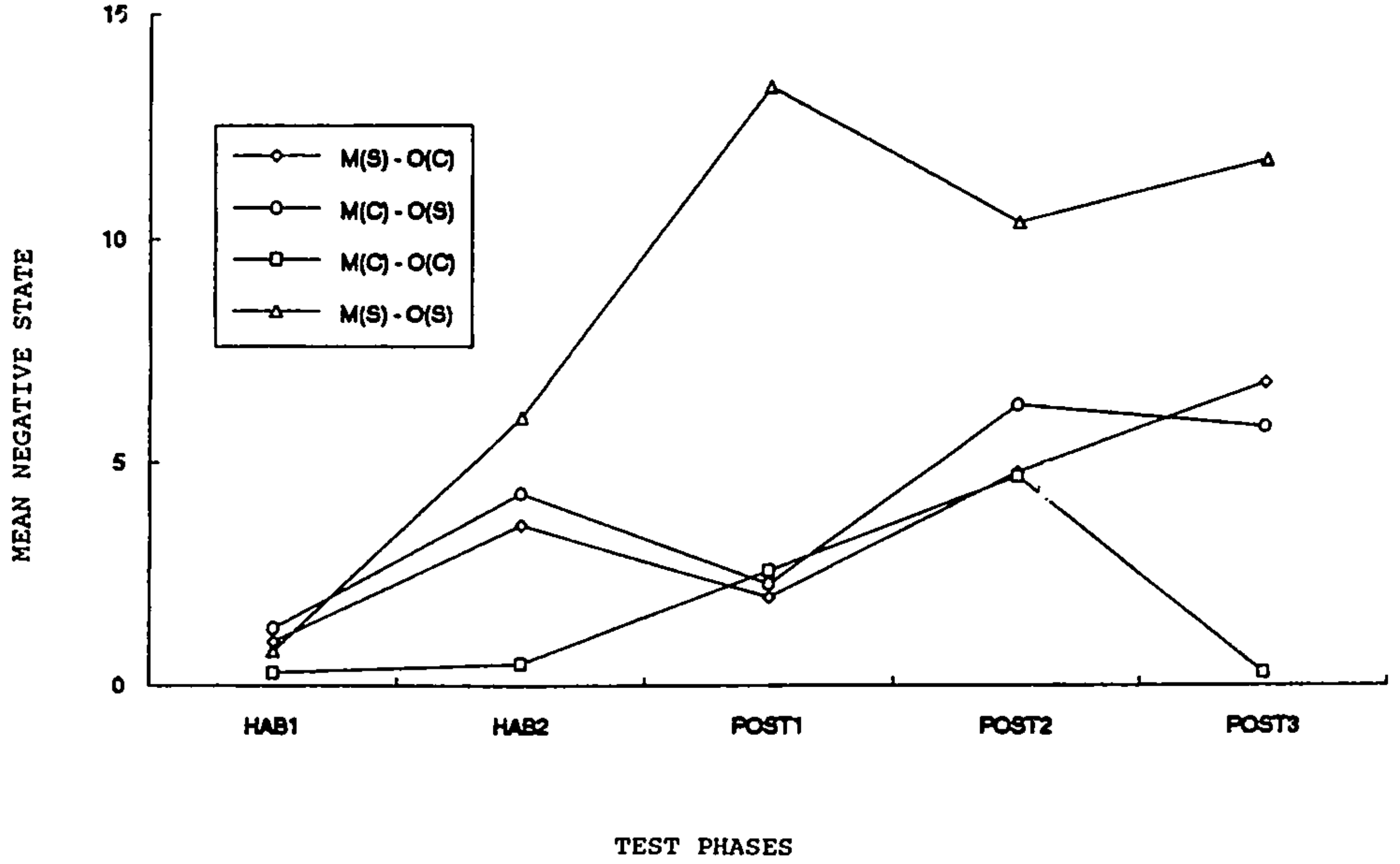

Figure 11. Mean negative state (seconds) for newborns in the Movement (Same) - Orientation (Change) [M(S) - O(C)], Movement (Change) - Orientation (Same) [M(C) - O(S), Movement (Change) - Orientation (Change) [M(C) - O(C)], and Moment (Same) - Orientation (Same) [M(S) - O(S)] conditions during the two Trial Blocks of the habituation phase (HAB1 and HAB2) and the three trials of the post-habituation phase (POST1, POST2, and POST3).

Latency to First Fixation. The 4(Condition) X 2(Trial Block) ANOVA revealed a Trial Block main-effect, F(1,28)= 19.161, $p <$ .0003, indicating that newborns in all conditions took longer to fixate the stimulus during the second Trial Block compared to the first Trial Block. No Condition main-effect nor Condition X Trial Block interaction were obtained. See Figure 12.

Visual Fixation. The 4(Condition) X 2(Trial Block) ANOVA revealed the expected Trial Block main-effect was obtained, F(1,28)= 857.278, $p <$ .0001, indicating that newborns from all conditions decreased their level of visual fixation across the two Trial Blocks (Figure 13). More importantly, no Condition or Condition X Trial Block effect were obtained. Therefore, any subsequent differences obtained during the post-habituation phase cannot be attributable to initial fixation differences.

Trials to Habituate. A one-way ANOVA for Condition for the number of trials to habituate revealed no significant effects. Newborns in the M(S)O(C) condition required on average 7.1 trials (sd: 1.9; Range: 6-11) to reach the criterion of habituation. Newborns in the M(C)O(S) condition required 7.5 trials (sd: 2.7; Range 6-14) to obtained habituation. Newborns in the M(C)O(C) condition required 11.3 trials (sd: 6.2; Range: 6-21) to habituate. Finally, newborns in the M(S)O(S) condition required a mean of 7.3 trials (sd: 1.3; Range: 6-10) to reach the criterion of habituation.

