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A BEHAVIORAL MODEL OF INFANT SLEEP DISTURBANCE

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Chronic sleep disturbance, such as bed refusal, sleep-onset delay, and night waking with crying, affects 15% to 35% of preschool children. Biological factors, particularly arousals associated with recurrent episodes of rapid-eye-movement sleep, render infants vulnerable to repeated awakenings. Parental failure to establish appropriate stimulus control of sleep-related behaviors and parent-mediated contingencies of reinforcement for sleep-incompatible behaviors may shape and maintain infant sleep disturbance. Treatment and prevention strategies are discussed, and research needs are identified.

DESCRIPTORS: infant sleep, night waking, parent interaction, stimulus control, contingencies

The stream of individual human behavior that begins at birth is modulated by several cyclic patterns. Conspicuous among these is the circadian cycle of waking and sleep (Finger, 1982). During infancy, children have to begin to adjust their patterns of sleep and waking to correspond with familial and culturally determined sleeping practices. Anthropological research suggests that, because of variation in the nature of these practices, there is considerable variation among cultures in the age at which infants and children typically demonstrate accomplishments such as sleeping through the night (see Konner & Super, 1987, for a review). This indicates that the development of sleep can be modulated through "regulatory intervention" by parents and caregivers (Chess & Hassibi, 1986).

In western societies, at least, this process of adaptation may include the child learning to go to bed at times different from other members of the family; sleeping alone in his or her own cot or bed, separate from parents, although possibly sharing a room with other family members; and going back to sleep following a night waking without disturbance or attention. A behavioral account of this process of regulatory intervention and its failures is the purpose of this paper.

BEHAVIORAL ANALYSIS OF SLEEP

A behavioral model of sleep must contain, at least implicitly, an account of the relationship between sleep and the variables that are important to a behavioral analysis, such as conditioned and unconditioned stimuli for respondent behavior and three-term contingencies involving antecedent stimuli, behaviors, and response consequences for operant behavior. The purpose of this section is to make such an account explicit.

Is sleep respondent or operant behavior? Skinner suggested that "We may conveniently regard sleep as a special form of behavior" (Skinner, 1953, p. 155), but it is not clear what he meant by "special." Perhaps he regarded sleep as being neither respondent nor operant behavior. If sleep is a respondent, then it should be possible to consistently elicit it by presenting the unconditioned stimulus (US) for sleep. No such exteroceptive US is known, nor, despite much investigation, has a natural, universal, interoceptive biochemical sleep US been identified (Borbéley & Tobler, 1989).

The defining characteristic of operant behavior is that it is strengthened or weakened by its con-

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sequences, so if sleep is an operant it should be possible to increase or decrease its frequency and duration by reinforcing or punishing it. There has been much research into the treatment of adult insomnia (see Buysse & Reynolds, 1990; Lilie & Rosenberg, 1990; Mendelson, 1987; Morin & Kwentus, 1988, for reviews), but no behavioral treatment can unambiguously be described as a sleep-reinforcement procedure, suggesting that investigators have been unable to identify a reinforcer for sleep.

Punishment might be used to alter the place and time of day for sleeping, but there are clear limits to reducing the frequency and duration of sleep by punishment. When rats were punished for falling asleep by being required to walk a short distance (to avoid falling into water), time spent asleep was reduced by 87%. However, sleep was suppressed only as long as the punishing consequence was provided. In addition, the procedure produced severe physiological debilitation, leading to death in 38% of the subjects (this was not due to the stress of the forced exercise) (Rechtschaffen, Gilliland, Bergman, & Winter, 1983). Such experiments are, of course, conceived of as research into sleep deprivation, not sleep punishment, and it is hard to envisage a sleep-punishment procedure that is not also a sleep-deprivation procedure. Given these failures to identify unambiguously the eliciting stimuli or reinforcers and punishers for sleep, it seems unlikely that sleep is either operant or respondent behavior.

Sleep may better be viewed as a biobehavioral state, for which state is a contextual variable for all other behaviors (Thoman, 1990). Respondents and operants are involved in the transition into the state and possibly in its maintenance and coordination. Parallels may be drawn with other states of the organism, such as digesting food or being pregnant. As with sleep, distinctive respondents and operants (such as secreting digestive enzymes, coitus) are associated with the instigation of these states. Sleep, however, is distinctive in that the context it establishes is associated with a major reduction in the quantity and quality of overt behavior associated with it.

