International Journal of Biological and Pharmaceutical Sciences Archive

ISSN: 0799-6616 (Online)

Journal homepage: https://ijbpsa.com/

(RESEARCH ARTICLE)

Check for updates

Visually guided reaching and waking behavior in early infancy

Debra Harkins *

Suffolk University, Sociology Department, Boston MA, USA.

International Journal of Biological and Pharmaceutical Sciences Archive, 2023, 06(01), 018–022

Publication history: Received on 14 June 2023; revised on 24 July 2023; accepted on 27 July 2023

Article DOI: https://doi.org/10.53771/ijbpsa.2023.6.1.0073

Abstract

Alert wakefulness is a critical aspect of state regulation in early infancy, yet little is known of this process. This study sought to examine how brief periods of unstable waking transition into more stable stages of alert wakefulness. Fifteen infants were videotaped as they woke from naps beginning at 3-4 weeks of age and followed weekly until they were 24 weeks of age. Infant reaching for a rod was recorded beginning at 12 weeks to determine onset of visually guided reaching. Infants who exhibited longer transitions from sleep to more alert state showed a later onset of visually guided reaching suggesting state organization and transitions seem to be an early indicator of behavioral coordination that predicts t rate of cognitive development.

Keywords: Motor Development; Infant Reaching; Waking Behavior; Neuromotor; Infant Development; Early Infancy

1. Introduction

One of the most important aspects of state regulation during early infancy is the emergence of alert wakefulness during the early weeks or months after birth [1, 2], yet we know remarkably little about this process. In the neonatal period, alert wakefulness comprises only brief fragile episodes usually followed by a shift to fussing or crying. The question arises how brief periods of unstable waking transform into stable states of alert wakefulness. Researchers propose that the infant's active engagement with the environment can maintain the stability of alert wakefulness states and that the primary mechanism for maintenance of this alert state is the infant's ability to engage in goal-directed actions with environmental stimuli. The main goal of the proposed research was to examine alert wakefulness in healthy newborns under the guiding assumption that infants who make smooth transformations into alertness explore their environment more and develop their processing capacities better than infants who exhibit unstable state transitions and likely to exhibit delayed or abnormal development.

In the neonatal period, alert wakefulness comprises only brief fragile episodes usually followed by a shift to fussing or crying [3, 4]. The question arises how brief periods of unstable waking transform into stable states of alert wakefulness and what factors contribute to the stabilization of the alert wakefulness states. We hypothesized that infant's active engagement with the environment can maintain the stability of alert wakefulness states and that the primary mechanism for the early maintenance of the active alert state is the infant's ability to engage in goal-directed actions with environmental stimuli [2]. The ability to coordinate movements into stable motor patterns provides more opportunity for infants to interact with the social and physical environment along with the extended duration of the active alert state.

Although infants may occasionally exhibit visually directed reaching shortly after birth, stable and reproducible more advanced visually guided reaching occur later between 3-5 months after birth [5]. Visually guided reaching behavior requires correspondence in arm and hand -controlled by the observed spatial characteristics of the object. We examined the relation between individual differences in the induction of alert wakefulness during the first three months and the

* Corresponding author: Debra Harkins

development of visually guided reaching during an infant's fourth month, to test our hypothesis regarding alert waking states and cognitive development.

Past research shows that social interaction prolongs the mean duration of wakefulness [6, 7] suggesting that specific parental intervention facilitate transitioning from sleep to wakefulness process. Therefore, the characteristics of the mother-infant interaction may either facilitate or interfere with transitions from sleep to waking, the stability and duration of alert wakefulness, and therefore social and cognitive development.

Past studies found relation of sex differences in the maintenance of no distress wakefulness [8, 9] such that preterm males exhibit more fussiness at 34 weeks post-conceptual age than females [8] and females exhibit a more "quiet alert" states for longer durations than males. However, both studies involved handling the neonate for neurobehavioral assessment and maneuvering of the limbs, and may therefore, represent differences in ability to sustain non-distress wakefulness in response to handling rather than in a free-field situations. In this study, we sought to determine if infants who make smooth transitions into waking develop advanced visually guided reaching behavior earlier than infants with more irregular sleeping transitions.