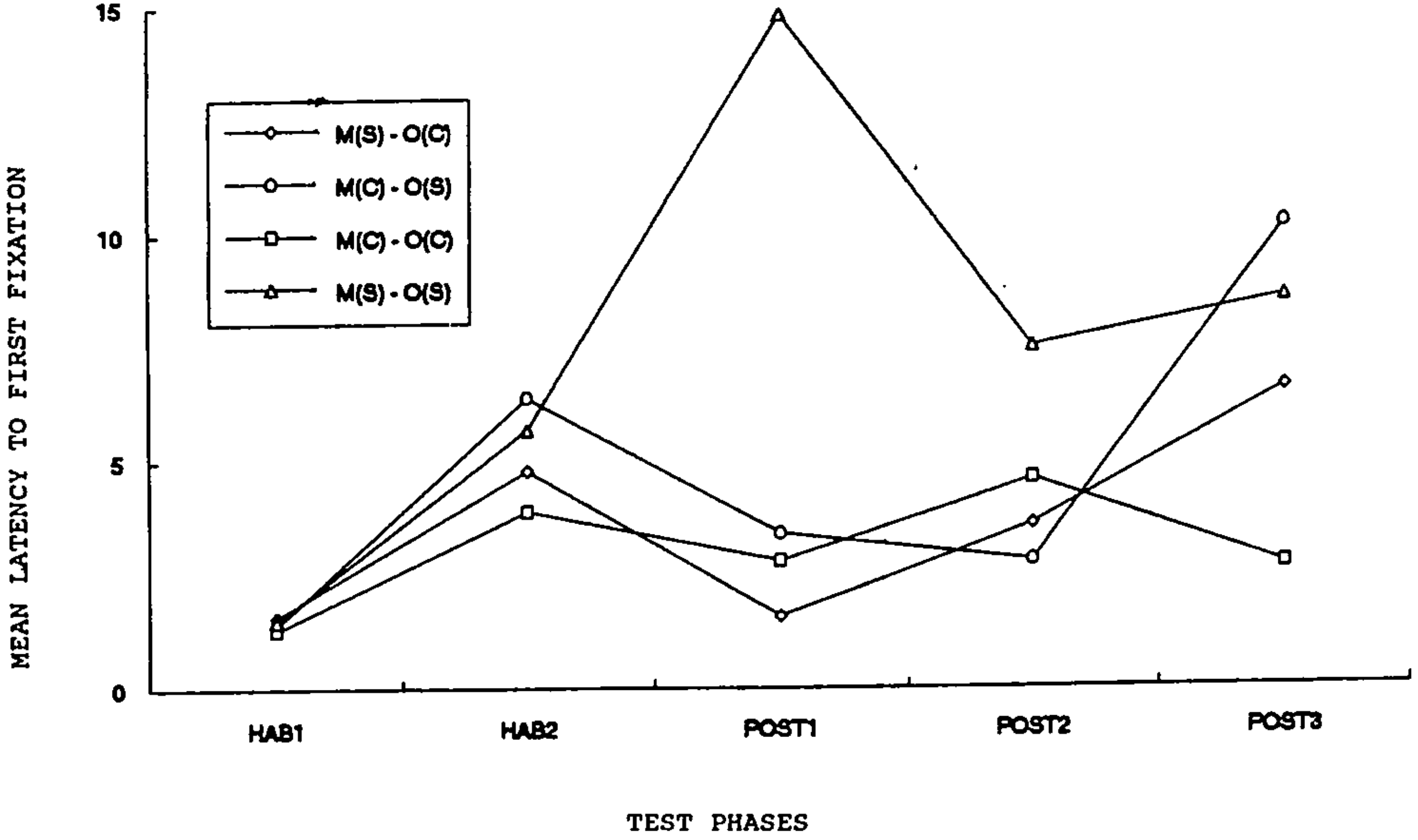

Figure 12. Mean latency to first fixation per trial (seconds) for newborns in the Movement (Same) - Orientation (Change) [M(S) - O(C)], Movement (Change) - Orientation (Same) [M(C) - O(S), Movement (Change) - Orientation (Change) [M(C) - O(C)], and Moment (Same) - Orientation (Same) [M(S) - O(S)] conditions during the two Trial Blocks of the habituation phase (HAB1 and HAB2) and the three trials of the post-habituation phase (POST1, POST2, and POST3).

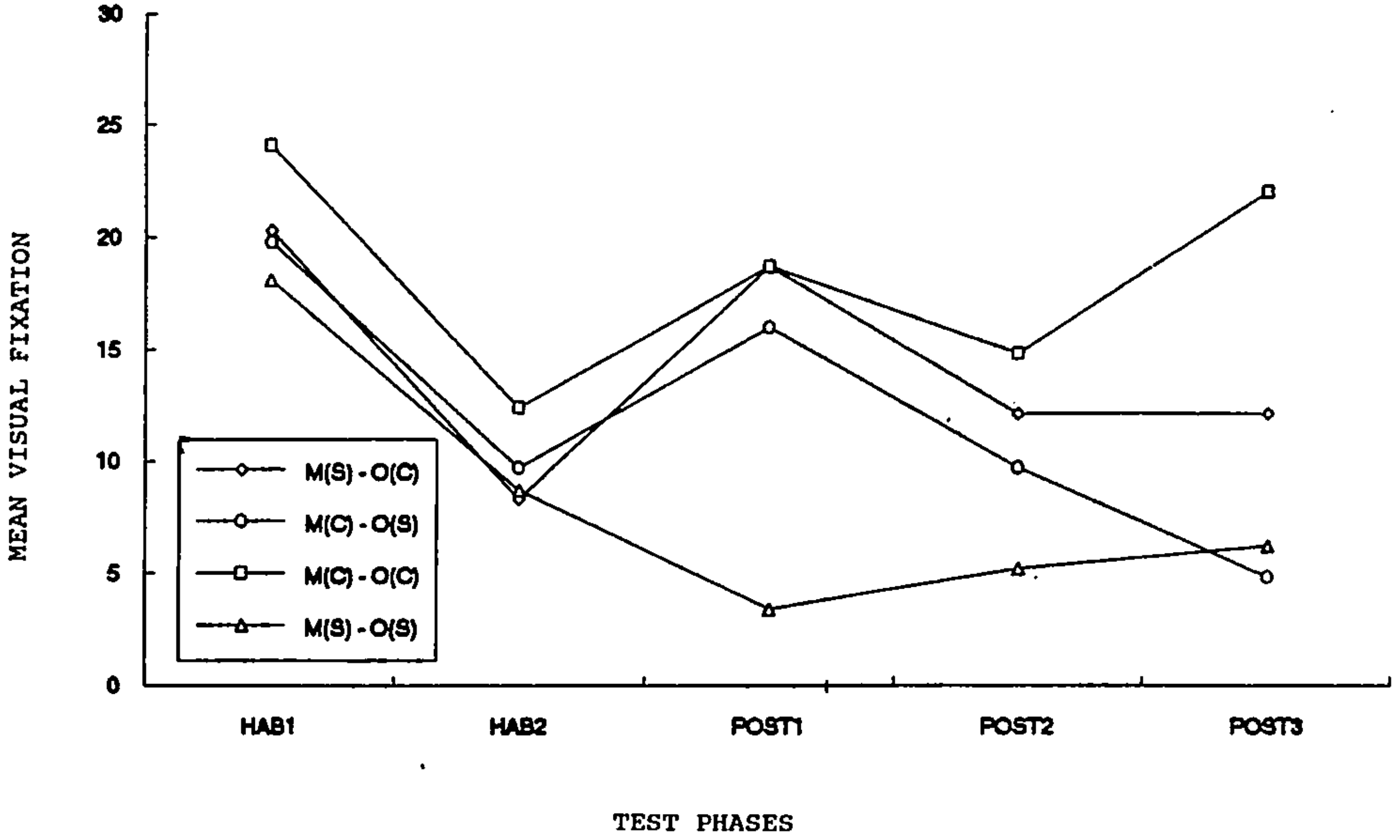

Figure 13. Mean visual fixation (seconds) for newborns in the Movement (Same) - Orientation (Change) [M(S) - O(C)], Movement (Change) - Orientation (Same) [M(C) - O(S), Movement (Change) - Orientation (Change) [M(C) - O(C)], and Moment (Same) - Orientation (Same) [M(S) - O(S)] conditions during the two Trial Blocks of the habituation phase (HAB1 and HAB2) and the three trials of the post-habituation phase (POST1, POST2, and POST3).

Data Summary. The analyses revealed that newborns in the M(S)O(S) condition had a significantly higher level of negative affect during the habituation phase. No differences in latency to fixate the compound during each trial nor visual fixation were obtained.