Bootzin (1977) has suggested that falling asleep is an instrumental act (i.e., an operant) emitted to produce sleep, which functions as the reinforcer of falling asleep (just as food ingestion and digestion do for food acquisition). By extension of this argument, falling asleep can be thought of as the end of an operant chain (Ferster, Culbertson, & Boren, 1975) that begins with bed-preparation behaviors and ends in a period of behavioral quietude just before sleep begins. This period of behavioral quietude is the consummatory response for sleep.

This view of behavioral quietude is supported by studies using the multiple sleep latency test with adults, adolescents, and older children (Carskadon & Dement, 1987) and it is reasonable to extrapolate this to infants and young children. This suggests that the quality and duration of recent sleep combine with the length of time since last awakening as an establishing operation (Michael, 1982) that (a) alters the reinforcing value of sleep and (b) changes the probability of emission of the sleep consummatory response and other responses chained with it.

A key assumption (Bootzin, 1977) is that if sleep is to occur reliably and appropriately, the operant chain of preparing for and falling asleep needs to come under the control of appropriate discriminative stimuli (SDs). Each component of the chain may have separate SDs, which may be both external and internal cues, and one component may provide the SDs for the next. In the absence of SDs for falling asleep, individuals will be affected by sleep initiation difficulties.

As already noted, entering sleep requires general behavioral quietude. This period of reduced behavioral output may be preceded and accompanied by internal cues, which the verbal community (Skinner, 1963) may teach us to call "tiredness" or "sleepiness." A period of reduced activity may be necessary, or at least helpful, in permitting these and other sleep-controlling internal cues to be discriminated. Continued activity will compete and interfere with falling asleep under the control of natural internal cues, thereby delaying sleep, whereas cessation of activity and exposure to distinctive sleep-preparatory cues (e.g., adopting a consistent

sleep posture, Boynton & Goodenough, 1930) facilitate sleep.

A second key assumption (Bootzin, 1977; Bootzin & Nicassio, 1978) is that sleep difficulties may be associated with a repertoire of inappropriate, sleep-competitive activities. These competing behaviors may be maintained by a variety of positive and negative reinforcers and may come under the control of SDs that otherwise would control falling asleep. Such circumstances will again produce sleep initiation difficulties.

Before considering how this analysis may help us to understand sleep disturbances in infants, we need to consider, first, the development and organization of sleep in infancy and, second, some definitional, epidemiological, and methodological issues.

INFANT SLEEP: ORGANIZATION, DISRUPTION, AND MEASUREMENT

Infant Sleep State Organization

The sleep phase of the circadian cycle is itself marked by cycles of phases of rapid-eye-movement sleep (REM or active sleep) and non-REM sleep (NREM or quiet sleep). Although sleep–wake and REM–NREM cyclicity is evident from birth, the temporal distributions and phase durations of these cycles in the neonate are different from those in the older child and adult (Ellingson, 1985). The newborn infant sleeps an average of 16 out of 24 hr, with sleep episodes and relatively brief wakings occurring both day and night. Over the first few months of life, consolidation of the sleep and awake periods occurs, so that episodes of both increase in duration. Moore and Ucko (1957) found that the proportion of children (in a British sample) who awoke only once per week between the hours of midnight and 5 a.m. increased from 19% at 1 month to 80% at 4 months and 90% at 10 months.

Although infant sleep may be differentiated into REM and NREM sleep from birth, many aspects of neonate sleep differ from that of older children and adults. Rapid maturation of sleep stages seems to occur over the first 3 to 4 months (Sostek & Anders, 1981), with less dramatic changes continuing throughout childhood into adolescence (Ferber, 1990b). When asleep, the infant cycles between REM and NREM phases more quickly than does an adult, with phase lengths close to 60 min (vs. 90 min for adults). Initially, about half of all sleep is spent in the REM phase (vs. 25% in adults), but the proportion of REM sleep diminishes quite steeply over the 1st year, decreasing to about 33% at 8 months of age and to 30% at 1 year (see Ferber, 1990b; Hobson, 1989; Pivik, 1983, for reviews).