2. Material and methods

Fifteen (8 females, 7 males; 9 breast-fed 6 botte-fed) infants served as participants. All infants were from the greater Boston, MA, area and recruited by contacting their mothers shortly after the birth of their children, while still patients at a hospital in Boston, MA. All infants were from normal full-term (38- 41 weeks) pregnancies with uneventful deliveries, normal birthweight and Apgar scores (over 8/8),with all observations.

We videotaped weekly infants in their homes beginning at 3-4 weeks of age as infants woke from naps until approximately 24 weeks of age. To capture waking behavior, recording included at least 10 minutes of sleep before waking behavior began and at least 3 minutes of alert behavior after waking or 10 minutes of sleep. Parents were instructed to interact with their infant how they normally would. We defined sleep as eyes closed, relaxed face, no vocalizations and less than three generalized movements for at least 10 minutes. Infant behaviors during sleep included intermittent eye opening of less than two seconds; intermittent grimace face with closed eyes; intermittent heavy sighs: and sudden writhing movement (less than one per 10-minute period) were ignored. We defined alert behavior as eyes opened, relaxed face, no fussy/crying behavior, no writhing, with or without generalized movement for at least three minutes. We should note that three infants never transitioned into an alert state using the criteria set forth here. Parents reported during these visits that their infant was "awake." Repeated visits during the same and following week revealed similar sleep-transition- sleep behavior for these infants.

In addition, we recorded parents as they responded to their waking infants including handling (holding, rubbing, kissing, touching); feeding (breast or bottle); talking (including singing); and/or providing a pacifier. Visually guided reaching, as opposed to more ballistic reaching (swiping) was tested weekly and videotaped, beginning at 12 weeks and continued until infant exhibited visually guided reaching or reached 24 weeks of age. We presented infants with several rod-shaped objects (1/8 to 1/2 inch in diameter; six to 15 inches) while they were seated in an infant seat (or parent's lap). Once the infant reached for the rod-shaped object, the rod was rotated by 90 degrees horizontal and vertical presentations were counterbalanced). We continued presenting rod until infant showed reaching or infant became fussy. We rescheduled visits when infants exhibited fussy/crying behavior.

2.1. Data Analysis

We analyzed videotapes of waking activity for: 1) switch time from one stable state to another as measured by time from first vocalization and/or eyes opening to first three consecutive minutes of non-distress wakefulness; 2) frequency and type of movements (writhing, generalized movements, none); 3) frequency and duration of vocalizations (fussing, crying, none); 4) frequency and duration of eye movements (open, closed or drowsy); 5) frequency and duration of facial responses (relaxed or grimaced); 6) duration of fussing and crying until first parental response; and 7) duration of generalized movements until first parental response. We analyzed parental intervention for frequency and duration: 1) of handling, talking, feeding, and pacifier; 2) until infant fussing and crying stopped; and 3) until generalized movements stopped.

Onset of visually guided reaching behavior was determined by slow-motion analysis of hand orientation during reaching. Any change of the hand to orientation (i.e., vertical to horizontal; horizontal to vertical) of the rod during the reaching phase, as opposed to more ballistic reaching, was used as evidence of coordinated looking and reaching action schemes. Reliability of four waking cycles and reaching behavior for the above measures was .82 -.97 (kappa).

3. Results

Pearson correlation performed between infant's onset of visually guided reaching and duration of transition from sleep to wakefulness during the first month after birth revealed a significant positive relationship r (15) =.60, p. <.05, with infants who exhibited longer transitions from sleep to an alert state showing later onset of visually guided reaching. Infant behavior during transition

from sleep to wakefulness in relation to onset of visually guided reaching revealed significant correlation in frequency of generalized movements r(15) =.81, p <.01; and the proportion of generalized movements during transition from sleep to wakefulness r =.51, p <.05 were related to onset of visually guided reaching. We found no other relationships between other infant waking behavior and their later onset of reaching.

As expected, MANOVAs followed by post hoc analyses revealed significantly longer state transitions, F (1, 12) = 14.08, p <.003; more generalized movements F = 5.37, p <.02; and drowsy behavior (F = 4.73, p <.05) but not grimacing or fussy/cry behavior for males than female infants (See Table 1).