Post-Habituation Phase

It was hypothesized that movement and spatial orientation changes would have differential effects on the newborns visual fixations. Following Cohen's (1975) model of attention-getting and attention-holding components of a stimulus, it was expected that changes to the stimulus' movement would result in an increase of visual attention during the first trial only, but would not sustain attention over the three post-habituation trials. This is because movement is considered an attention-getting component that has no sustaining value. Likewise, it was expected that a change to the stimulus' spatial orientation would result in an increase of visual attention across the three trials. This is because spatial orientation is viewed as an attention-holding component, but does not have any attention-getting value. However, it was hypothesized that changes to both the spatial orientation and direction of movement would result in the highest level of visual fixation increases during the three post-habituation trials because the newborns would be able to utilize information from both these dimensions. Because no Compound main-effects were obtained during the habituation phase, analyses for these variables during the post-habituation phase will be collapsed over this factor. Means and standard deviations for negative state, latency to first fixation, and overall visual attention for each Condition X Compound category during the three post-habituation phase trials are located in Tables 4, 5, 6, and 7.

Negative State. The 4(Condition) X 3(Trial) ANOVA revealed a significant Condition main-effect, $F(3,28)= 5.555$, $p< .0045$. Newman-Keuls post-hoc analyses revealed that the newborns in the M(S)O(S) condition had a higher level of negative affect relative to the M(S)O(C) and M(C)O(S)($p< .05$), and M(C)O(C) ($p< .01$) conditions (Figure 11). No Trial main-effect or Condition X Trial interaction was obtained.

Latency to First Fixation. A 4(Condition) X 3(Trial) ANOVA was performed to determine whether the hypothesized movement effect obtained. The analysis revealed a significant Condition main-effect, $F(3,28)= 4.320$, $p< .013$. As indicated in Figure 12, Newman-Keuls post-hoc analyses revealed that the only significant differences were found between M(S)O(S) condition and the remaining three conditions, all $ps< .05$. Newborns in the M(S)O(S) condition took longer to fixate the visual compound during this phase than newborns in the remaining three conditions.

Visual Fixation. The 4(Condition) X 3(Trial) ANOVA indicated a Condition main-effect, $F(3,16) = 16.556$, $p < .0001$, but was qualified by a Condition X Trial interaction, $F(6,32) = 2.930$, $p < .025$ (Figure 13). Separate one-way ANOVAs for Condition were performed on each of the trials to determine the cause of the interaction. For the first post-habituation trial the analysis revealed a Condition main-effect, $F(3,28) = 9.779$, $p < .0001$. Newman-Keuls post-hoc analyses revealed that newborns in the M(S)O(S) condition displayed significantly less visual fixation than the remaining three conditions, all $ps < .01$. The visual fixation level of newborns in the remaining three conditions did not differ significantly. No significant Condition differences were obtained for the second post-habituation trial. However, the analysis for the last post-habituation trial once again revealed a significant Condition main-effect, $F(3,28) = 10.336$, $p < .0002$. Newman-Keuls post-hoc analyses revealed that newborns in the M(C)O(C) condition displayed a higher level of visual fixation than newborns in the remaining three conditions, $ps < .01$. The visual fixation level of newborns in the remaining three conditions did not differ significantly. Likewise, separate one-way ANOVAs were performed on the visual fixation data observed on each post-habituation trial for each condition. The analyses revealed that only newborns in the M(C) -O(S) condition displayed a change in level of visual fixation across the three post-habituation trials, $F(1,7) = 6.697$, $p < .0095$. Post-hoc Newman-Keuls analyses revealed that newborns in this condition fixated the stimulus longer in the first trial compared to the third trial, $p < .01$. Therefore, it appears that the obtained interaction can be explained by the decrease in attention across the three post-habituation trials displayed by newborns in the M(C)O(S) condition contrasted with the relatively high and stable level of visual fixation displayed by newborns in the M(C)O(C) condition.

Data Summary. The analyses revealed that a movement change did not result in the anticipated shorter latency to fixate time during the post-habituation phase. However, latency times were significantly shorter for the conditions that were presented a changed visual compound during the post-habituation compared to the times displayed by the control condition. The expected visual fixation differences between the three conditions viewing a changed stimulus during the post-habituation and the control condition were obtained. The obtained Condition X Trial interaction indicated that the level of visual fixation changed across the three post-habituation trials differently for the newborns in the four conditions. As expected, newborns in the M(C)O(C) condition displayed the highest level of fixation during the post-habituation phase. This was followed by the level displayed by newborns in the M(S)O(C) condition. Newborns in the M(C)O(S) condition displayed an initial increase in visual fixation, but it was not sustained across the three post-habituation trials.Finally, newborns in the M(S)O(S) condition significantly lower levels of visual fixation.

CHAPTER IV

DISCUSSION

Orientation Effect

Slater and Sykes (1977) reported that newborn infants directed a higher level of visual fixation towards stationary horizontally oriented high contrast, black-and-white lines than identical lines oriented vertically. This finding was used to demonstrate that newborn infants were capable of detecting differences in the spatial orientation of stationary lines, and preferred the horizontal over the vertical orientation. They offered a potential explanation for their findings. Preference for horizontally oriented lines may have resulted from the fact that newborn eye movements are more frequent (and more easily made) in the horizontal direction (Salapatek & Kessen, 1966) Therefore, they suggested that when horizontal and vertical lines were presented together, horizontally oriented lines are attended to more easily than are comparable vertical lines.

The findings of the present study do not support this position. Newborns in the present study did not fixate stationary horizontally oriented lines at a higher level than stationary vertical lines. When the lines containing different spatial orientation were presented separately, one orientation did not elicit more attention than the other. The results suggest that for the newborn infant, stationary vertically orientated lines are no less enticing than are horizontally oriented lines.

Nevertheless, the findings of the present study cannot be used to refute those obtained by Slater and Sykes (1977). The obtained differences in visual fixations levels directed at the different orientations obtained in the two studies may have resulted from the different methodologies used to collect the data. Slater and Sykes based their conclusions on findings obtained in a visual preference paradigm where both the vertical and horizontal lines were simultaneously presented. When the two spatial orientations were presented together, Slater and Sykes found that newborn infants preferred the horizontal orientation. The present study did not measure preference for one orientation over another, but instead, compared visual fixation levels obtained between groups of newborns viewing each orientation separately. Whereas Slater et al. (1985) used simultaneous presentations of the stimuli, the present study presented only one spatial orientation at a time to the newborns. Therefore, newborns in the present study never had the opportunity to compare and contrast the two spatial orientations within the course of one trial.

Thus, it is possible that when the horizontal and vertical spatial orientations are paired, newborns prefer to fixate the horizontally oriented lines, as this form of visual fixation may be biologically easier (Hebb, 1949). However, preference for horizontally oriented lines does not imply that vertically oriented lines are attended to less. Therefore, it appears that the newborns' apparent preference for horizontally oriented lines does not interfere with their ability to attend to, and hence process, vertically oriented high contrast, black-and-white lines. As the results of the present study indicate, the spatial orientation of the high contrast, black-and-white lines did not influence the visual fixation level, nor the latency to first fixation per trial of newborn infants.

Spatial Orientation Processing

The results of the present study support early findings (Weiss et al., 1991) indicating that newborns are capable of distinguishing between the horizontal and vertical spatial orientations of high contrast, stationary, black-and-white stripes. The relative recovery of visual fixation by the subjects in the Movement (None) - Orientation (Change) condition in Question I during the post-habituation trials can be used as evidence that spatial orientation processing is being accomplished by 2-day-old newborns. Since recovery of visual fixation only occurred in newborns who were presented with a novel spatial orientation, it can be assumed that recovery was the result of the experimental manipulation. This assumption is strengthened by the fact that the newborns in the two conditions did not differ in their level of negative state during either experimental phase. Therefore, the differential visual fixation levels obtained during the post-habituation phase were the result of the newborns ability to discriminate between spatial orientations of black-and-white lines. The differential increase of visual fixation seen only in the newborns who were presented with a stimulus of changed spatial orientation can be explained in two manners.