Electroencephalographic (EEG, Coons, 1987) and all-night video (Anders, 1979) studies have shown that REM sleep regularly precedes arousals in infants, and that these arousals are generally sufficient to cause the child to wake, at least partially. Thus, because of the frequency with which REM periods recur and their association with arousal and waking, infants are vulnerable to regular waking during extended periods of sleep. Sometimes these arousals and wakings are accompanied by signals of wakefulness, especially crying, so that parents may become aware of them. Otherwise, the child resumes sleep without overt evidence of awakening. Ferber and Boyle (1983), therefore, distinguish partial arousals, which are unsignaled and from which sleep is resumed with minimal interruption, and complete arousals, which lead to waking with crying and calling out. Recurrent arousals and at least partial wakings are normal. If problems occur, they are, then, problems of sleep reinitiation, not of sleep maintenance (Ferber, 1985).

Viewed from a developmental perspective, these cyclic REM-associated arousals are an almost universal vulnerability factor, which, in interaction with other less widespread factors, such as parenting style (Anders, Halpern & Hua, 1992), renders many infants at risk of making contact with contingencies of positive and negative reinforcement for night waking that are mediated by parents' responses to their child's behavior (Anders et al., 1992; France & Blampied, 1993). The analysis of these vulnerability factors and their interaction with antecedents of and consequences for sleep-inappropriate behavior chains may account for the development of infant sleep disturbance (ISD), provide a rationale

for effective treatment, and suggest strategies for prevention (France & Blampied, 1993).

Definitional, Epidemiological, and Methodological Issues

Definitions. A number of formal schemes for the definition and diagnosis of childhood sleep disorder have been proposed (Diagnostic Classification Steering Committee, 1990; Rollwarg, 1979). We have eschewed the use of these schemes for several reasons, including the following. First, we have reservations about labeling as a "disorder" behavior that is universal at some ages and extremely common at later ages (see below). For this reason, we (and others, see Carskadon, Anders, & Hole, 1982; Dollinger, 1977) refer to infant sleep disturbance. Second, these classification systems appear to lump together sleep disturbances that have very different etiologies. For instance, the Diagnostic Classification Steering Committee's (1990) diagnostic system includes, in its category of dyssomnias, sleep problems that appear to be genuine diseases of childhood, such as narcolepsy, and behavioral problems such as "limit-setting sleep disorder." Finally, reviews that adhere in some degree to these classification systems (e.g., Doleys, Weiler, & Pegram, 1982; Dollinger, 1977; Mindell, 1993) tend (a) to emphasize problems among older children and adolescents and (b) to focus on parasomnias, such as sleep walking and sleep terrors. Our interest is in what Werry (1986) referred to as "simple sleep problems" in infants from 3 months to 2 years of age. This age range is of interest because it lies between the period of largely endogenous control of sleep (the first 3 to 6 months of life) and the age at which the development of speech and general social functioning expands both the potential causes of behavioral dysfunctions and the possible range of interventions for them.

These simple sleep problems, collectively referred to as infant sleep disturbance (ISD), we have defined to include bed refusal (refusal to go to bed at a regular time or when instructed); sleep-onset delay (delay in going to sleep, often accompanied by demands—tantrums—for parent attention and/or specific rituals); night waking (repeated night waking with crying or calling out and sometimes getting out of bed); and cosleeping (sleeping in other family members' beds when this is undesired by the other person[s]; France, 1989; Sanders, Bor, & Dadds, 1984). A child who has never settled into appropriate sleep patterns has primary ISD. Some children, after having had a period of settled sleep, develop secondary ISD, resuming one or more of the above problem behaviors. This may occur following illness, stress, or some change or disruption in family circumstances (France, 1989; Moore & Ucko, 1957).

Epidemiology. Night waking is the ISD for which parents are most likely to seek help, and therefore is the one for which there is epidemiological data. There have been several relatively large-scale surveys of the prevalence of night waking in infants, from several different countries (United States, United Kingdom, and New Zealand). Richman (1981) reported that 24% of her sample woke 2 to 4 nights per week, and Fergusson, Shannon, and Horwood (1981) reported that 47% of the children they studied woke at least once per week (N = 771 and 1,144, respectively). Using a different survey methodology (a telephone survey, N = 289), Johnson (1991) reported 38% of infants to be problem wakers, waking, on average, 1.8 times per night 6 nights per week.