Table 1 Infant behavior during waking transition

	Male	**Female**
Duration of transition (minutes)	21.80 (10.57)	5.71 (7.06) **
Mean # of:+ General movements	7.43 (3.95)	2.80 (2.62) *
Grimace behavior	1.96 (2.06)	0.78 (1.03)
Drowsy behavior	3.53 (5.16)	2.65 (1.36)
Fuss/cry behavior	3.59 (1.12)	2.06 (1.90)

*p < .02;**p < .003 += Mean # across three-minute moving time window

Pearson correlations performed between infant behaviors (duration of state transition, generalized movements, fussy/crying, drowsy behavior, and grimacing behavior) and parental behaviors (duration of parental handling, talking, feeding, and offering pacifier) during infant state transition revealed duration of parental handling related to the duration of fussy/crying behavior r (15) =.65, <.01 and duration of state transition (15) = .74, p <.01, but not parental talking, feeding or offering pacifier. Correlational analyses revealed that number of stimuli (handling, talking, feeding and offering pacifier) parents provided to calm r (14) =.88, p <.001 related to duration of infant fussing and crying behavior, but not generalized movements, drowsy behavior, grimacing behavior or duration of state transition. Further analyses revealed that duration of parental stimuli provided until generalized movements stopped was significantly longer for male than female infants F(1,14) = 12.61, p <.003.

4. Discussion

As hypothesized, individual differences in waking behavior related to the onset of visually guided reaching with infants who took longer to switch from sleep to an alert state exhibiting later onset of visually guided reaching than infants with brief state transitions. Infants with more frequent generalized movements during state transitions exhibited later onset of visually guided reaching compared to infants with less frequent movements during transitions. Male infants took longer to switch from sleep to an alert state and exhibited more drowsy behavior and generalized movements Patterns of state organization and state transitions seems to be an early indicator of behavioral coordination that predicts the rate of cognitive development [2, 10].

The finding that infant waking behavior related to later onset of visually guided reaching is consistent and extends previous research on early infant state behavior and later behavioral development [11, 12, 13, 14, 15, 16]. Previous research demonstrated that the appearance and form of general movements in early infancy depends on the integrity of the nervous system [17, 18, 19, 20].

The finding that male infants have longer transitions from sleeping to waking and have more general movements than female infants is consistent with and extends previous research which revealed that male infants are more vulnerable to prenatal stress and birth trauma [21] which seems to be related to a less developed nervous system [22]. Similarly, Harkins, et. al [9] found that female infants remain in "quiet alert" states longer than male infants who exhibit more

crying and sleeping as well as more frequent state transitions. Taken together, these studies suggest that the integrity of the female nervous system provides briefer and calmer transitions into wakefulness thereby providing longer periods of quiet alertness. The relationship between general movements and nervous system integrity has also been found with premature infants who engage in more general movements than full-term infants. General movements typically involve limbs, head and trunk without any distinctive sequence or pattern. Although there is much research [17, 19] on the development of general movements, more research is needed to discern the many forms of infant movements that may be related to individual differences in infant development. The organization of state behavior has often been used as an index of the integrity of the central nervous system [8, 23]. The sex differences in waking behavior reported here and in previous studies [8, 9] suggest sex differences in the maturation of the central nervous system.

The finding that mothers respond to most distressful infant behavior by holding their infant and the finding that male infants generally exhibited more fuss/cry behavior may explain the further finding that male infants were being handled by their mothers significantly more than female infants. Male infants may require more maternal attention than female infants. The findings of this study suggest that infant temperament has a significant effect on maternal styles of mother-infant interaction. Further research is needed to examine whether these maternal differences in frequency and/or duration of maternal handling differentially affect later infant waking behavior. It remains unclear whether differences in maternal handling increases or decreases the infant's transition from sleeping to waking and its possible relation to later behavioral development.

5. Conclusion

Patterns of state organization and state transitions seem to be an early indicator of behavioral coordination that predicts the rate of cognitive development. The finding that waking behavior was related to the onset of visually guided reaching lends support to the hypothesis that an infant's inability to change state appropriately may be maladaptive to later development.

Compliance with ethical standards

Acknowledgments

Thank you to the *National Institute of Health* for supporting this postdoctoral research. Thank you to Peter H. Wolff who served as a wonderful mentor of this project.

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of ethical approval

The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved.

Statement of informed consent

Informed consent was obtained from parents of infant participants included in the study.

References

[1] Colombo, J. and Horowitz, F.D. 1987. Behavioral state as a lead variable in neonatal research. Merrill-Palmer Quarterly, 33(4): 423-437.