First, Dannemiller and Banks (1983, 1986) have suggested that habituation and subsequent recovery of visual fixation in the infant below four-months of age are the result of selective receptor adaptation. As discussed earlier, behavioral (Zelazo et al., 1990) and neurophysiological evidence (Ackles and Karrer, 1991) suggest that Dannemiller and Bank's model does not adequately explain the phenomenon of habituation-dishabituation. Since the inter-trial periods of the present study were approximately 10 seconds in duration, and since the newborns were not exposed to a striped pattern during this interval, it seems unlikely that neuronal fatigue during the habituation phase and differential receptor selection during the post-habituation phase can best explain the findings. Moreover, unlike Hubel and Wiesel (1962) who were able to continuously expose a single neuron to a visual stimulus, thereby demonstrating response decrement and subsequent recovery when a new neuron was stimulated, newborns in the present study were not physically restrained to the point were no head and/or eye movement were restricted. Thus, it appears very unlikely that the same neuron, or groups of neurons, were being excited with each presentation of the stimulus. Also, whereas Hubel and Wiesel used a continuous stimulus presentation, newborns in the present study were exposed to a series of 30-second trials with a 10-second inter-trial interval. The interval period, and the fact that the newborns frequently looked away from the stimulus during the trial, suggests that neural fatigue, similar to that obtained by Hubel and Wiesel in the cat, was not seen in the newborns. Nevertheless, the selective receptor adaptation model cannot be discounted from these findings alone. A more thorough investigation into this question is still required.

An alternative explanation has been put forward (Bornstein, 1985, 1989; Werner & Perlmutter, 1979) which assumes that visual fixations are representative of the underlying processes required for cognition. As previously discussed, Bornstein (1988) suggests that habituation of visual fixation reflects the construction of a mental representation of an observed object. Likewise, response recovery to a novel stimulus following habituation is seen as the infant's active comparison of the novel and encoded stimuli. In order to determine whether one object is more novel than another, memory for the first object must be involved (Cohen, 1988). Thus, increases in visual fixation to a novel stimulus may be evidence that a rudimentary information-processing system is present at, or very soon after (Weiss et al., 1991).

The increase in visual fixation observed in the newborns who were presented with the novel spatial orientation during the post-habituation phase in Question I indicated that newborns can detect differences between the two spatial orientations. The ability to distinguish one spatial orientation from another indicates that a memory for the habituation phase stimulus must have been formed. Although it is not possible to determine exactly what is encoded (Slater, 1988), the ability to discrimination of spatial orientation information by newborn infants could not occur without the presence of a mental representation of the habituation stimulus. In order to determine that one spatial orientation was different from the other during the post-habituation phase, the newborns must have had a mental image of the stimulus. Moreover, the newborns must have been able to utilize their mental engrams to process incoming information. If the incoming visual information matched the existing engram not further visual attention was required. Therefore, visual fixations would remain low. However, if the incoming information was sufficiently different from the engram, visual attention was redirected toward the stimulus. Therefore, an increase in visual fixation would follow. This is the pattern of visual fixation obtained in the present study. Therefore, the present findings validate the previous work of Slater and Sykes (1977) and Weiss et al. (1991).

The differences obtained in mean latency to first fixation for the newborns in the Movement (None) - Orientation (Change) and Movement (None) - Orientation (Same) conditions during the post-habituation phase cannot be readily explained. Inspection of the individual latency times obtained for the Movement (None) - Orientation (Change) condition suggests that the significant effect might have been the result of the much higher mean latency time displayed by one subject during the seconds habituation trial block. This individual's mean latency time was more than double that of all subjects in either condition.

Even with the initial differences in latency times obtained during the habituation phase, the findings indicate that when a stationary stimulus containing a novel spatial orientation is presented to newborns following a drop in visual fixation, newborns tend to fixate the stimulus quicker during the post-habituation trials than newborns presented with a stimulus containing a familiar spatial orientation. Changes to the visual environment of newborns appear to result in shorter periods of visual inactivity.

However, why should a stationary stimulus containing a new spatial orientation capture a newborn's attention more rapidly than a stimulus containing a familiar orientation? One possible explanation is design related. Visual fixations were coded only when fifty percent of the stimulus overlapped with at least one of the newborn's pupil. This criterion of visual fixation is not based on any neurophysiological evidence suggesting object perception requires at least half of the pupil be stimulated, but rather on the past research (Fantz, 1956). Therefore it is possible that object detection occurs much earlier than the present criteria suggest. Consequently, visual fixations that do not reach criteria may have been sufficient to judge whether the spatial orientation of the lines was the same or novel. Therefore, the failure to obtain the hypothesized effect might have resulted from the criteria used to determine visual fixation.

To summarize, the results of the present study demonstrate that newborns will readily attend to and habituate to the repeated, successive presentation of a stationary black-and-white lined stimulus within an infant controlled procedure. Also, it appears that the initial spatial orientation of the stimulus does not effect the newborns level of visual attention, nor their ability to habituate to repeated presentations of the stimulus. More importantly, the differential increase of visual attention directed at a novel spatial orientation during the post-habituation trials demonstrates that newborn infants are capable of remembering and utilizing visual information. As the present study indicates, the ability to remember information concerning the spatial orientation of lined stimuli is not limited to recognition memory, as assessed using a paired comparison procedure, but recall memory is also available by or very soon after birth. This distinction is important since Crowder (1976) suggests that recall memory is a more sophisticated form of memory than recognition memory. Likewise, the data does appear to indicate that newborns redirect their attention to a stimulus containing a novel spatial orientation faster than to a stimulus containing familiar spatial orientation. In general, the results indicate that an infant controlled procedure using successive presentations of a stimulus is an effective tool for assessing the information processing capabilities of newborn infants.

Movement Effect

Burnham (1987) has identified four potential roles that stimulus movement may play in object perception. Movement may suppress or facilitate of object perception and discrimination. Likewise, infants may treat movement either as an incidental or a salient feature of an object. The results of the present study will be used to examine the potential roles that movement may play in object perception and discrimination.

Bower, Broughton, & Moore (1971) has reported that infants below 20-weeks of age cannot attend to the internal features of moving objects. Bower (1978) suggested that because infants below 20-weeks of age do not have the cognitive capabilities for processing multiple dimensions of a stimulus concurrently, the processing of dynamic information, such as direction of movement, takes precedence over the processing of stimulus specific, static information, such as the spatial orientation of the black-and-white lines. This hypothesis was based on Bower's inability to demonstrate that infants below 20-weeks could perceive the relationship between an object when it was stationary and when it was moving.