These prevalence rates are, however, derived from often retrospective parent reports, the reliability of which has not been checked. A second methodological problem with these studies is that the criteria for determining that a sleep problem exists are essentially arbitrary. Longitudinal studies seeking to relate childhood sleep problems to problems later in childhood, adolescence, or adulthood are uncommon, and have generally not found numerous or consistent predictive relationships. In the short term, however, ISD is associated with other difficulties (e.g., Klackenberg, 1982; Richman, 1981; Zuckerman, Stevenson, & Bailey, 1987). Children do not necessarily "grow out" of ISD (Zuckerman et al., 1987), and the development of secondary ISD is quite common, affecting be-

tween 19% to 50% of families (Fergusson et al., 1981; Moore & Ucko, 1957).

Epidemiological studies also show that in families that meet researchers' criteria for the presence of ISD, a significant proportion of parents do not claim that they have a problem (e.g., 47% vs. 24% in Fergusson et al., 1981). In the absence of consistent epidemiological data linking defined levels of ISD to later behavioral difficulties, this raises the question of how (or by whom) the problem of ISD is to be defined. Anders et al. (1992) note that in the absence of any quantitative diagnostic system for ISD, parents' reports of concern remain the primary source of clinical data. This reliance upon parental specification of concern is, however, consistent with an applied behavior analysis of what a problem is, namely displaying or complaining of a problem (Baer, Wolf, & Risley, 1987, p. 314).

Reliance on parental complaint as the primary source of problem definition does not preclude others who have knowledge of the family from identifying ISD. It is important, in fact, that professionals should be sensitive to the possibility of ISD, because parents, whether or not they recognize ISD, are likely to experience negative side effects. Problems include parental (especially maternal) stress, depression, and marital difficulties, plus daytime sleepiness and irritability in the child and possibly in affected siblings, and restrictions in the frequency and intensity of positive parent–child interaction (Chess & Hassibi, 1986; Durand & Mindell, 1990; Fergusson, 1982; Pritchard & Appleton, 1988; Seymour, 1987). More research is urgently needed into the negative effects of ISD on families and into the generality of any positive effects wrought by effective intervention.

Methodological issues. Alternatives to reliance on subjective parental report have been sought. Initial studies of infant sleep employed EEG measures, normally taken in a sleep laboratory. The unfamiliarity of the location and the stress of the procedure produce distortions in sleep patterns (Sostek & Anders, 1981), and EEG measurements are impractical for either general research or clinical use. In addition, EEGs measure only sleep phenomena and not other activities of interest (e.g., parent–child interaction). EEG measures remain, however, the method by which other measures of infant sleep state are calibrated.

Anders and Sostek (1976) developed a time-lapse video procedure for making all-night records of infant sleep. These records permit the analysis of both infant sleep state and some parenting activities during the night (Anders et al., 1992). Technological improvements have dramatically improved these systems, and all-night video recording using infrared illumination is the measurement system of choice for research, even if it remains impractical for routine clinical work. Other advances in technology have resulted in devices such as the Actigraph (Sadeh, Lavie, Scher, Tirosh, & Epstein, 1991) and the Home Monitoring System (Thoman & Glazier, 1987), which nonintrusively measure sleep, gross activity, and various physiological changes in the infant, but do not measure parent–child interactions.

Time-lapse video yields information relevant to night waking and sleep-onset delay (although it is limited to in-bed events) but does not routinely record the prebedtime activities involved in bed refusal or cosleeping. In-home observation during the prebedtime period, ideally using regular video recording technology (Durand & Mindell, 1990; Sanders & Christensen, 1985), may be used for this purpose, although it raises difficult issues of intrusiveness and reactivity to observation.

Despite advances in recording methods, both research and clinical practice are likely to continue to require the use of parent recording of infant sleep. Parent observations are normally systematized by a sleep diary (e.g., France & Hudson, 1990; Richman, Douglas, Hunt, Lansdown, & Levere, 1985; Seymour, 1987). The Sleep Behavior Scale (Richman, 1981, 1985) permits the quantitative synthesis of diary information into a composite score of ISD severity, permitting standard comparisons to be made across studies. Also from diary information, Lawton, France, and Blampied (1991) developed the Deviation from Ideal Score to rate a variety of sleep problems. The derived

weekly score was then used as a measure of overall clinical significance of the treatment outcome.

Prior to 1988, most infant sleep researchers did not customarily assess the reliability of parent reports, but recent research has systematically done so, using a number of methods. Most reliability estimates (generally calculated by dividing the number of agreements by the number of agreements plus disagreements and multiplying by 100%) have been made using frequencies and durations of night wakings, but occasionally frequencies or durations of bedtime tantrums and/or sleep-onset latencies have been examined. Where times or durations of events have been recorded, a 10- to 15-min tolerance has generally been used.