[2] Wolff, P.H. 1987. The Development of Behavioral States and the Expression of Emotions in Early Infancy. Chicago: University of Chicago Press.

[3] Dias, CC. and Figueiredo, B.. 2020. Sleep-wake behaviour during the first 12 months of life and associated factors: a systematic review. Early Child Development and Care, 190(15), 2333-2365.

[4] Spruyt K, Aitken RJ, So K, et al., 2008. Relationship between sleep/wake patterns, temperament and overall development in term infants over the first year of life. Early Human Development, 84(5), 289-96.

[5] Bushnell, E. 1985. The decline of visually guided reaching during infancy. Infant Behavior and Development, 8, 139-155.

[6] Peirano, P. Algarin, C. & Uauy, R. et al., 2003 Sleep-wake states and their regulatory mechanisms throughout early human development. Journal of Pediatrics, 143 (4), DOI: 10.1067/s0022-3476(03)00404-9

[7] Thoman, EB. & Ingersoll, EW. 1999. Sleep/Wake states of preterm infants: Stability, developmental change, diurnal variation, and relation with caregiving activity. Child Development, 70(1), 1-10.

[8] Korner, A., Brown, B.W., Reade, E.P., et al. 1988. State behavior of preterm infants as a function of development, individual and sex differences. Infant Behavior and Development, 11, 111-124.

[9] Harkins, D.A., Meserve, A., & Michel, G.F. 1988. Sex differences in neonatal states and head orientation differences. Infant Behavior and Development, 11, 132.

[10] Korner, A. 1972. State variable, as obstacle, and as mediator of stimulation in infant research. Merrill-Palmer Quarterly, 18, 77-94.

[11] Anders, T.F. and Keener, M.A. 1985. Developmental course of nighttime sleep-wake patterns in full-term and premature infants during the first year of life. Sleep, 8(3), 173-192.

[12] Caldera, Y., Schwartz, S., & Horowitz, F. 1985. Prediction of later developmental status from repeated neonatal assessments. Paper presented at the meeting of the Society for Research in Child Development, Toronto.

[13] Green, J., Bax, M. and Tsitsikas, H. 1989. Neonatal behavior and early temperament: A longitudinal study of the first six months of life. American Journal of Orthopsychiatry, 59(1): 82-93.

[14] Pennestri, MH. Moss, E. O'Donnell, K. et al., 2015. Establishment and consolidation of the sleep-wake cycle as a function of attachment pattern, Attachment & Human Development, 17(1), 23-42.

[15] Thoman, E.1990. Sleeping and waking states in infants: A functional perspective. Neuroscience and Biobehavioral Reviews, 14, 93-107.

[16] Vaughn, B., Taraldson, B., Crichton, L. and Egeland, B. 1980. Relationships between neonatal behavioral organization and infant behavior during the first year of life. Infant Behavior and Development, 3, 47-66.

[17] Ferrari, F., Cioni, H.F.R., Prechtl, H.F.R. 1990. Qualitative changes of general movements in preterm infants with brain lesions. Early Human Development, 23, 193-232.

[18] Gorga, D., Stern, F.M., Ross, G. and Nagler, W. 1988. Neuromotor development of preterm and full-term infants. Early Human Development, 18, 137-149.

[19] Hadders-Algra, M. and Prechtl, H.F.R. 1992. Developmental course of general movements in early infancy. I. Descriptive analysis of change in form. Early Human Development, 28, 201-213.

[20] Hopkins, B. and Prechtl, H.F.R. 1984. A qualitative approach to the development of movements during early infancy. In H.F.R. Prechtl (Ed.) Continuity of Neural Functions from prenatal to postnatal life. Oxford: Blackwell.

[21] Tanner, J.M. 1978. Fetus into man: Physical growth from conception to maturity. Cambridge, MA: Harvard University Press.

[22] Hutt, C. 1972. Sex differences in human development. Human Development,

[23] Becker PT. & Thoman, EB. 1982. 'Waking activity': The neglected state of infancy. Developmental Brain Research, 4(4), 395-400.

[24] Thoman, EB. & Ingersoll, EW. 1999. Sleep/Wake states of preterm infants: Stability, developmental change, diurnal variation, and relation with caregiving activity. Child Development, 70(1), 1-10.