The results of the present study demonstrate that the ability to perceive the internal features (i.e., spatial orientation) of moving objects is present at, or very soon after birth. If movement interfered with the newborns ability to perceive the features of an object as suggested by Bower (1978), newborns in the Movement (Same) - Orientation (Change) condition should not have demonstrated a recovery of their visual fixation during the three post-habituation trials. According to Bower (1978), young infants when attending to an object's movement loose their ability to identify the objects structural features. As such, newborns who saw the stimulus moving either vertically or horizontally across their visual fields should not have been able to detect the change to the spatial orientation of the stripes since they would not have been able to determine what features the stimulus contained. Therefore, the stimulus would have been a meaningless, moving object for all newborns regardless of whether the spatial orientation changed or remained the same. During the post-habituation phase, their visual fixation level should have resembled that of the newborns in the control condition who continued to see a stimulus with the same, familiar spatial orientation and direction of movement. In fact, the visual fixation behavior paralleled that of the newborns in the stationary condition who were presented with a changed spatial orientation during the post-habituation phase. The recovery of the newborn infants' visual fixation to the novel stimulus demonstrates that the processing of an object's spatial orientation is not hindered by stimulus movement. Thus, it appears that newborns are capable processing stimulus-specific, static information of moving objects.

The above results imply that stimulus movement does not interfere with newborn infants' ability to process spatial orientation changes. However, the above findings says nothing about whether stimulus movement attracts newborns' attention to a greater extent than an identical stationary object. If movement is a facilitator of object perception, movement should increase the level of attention directed towards an object. As such, newborns in the present study should have displayed a higher level of visual attention toward the moving striped pattern than an identical stationary object.

The results of the present study do not lend support to this hypothesis. The latency times to first fixation and the overall visual fixation levels during the first trial block, and for that matter the entire habituation phase, were comparable between newborns in the moving and stationary conditions. Stimulus movement does not appear to increase the newborns' attention nor the speed in which they first visually engage an object. For newborn infants, visual attention is not increased by stimulus movement.

However, it is possible that a procedural error may have masked any potential stimulus movement differences. The visual chamber used to collect the visual fixation data was constructed so that a blackout screen could be lowered and raised between trials. This permitted the experimenters to easily remove the stimulus from the newborns' view between trials. Also, the procedure stipulated that the stimulus would commence its movement only after the screen was completely raised. Also, the computer programmed used to store the visual fixation information only started after the blackout screen was fully raised.

Therefore, it is possible that newborns from both the moving and stationary conditions saw the stimulus prior to it beginning its movement (if movement was necessary). In other words, it is possible that all newborns, regardless of the experimental condition assignment, saw a stationary stimulus at the beginning of each trial. These problems may have negated any potential stimulus movement effects.

To summarize, the above sections suggest that stimulus movement does not hinder the detection and subsequent processing of spatial orientation information contained within a visual stimulus. Yet, the results of the present study do not support the notion the movement increase the amount of attention directed toward an object. More work is required to substantiate these findings.

The above findings do not answer the most important question; do newborn infants treat movement as an incidental component of a visual stimulus or do they view movement as an integral feature of a visual stimulus? Slater et al's (1985) finding supports the position that newborns cannot detect changes in the direction of rotation. When presented with two identical stimuli, one rotating in a novel direction and the other rotating in the familiar direction, newborns do not direct their attention more frequently toward the stimulus rotating in the novel direction. As a result, they concluded that newborns do not demonstrate the ability to process changes in stimulus movement. While they demonstrated that newborns attend differentially to various rotation velocities, direction of rotation information was not processed.

The results of the present study are not consistent with those obtained by Slater et al. (1985). Newborns who were presented with a stimulus containing a familiar spatial orientation but which travelled in a different direction during the post-habituation trials, displayed a higher level of visual fixation than newborns in the control condition. In fact, the recovery displayed by the newborns in the Movement (Change) - Orientation (Same) condition was similar to that displayed by the newborns in the Movement (Same) - Orientation (Change) condition. Since response recovery of visual fixation is accepted as a valid indicator that newborns can create memories for the spatial orientation of an object and then use these memories to detect a novel object, it is not unreasonable to assume that newborns are also capable of developing and utilize memories for the direction in which a stimulus moves across their visual fields. Therefore, the results of the present study suggest that newborns treat movement as a salient feature of a visual stimulus.

One reason why the present study obtained different findings is that it was designed in a manner that attempted to by-pass the limitations existing in the Slater et al. study (see introduction for a detailed account). First, successive rather than simultaneous presentations of the different movements were used. As mentioned earlier, it was believed successive presentations of the habituation and post-habituation stimuli would make the task of processing movement changes perceptually easier for the newborns. Because the pre- and post-habituation stimuli contained the same spatial orientation, it was believed this information might hinder movement processing when both stimuli were available for inspection during the post-habituation trials. Therefore, by removing a potential perceptual hindrance, the task of movement discrimination was believed to be made easier.

Second, rather than forcing the newborns to attain a total of 20 seconds of visual fixation per post-habituation trial, three trials of 30 seconds each were used. Since the length of the trials were independent of the newborns visual fixation activity, all trials ended after 30 seconds regardless of the amount of visual fixation the newborns directed at the stimulus. It was believed that this approach would provide a more accurate assessment of the newborns visual fixation behaviors.

Finally, the latency times and visual fixation levels were analyzed using the three post-habituation trials as a repeated measure rather than using one mean score for each measure. This procedure was deemed more valid as it permitted the investigation of the newborns visual fixation performance over the three trials. Since it was anticipated that the effect of a change in stimulus movement would be seen only within the first trial, it would not have been appropriate to collapse the visual fixation data obtained during the post-habituation trials into one score for each measure.

If direction of movement information changes could not be processed by newborns, these methodological modification would not have made a difference. If newborns could not process the movement change, the visual fixation level of newborns in the Movement (Change) - Orientation (Same) condition would have remained at habituation levels during the three post-habituation trials. However, if the newborns in the condition detected the change in the stimulus' motion, their visual fixation level, at least during the first post-habituation trial should have paralleled those of newborns presented with a stimulus containing a novel spatial orientation during the habituation phase. The latter, rather than the former finding was obtained.

Therefore, the data strongly supports the argument that methodological limitations often mask potential abilities. It is possible that if only one mean score for visual fixation was obtained for the three post-habituation trials, the initial increase of visual attention directed at the novel direction of movement during the first post-habituation trial would have been lost. This study indicates that it is necessary for researchers to closely examine the way in which they plan to collect, store, and analyze their data, since preventable methodological faults could lead to faulty statements about the information-processing capabilities of newborns or other groups under study. It is possible that the newborns in Slater et al's (1985) study did demonstrate the ability to process movement information, but this ability was lost as a result of their procedures to collect and analyze the visual fixation data.

Because Cohen (1973) suggested that stimulus movement has attention-getting properties, it was hypothesized that during the post-habituation phase, newborn infants would fixate a stimulus undergoing a novel direction of travel, but containing the same spatial orientation [i.e., M(C) - O(S)], faster than newborns who saw a stimulus containing a novel spatial orientation, but moving in the same direction of travel [M(S) - O(C)]. The results did not support this hypotheses. While newborns who saw a stimulus containing at least one changed component (spatial orientation or direction of movement) during the post-habituation trials displayed shorter latency times than newborns in the control condition, no differences between the M(S) - O(C) and M(C) - O(S) conditions were obtained. The data indicates that stimulus change may influence latency times. However, change to the direction of movement has no greater attention-getting effect than does a change to the spatial orientation.

As with the failure to demonstrate that a moving stimulus is more attractive than an identical stationary stimulus, it is possible that the failure to demonstrate that a change in movement of a familiar stimulus captures the attention of newborn infants faster than a change to the spatial orientation of a stimulus was the result of the procedural error. Until the design of the visual chamber has been modified and new data collected, it is not possible to make a firm statement about whether newborns notice a change to a stimulus movement faster than they notice a change to its spatial orientation. At present, the data does not support the hypothesized movement effect.