The most common procedure has been to have one parent (occasionally a friend) act as the reliability observer for the other parent's observations. There are potential problems here of (a) collusion between observers and (b) failure of the reliability observer to wake up or attend when the child cries. However, spousal measures of adult insomnia have been shown to be reliable (Coates et al., 1982), suggesting that spousal reliability checks of infant sleep should also be valid. Agreement between parents has ranged from 70% to 100% (Adams & Rickert, 1989; France, Blampied, & Wilkinson, 1991; Rickert & Johnson, 1988; Rolider & Van Houten, 1984), averaging 90%. Researchers have also recorded agreement between daily telephone reports of the previous night's sleep and sleep diary records. Agreement estimated by this method has ranged from 73% to 100% (averaging 92% for Adams & Rickert, 1989; France & Hudson, 1990, Lawton et al., 1991).

Lawton et al. (1991) developed a voice-activated relay (VAR) to detect children's crying and a switch mat to detect bedside activity. Reliability of parent recording measured by the VAR ranged from 40% to 100% (M = 85%), and switch-mat agreement ranged from 77% to 100% (M = 90%, France et al., 1991; France & Hudson, 1990; Lawton et al., 1991). This VAR and switch-mat method is, however, liable to false positive and false negative reports and is therefore inherently unreliable to an unknown degree; thus, it is not a perfect system to use to calibrate parent reports (see Lawton et al., 1991, Appendix).

To put the accuracy of parental records of infant sleep in context, it might be noted that agreement between trained observers coding videotapes of infant sleep typically exceeds 85% (Anders et al., 1992). Agreement between trained observers observing parent-child interactions in home settings typically falls in the range of 75% to 85% (e.g., Cordisco, Strain, & Depew, 1988; Webster-Stratton, 1985), whereas agreement between trained observers' and parents' records of in-home parent–child interactions ranges between 70% and 90% (e.g., Endo, Sloane, Hawkes, & Jenson, 1991; Sloane, Endo, Hawkes, & Jenson, 1990, 1991), depending somewhat on the complexity of the observations and the base rate of the behavior.

Conclusions. Although it thus can be concluded that parent records of aspects of infant sleep, especially the number and duration of night wakings, are sufficiently accurate for research and clinical use, researchers need to be encouraged to use existing technology (e.g., infrared video recordings) whenever possible, and to strive to develop innovative, unobtrusive, and inexpensive in-home recording methods.

Technical developments to date have focused on measures of infant sleep, but it is equally important to have detailed and accurate measures of parental behavior. It is also important to extend the times and places in which observations are made from bedtime and the bedroom to include other parts of the prebed sequence that occur in other locations. This is especially important given that Sanders and Christensen (1985) have identified bedtime as a high-risk setting for coercive family interactions in both clinic-referred and control families.

It must also be noted that the sample sizes of many of the reported studies have been very small. Even the descriptive studies of infant sleep states (Anders et al., 1992; Sostek & Anders, 1981) have used only moderate numbers of children. The generality of conclusions reached, especially about the role of parent–child interaction in ISD, would be enhanced by increasing the diversity of settings and family types studied, and by observations extending

over a wider age range through infancy and early childhood.

A full test of the behavioral model presented here will require prospective, longitudinal observations of parent–child interactions, gathered from before bedtime and throughout the night. The data must be collected prospectively, before any evidence of ISD was noted, to determine whether the predicted distinctive patterns of parent–child interaction were associated with the development of ISD. Such time-coded event sequence data might then be analyzed using lag-correlational techniques to identify putative SDs and reinforcing and punishing consequences (Bakeman & Gottman, 1986; Patterson, 1974). This is not necessarily to advocate undertaking large-sample, between-groups research. The aggregation of methodologically sound, measurement-rich, single-case studies would, in time, yield much valuable data if attention were paid to the representativeness and diversity of the cases studied.