Another possible explanation for the failure to support the hypothesized movement effect comes from the work of Haith, Hazan, and Goodman (1988). They have suggested that by 3.5 months, infants have developed the ability to anticipate the location of a regularly appearing stimulus. When infants were presented with a stimulus alternating between the right and left sides of their visual field, they demonstrated shorter reaction times (i.e., latency times) than infants who were presented with a series irregularly alternating stimuli.

Applied to the present study, the above work suggests that the newborns in the conditions in which the direction of travel changed should have displayed longer latency times as they would be initially looking in the incorrect location for the stimulus during the first post-habituation trial. If newborns are able to anticipate location of objects, or in this instance the direction that an object will travel, it is possible that the failure to demonstrate that changing the direction of travel decreased latency times during the first post-habituation trial resulted because newborns in the two conditions in which the movement changed directions were initially looking for the visual stimulus where they previously observed it during the habituation phase. For example, if the newborns had built up an expectancy that the stimulus always travelled to their right at the beginning of the trial and then they were shown a stimulus moving upwards, it is possible that they would not have located the stimulus until after they had check were they believed the stimulus should be; that is to their right. However, until the procedural errors mentioned earlier are corrected, it is not possible to adequately determine whether newborns can develop expectancies concerning the direction of travel a stimulus will undertake.

Prior to discussing the issue of whether newborns can process information pertaining to two dimensions of a stimulus simultaneously, two additional points related to the processing of stimulus movement and spatial orientation need to be addressed. First, the attention-getting and attention-maintaining qualities of a stimulus will be examined. Second, issues pertaining to stimulus encoding during the habituation phase will be covered.

Cohen (1973) has proposed a model that suggesting that newborns decompose a visual stimulus into two components: attention-getting and attention-maintaining. As mentioned earlier, Cohen believes that stimulus movement acts as an attention-getting factor while spatial orientation of the stripes operates as an attention-maintaining element. The present data supports the notion that stimulus movement, or more specifically a change to the direction of movement, does have attention-getting, but not attention-maintaining properties. However, the data does not fully support the notion that a change in the spatial orientation maintains the newborns attention any better than the change in direction of movement. Since the differences in visual fixation obtained during the post-habituation trials between the newborns in the two conditions that were presented with a change in only one component (spatial orientation or direction of movement) never reached significance, it cannot be concluded that newborns treat changes in dynamic (movement) or static (spatial orientation) information differently. Therefore, Cohen's delineation between attention-getting and attention-maintaining components may not be valid when only one stimulus dimension is modified. The present data indicates that changes to either the spatial orientation of lines or the direction in which a stimulus moves have attention-getting qualities for newborn infants. However, neither dimension alone can hold the newborns attention across the three post-habituation trials. In both cases, visual fixation levels declined across the two remaining post-habituation trials. As such, it appears that a change to a single dimension of a stimulus can only attract the newborns attention; it cannot sustain it.

The obtained levels of visual fixation for the two conditions which were exposed to a stimulus containing only one novel dimension during the post-habituation trials, suggests that newborns are able to detect differences in individual dimensions of an object. More importantly, the data indicates that newborns must encode both direction of movement and spatial orientation information during the habituation phase. The encoding of both forms of information is apparent because the newborns displayed recovery of visual fixation to both the movement and spatial orientation changes. If the newborns were able to encode only direction of movement information (ignoring spatial orientation) or spatial orientation information (ignoring direction of movement), recovery of visual fixation should have occurred for only one dimension. For example, if motion suppressed object identification then recovery of visual fixation should have been seen only in the condition that saw a novel direction of movement during the post-habituation phase. Likewise, if the direction of movement information was treated as incidental and ignored during the habituation phase, only newborns who saw a novel spatial orientation should have displayed response recovery. Since newborns in the Movement (Same) - Orientation (Change) and Movement (Change) - Orientation (Same) conditions displayed response recovery it can be assumed that both forms of information were encoded, remembered, and used during the post-habituation trials as a means of contrasting the novel incoming information. The ability to encode, store, and retrieve a variety of forms of information appears to be available at or very soon after birth.

In sum, the recovery of visual attention during the first post-habituation trial displayed by newborns who viewed the stimulus containing the same spatial orientation but undergoing a novel direction of travel indicates that newborn infants attend and process movement information. Unlike the findings of Slater et al. (1985), the present study suggests that newborn infants can detect direction of movement changes. Moreover, the findings indicate that newborns treat both spatial orientation and direction of movement information as salient properties of the stimulus. Unlike Cohen (1973), the present study did not find that newborns utilize movement and spatial orientation information differently when processing stimulus change. Also, the data indicates that newborns are capable of encoding information from more than one dimension concurrently and select the necessary mental engram when faced with a stimulus contain a novel dimension. Finally, the present study has provided evidence that newborn infants are capable of processing both spatial orientation and direction of movement information. The findings suggest that newborns are capable of developing mental representations for static and dynamic information. Moreover, the data suggests that they are capable of effectively using these mental representations within a recall memory task.

Compound Processing

The question that remains to be answered is whether newborn infants are capable of processing information pertaining to an objects spatial orientation and its direction of movement simultaneously. If the data indicates that processing two dimensions of a visual stimulus can occur concurrently, the present study will have demonstrated that the information-processing abilities of newborn infants are more sophisticated than previously believed.

In order for processing of both components to be clearly seen, the visual fixation levels of the newborns infants in the Movement (Change) - Orientation (Change) condition should be significantly different from newborns who were presented with either a spatial orientation change or a direction of movement change. If the pattern of visual fixation for the newborns in the Movement (Change) - Orientation (Change) condition did not differ from that of newborn infants in the two other change conditions, it would not be possible to determine whether dual processing in newborns exists.

The Condition X Trial interaction obtained for visual fixation during the three post-habituation trials and the subsequent Condition difference obtained for visual fixation during the last post-habituation trial indicates that newborns responded differently to various changes of the visual stimulus in their visual field. The non-significant difference in level of visual fixation obtained for the three condition which were presented a changed stimulus (spatial orientation, movement, and both) during the first post-habituation trial suggest that a change to any component of the stimulus has an initial attention-getting capabilities. However, as can be clearly seen in Figure 13, the level of visual fixation for the two conditions that were presented with a change in only one component (spatial orientation or direction of movement) dropped on the second trials and the then either remained at the same (Movement (Same) - Orientation (Change) or dropped even further (Movement (Change)

- Orientation (Same) on the third post-habituation trial, while the level of visual fixation displayed by the newborns in the Movement (Change) - Orientation (Change) condition remained relatively high and stable across the three post-habituation trials. It appears that the stimulus containing the two novel dimensions sustained the newborns attention longer during the post-habituation trials more than did the stimuli that contained only one novel dimension. Therefore, stimuli that contain two novel dimension appear to have both attention-getting and attention-maintaining capabilities.

Thus, newborn infants fixate a stimulus containing two novel dimensions more than stimuli containing only one novel dimension. This finding indicates that newborns are capable of encoding, remembering, and utilizing information pertaining to more than one stimulus dimension simultaneously. While the previous section indicated that newborns encoded information from both dimension concurrently during the habituation phase, the finding that newborns in the Movement (Change) - Orientation (Change) condition remain visually attentive across the three post-habituation phases suggests that newborn infants are also able to make object discriminations based two dimensions of a stimulus. Moreover, this ability results in a more robust increase in visual fixation. Consequently, the visual information-processing capabilities of newborns infants are shown to be more sophisticated than previously thought.

The finding that newborn infants respond differently to changes in two dimensions of a stimulus goes beyond demonstrating that newborns are capable of encoding information from various components of a visual stimulus simultaneously. The data suggests that newborns are also capable of using these memories to attend to and discriminate stimuli based on two dimension changes simultaneously. Not only do newborn infants have the cognitive capabilities to encode information from multiple dimensions, they have the capability to discriminate between objects containing more than one novel dimension. As such, the data supports the argument that the underlying structure to process multiple forms of information is available much earlier than previously thought. The present study illustrates that when the correct procedures are used to collect visual fixation levels, capacities previously not believed available to the newborn infant are clearly demonstrated. However, it should be stated that the procedures used to obtain the current data did not artificially bestow dual processing on the newborn infant. The ability to process two dimensions concurrently had to be already present for the effect to be seen. Methodologies can only highlight what is present, they cannot extract what does not exist.

Moreover, the present findings are similar to those obtained with older infants (Burnham & Day, 1979; Burnham & Kyriacus, 1982; Mundy, 1985) The fact that similar findings were obtained between various ages lends support that the argument that the underlying structures required for information-processing are already in place at, or very soon after birth. This ability to process multiple stimulus dimensions did not develop because of the present study. However, the proficiency to process multiple form of information concurrently was not observed earlier because earlier research focused on single dimension processing only (i.e., Fantz, 1956; Friedman, 1972; Slater & Sykes, 1977; Slater et al., 1985; Weiss et al., 1991). Therefore, the right questions had not been previously asked. While it was not the purpose of the present study to demonstrate that newborns are as efficient processors of visual information as are older infants, the study does demonstrate that the underlying structures required for processing information are available much earlier than previously thought.

How can the phenomenon of multiple stimulus processing be interpreted. Again, Cohen's (1973) model of attention-getting and attention-maintaining will used as a guide in attempting to explain what goes on inside newborn infants when they are confronted with a novel stimulus containing at least two modifications to its structural components. As previously discussed, the results of the present study do not support the claim that stimulus movement acts as an attention-getting factor while spatial orientation information works as the attention-maintaining factor. However, the theoretical processes of attention-getting and attention-maintaining can still be to explain how visual compounds are processed by newborns. While, it is not possible to determine what dimension first recaptured the newborns attention, it is possible that the processing of the visual compound involved the decomposition of the compound into its component parts (i.e., direction of movement and spatial orientation). Furthermore, one dimension could have recaptured the newborns' attention during the first post-habituation trial and the second dimension sustained the attention over the remaining trials. Therefore, it is not necessary to postulate which dimension attract attention and which dimension sustained attention. What is important is that a stimulus requires at least two dimension changes to remain attractive to newborn infants.

The belief that newborns decompose and attend to separate dimensions of the visual stimulus was derived from Treisman's (1986) premise that adult visual processing involves stimulus decomposition. Treisman believes that encoding of a visual stimulus involves the creation of separate mental engrams for the various components of the stimulus. As such, a stimulus is not encoded as a single unit, but rather as a set of component parts. While Treisman's thesis was not developed to explain the processes involved in newborn visual processing, her basic assumptions are consistent with the argument that the underlying structures required for visual processing are available at birth. Therefore, Treisman's position can be used as a model for how newborns process visual information.

Treisman's (1986) argues that visual information is encoded and stored as separate components of a visual compound, rather than as a single unit. When viewing an object, people do not encode the object in its entirety, rather they divide the object into several smaller components. It is the component parts that are stored in memories and later retrieved for processing, and not the stimulus as a whole. Cohen and Gelber (1975) have taken a similar position with infant visual processing. They suggest that young infants decompose stimuli into their component parts and later discriminate between objects based on the individual components. However, Mundy (1985) suggests that 3-month-old infants store information pertaining to a visual compound in a single memory, rather than in a set of related memories.

The present study cannot clearly ascertain which position is correct. However, the results of the present study suggest that newborn infants decompose stimulus information into its various components. Since the data clearly indicated that visual fixations increased for both direction of movement and spatial orientation changes, stimulus decomposition must be considered as a means by which newborns process visual stimuli. However, the more robust increase of visual fixation displayed by the newborns who were presented with a stimulus containing two novel stimulus dimensions indicates that all aspects of the to-be-remembered stimulus are retrievable. Likewise, the robust increase of visual fixation suggests that newborns are able to integrate the various components of a visual stimulus during recall. Thus, it is possible that stimuli are encoded as a single unit. This position is consistent with that proposed by Treisman (1986). However, more information is required before a firm position can be made.

At present, the data suggests that newborns encode stimulus dimension information separately, but can integrate the various memories during object discrimination.

While it is not possible to determine exactly what dimension of the stimulus recaptured the newborns attention during the post-habituation trials, an attempt will be made to try an explain the pattern of visual fixation obtained for the Movement (Change) -Orientation (Change) condition. The potential explanation is based on the premise that newborns encode stimulus dimension information into a series of related mental representations, and focus on only one dimension at a time during the post-habituation trials. An attempt will be made to illustrate that it is not necessary to delineate between the functions of stimulus movement and spatial orientation, as done by Cohen (1973). What will be emphasized is that newborns require a sufficiently complex stimulus (i.e., changes to two dimensions) to remain attentive once they have become habituated to, and hence familiarized with, the visual compound.

As such, it is possible that the newborns focused their attention on only one of the changed dimensions during the first post-habituation trial and then diverted their attention to the second component during subsequent trials. The idea that the newborns split their attention between the two stimulus dimensions might help explain the pattern of visual attention obtained during the post-habituation trials. During the first post-habituation trial the newborns may have focused their attention toward either the novel direction of travel or the novel spatial orientation at the expense of the other dimension. The obtained data does not permit speculation as to which dimension was attended to first. Therefore, their pattern of visual fixation was similar to those obtained for the Movement (Same) - Orientation (Change) and Movement (Change) - Orientation (Same) conditions.

During the second trial it is possible that the newborns attention was divided between the two dimensions of the stimulus. The splitting of attention between the two dimensions might explain the slight drop in visual fixation obtained for the newborns in the M(C) - O(C) condition. The ability to shift attention between the two dimensions might had required a cessation of visual fixation. While this is speculative, and cannot be directly assessed, it might be a possible interpretation of what was occurring during this trial. The position taken here is that shifting attention between dimensions of a stimulus requires that newborns stop visually fixating to the stimulus. Once the shift in attention is complete, visual fixation can resume.

Accordingly, by the third trial the newborns have because familiar with the novel visual compound to focus their attention of the other component, thus increase their level of visual fixation. The robust rebound of visual attention obtained during the third post-habituation trial can be seen as resulting from the shift in attention from the attention-getting dimension to the attention-sustaining dimension.

Therefore, it appears that a stimulus containing two novel dimensions is able to sustain the newborns' attention across three post-habituation trials. Moreover, it is possible that the pattern of visual fixation results from the attention-getting and attention-maintaining properties of the stimulus. While the present study cannot determine which dimension functioned as the attention-getting factor and which functioned as the attention-maintaining factor, it does suggest that a stimulus requires at least two novel dimensions to hold the newborns' attention across the three post-habituation trials. One dimension captured the newborns attention (i.e., attention-getting) while the second changed dimension sustained their attention (i.e., attention-maintaining).

The above explanation is in no way irrevocable. It is possible that newborn infants focus on both novel dimensions from the first post-habituation trial and that the drop in visual attention during the second post-habituation trial was a statistical anomaly. Until a replication of this work is carried out, the above statement is offered as a possible explanation as to how newborns process more than one dimension of a visual stimulus.

Conclusions and Implications

Several conclusions can be drawn for the present study. First, newborn infants are capable of processing spatial orientation changes in a stationary stimulus. This finding replicates the previous works by Weiss et al. (1991).

Second, newborns do not fixate one spatial orientation more than the other, regardless of whether the stimulus is stationary or in motion. This finding was contrary to that obtained by Slater and Sykes (1977), who demonstrated that newborns prefer horizontally oriented lines over vertically oriented lines. However, different methodologies may have resulted in these contrasting conclusions.

Third, the present study demonstrates that stimulus movement does not interfere with the newborn infants ability to detect spatial orientation changes. However, the study failed to demonstrate that a moving stimulus was more visually appealing than an identical stationary stimulus.

Fourth, the data clearly indicates that newborn infants are capable of processing direction of movement changes. This finding is contrary to that obtained by Slater et al. (1985), who failed to demonstrated that newborns could detect changes in rotation. The above two findings suggest that newborns encode information concerning the various dimensions of a visual stimulus into separate, but inter-related memories.

Finally, the data indicates that newborn infants are capable of processing two stimulus dimensions concurrently. This finding suggests that the underlying structures required to effectively process visual information are present at, or very soon after birth. Furthermore, this finding suggests that memories for the various individual components can be utilized simultaneously to process visual information.

The findings of the present study demonstrate the need for placing greater emphasis on trying to determine the exact information-processing capabilities of newborn infants. This study has clearly shown that more sophisticated abilities can be observed in the newborn infant when the proper theoretical questions are formulated, and the appropriate methodologies are employed to collect and analysis the visual fixation data.

Also, this study can be seen as a step toward developing more sophisticated procedures to assess the cognitive functioning of at-risk infants. Presently, the current assessment procedures used with older infants do not reliably predict subsequent cognitive functioning in healthy newborns (Bornstein & Sigman, 1986; Zelazo, 1989). They become even less reliable when newborns are assessed (Zelazo, Weiss, Laplante, & Papageorgiou, in preparation). Zelazo et al. reported only moderate correlations between recovery of visual fixation to a stationary stimulus at newborn and visual attention directed toward a complex, moving stimulus at 4-months. While it was found that visual attention directed at a novel spatial orientation at newborn (Weiss et al., 1991) and toward a dynamic stimulus at 4-months (Laplante, Zelazo, & Gauthier, 1989) discriminated between newborns born at various levels of risk for subsequent developmental delays, the predictions between newborn and 4-months were not what was hoped for.

It is the position of the present author that the predictions between newborn and 4-months and/or older ages can be bolstered if more complex visual stimuli are used to assess the information processing abilities of the newborn infant. It is expected that the stimulus used in the present study would result in a more diverse spread of obtained visual fixation levels during the post-habituation phase of the newborn assessment. As a result, better predictions from newborn to later ages may be obtained. Therefore, the more that can be learned about the sophistication of the newborn infants' information processing capabilities the better we will be able predict subsequent cognitive functioning. It is the present author's hope, that the above research will act as a catalyst for subsequent research into the area of newborn information-processing.

The findings of the present study support the suggestion that newborn researchers develop assessment techniques that are cognitively challenging without being perceptually difficult. If care is taken to used visual stimuli that are perceptually salient for newborn infants, it is possible that a better understanding of their true information processing capabilities will be revealed.

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APPENDIX

PARENTAL CONSENT FORM

Department of Psychology

University of Windsor

RELATIVE HABITUATION AND RECOVERY OF VISUAL ATTENTION TO ORIENTATION-MOVEMENT COMPOUNDS BY NEWBORN INFANTS.

Project Director: R. Robert Orr, Ph.D.
Master Student: David P. Laplante

Before your child can be included in this study, being conducted by David P. Laplante under the supervision of Dr. R. Robert Orr, the entire procedure must be explained to you. Any questions that you may have concerning the study must be answered to your satisfaction and if you agree to your child's participation you must sign the attached form.

The purpose of this study is to determine whether 3-day-old infants are capable of distinguishing between pictures with horizontal or vertical stripes and/or horizontal or vertical movement of the picture. In order to answer this question your child will be presented with pictures of the stripes and his/her visual attention (as measured by the amount of time your child looks at the picture) will be evaluated for a varying number of trials. The length of the participation depends upon how long your child looks at each presentation of the picture. Once your child's attention to the picture has declined your child will be presented with either the same picture moving in the same direction or one of three orientation-movement changes (same picture but a different motion direction; same motion direction but a different picture orientation; or different picture and a different motion direction) for an additional three trials.

During all phases of the procedure only your child's visual attention level, amount of drowsiness (as measured by incidence of eyes closed), and crying will be recorded. At no time will drugs or injection be given nor will your child come into direct contact with the equipment used to measure his/her visual attention. The results of the procedure will be explained to you after your child has completed this study.

During the study your child will be seated on the lap of one of the experimenters so that he/she can see the picture. The picture will be repeatedly presented to your child (30 seconds per trial) until he/she becomes disinterested of it. When your child looses interest in the picture a new picture or direction of movement may be presented to him/her. Whether your child sees a new picture or new direction of movement depends upon which group he/she is randomly assigned to.

Your child's visual attention will be measured by looking at the picture's reflection in his/her eyes. The viewing chamber is designed in such a manner that the lighting is never directed at your child's eyes. The amount of attention your child displays, as well as all instances of eyes closed and crying will be recorded and stored into a computer program. The information will be stored in such a manner that the identity of your child cannot be determined.

The study will be videotaped so that the information obtained can be later checked for its accuracy. Provision will be made so that you can obtain a copy of your child's participation.

This study is not an evaluation of your child and is not a test of how well your child is doing. We are conducting this study in an attempt to better understand how young babies react to changes in their surroundings. It is hoped that one day this type of study will lead to a test of newborn capabilities.

This research has been approved by the Ethics Committees of the Salvation Army Grace Hospital and the Department of Psychology (University of Windsor). If you have any complaints regarding the present study and/or the conduct of the researchers involved with the study, please feel free to contact Dr. Jim Porter at the University of Windsor Psychological Services Centre (253-4232, ext. 7012). Dr. Porter is the Chair of the Department of Psychology's Ethics Committee.

STATEMENT OF INFORMED CONSENT

NAME OF CHILD: ______________________________ DATE: ___________

The nature of this research procedure has been explained to my satisfaction. All of the procedures, including the equipment used to record the results were explained to me. I know that the interpretations of all test results will be shared with me.

My child's identity and study results will be kept confidential. I give my permission to use my child's results for any publications that may result from this study.

I have read and understand the description of this study and I am willing to allow my child to participate in this study. I have been given an opportunity to write in below any limitations or restrictions with this statement.

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I understand that I may choose not to have my child participate in this study. If for any reason I wish to discontinue my child's initial participation, I am free to do so. In no way will this affect my child's future care or treatment at the Salvation Army Grace Hospital.

Do you wish to obtain a copy of any scientific papers that may arise from this research. ____ Yes ____ No

I have received a copy of this consent form.

Date: ________________________

Signed: ___________________________________
Parent

SIgned: ___________________________________
Investigator

Signed: ___________________________________
Witness