A BEHAVIORAL ANALYSIS OF INFANT SLEEP AND ITS DISTURBANCES

Before seeking to apply the analysis developed above to infant sleep and its disturbances, it is helpful to specify in some detail the adjustments an infant and his or her parents must make during the 1st year or so of life if the child is to be regarded as a mature sleeper. In our view, the necessity for a transfer of the control of sleep from the essentially endogenous control evident in the first few months to a combination of endogenous and external controls is essentially a universal requirement for human infants and their caregivers. Our specification of ideal sleeping (and its developmental timing) is, in detail, culture specific, but a similar specification could be developed for any culture that has some regularity in its sleeping practices.

Ideally, the good sleeper will have a regular, consistent, but not ritualized prebed routine that is marked by relaxed, pleasurable, positive interaction between the child and all other participating family members. Bedtime will not be characterized by oppositional behavior or coercion. These children will be able to be placed into bed by a variety of caregivers, awake, without fussing or crying or undue delay in first falling asleep; upon awakening during the night, the child will return to sleep without crying or calling out, signaling only when ill or distressed. The child will remain in his or her own bed all night. Some or all of this prescription has been adopted by most, if not all, of the published intervention studies.

Based on the behavioral analysis of sleep presented above, our assumption is that the process of adjustment needed to meet these ideals has two aspects, encompassing the antecedents and consequences associated with the bedtime behavior chain. First, the elements of the chain, including the terminal response of behavioral quietude, need to be brought under appropriate discriminative stimulus control. Second, contingencies of reinforcement need to strengthen and maintain this behavior chain and the behaviors compatible with it, rather than sleep-incompatible behaviors. Therefore, in presenting a behavioral model of infant sleep, we first stress the importance of clear stimulus control for the initial instatement of appropriate sleep patterns in the developing child (Sanders et al., 1984), and then consider the reinforcement contingencies that may shape and maintain either appropriate or disturbed sleep. In each case, for convenience, we begin with a consideration of the more distal parts of the chain (bed refusal) and end by considering REM-associated arousals and their sequelae.

Antecedent Stimulus Control

If going to sleep requires the performance of a regular going-to-bed and falling-asleep behavior chain, then bed refusal and sleep-onset delay may occur because of the absence of consistent external cues that set the occasion for the chain. Beginning in infancy and continuing through early childhood, parent-provided SDs are likely to be closely interwoven with the bed-related behavior chain, as parents provide bed-related care or instruction for and supervision of the process (Beltramini & Hertzig, 1983; Ferber, 1990a). The distinctiveness and consistency of the cues provided will greatly affect the

regularity and orderliness with which the behavior sequence is completed. Many intervention programs have included a stimulus control component, such as requiring the setting of regular bedtimes and consistent, quiet prebed routines (e.g., France & Hudson, 1990; Pritchard & Appleton, 1988; Seymour, Bayfield, Brock, & During, 1983), but because these procedures have been combined with extinction, the outcomes of these studies are not purely a test of the stimulus control analysis.

For children exhibiting bed refusal (tantrums), a procedure called *positive routines* has been compared with both a no-treatment control group and graduated extinction (Adams & Rickert, 1989). Positive routines involved an individualized program of structured prebedtime activities and fading bedtime to earlier and earlier times. Completion of each step in the routine was praised, so this procedure is not a pure test of stimulus control. Both positive routines and graduated extinction were successful in significantly reducing bedtime tantrums but were not significantly different from one another. The effectiveness of positive routines suggests that the stimulus control aspects of the behavioral model are valid, at least for bed refusal and sleep-onset delay, but more research into antecedent and contextual variables is clearly necessary.

Anders et al. (1992) have shown that it is rare for 3-week-old infants to be put into their cribs awake, but that the proportion awake when put down to sleep increases to just over 50% at 8 months of age. Being placed into the crib asleep precludes exposure to the immediate bed environment and blocks the development of stimulus control of behavioral quietude by bed-related cues. However, when an infant or young child is first left to go to sleep awake and unattended, the child may initially experience some distress from the unfamiliar circumstances accompanying bedtime.

Parental attention to this distress reinforces and maintains crying (see below) and substitutes parent-related cues for the bed-related ones. If parental reinforcement is withheld, the distress behavior undergoes extinction. As the frequency of distress expression declines, exposure to the distress-evoking cues simultaneously occurs, leading to habituation to their distress-evoking power and loss of their negative affective tone. In the absence of competing distress and parental attention, these cues also come to be SDs for falling asleep, a response positively reinforced by sleep. Because stimuli paired with positive primary reinforcers come to have positive conditioned reinforcing properties themselves (Hendry, 1969; B. Williams & Dunn, 1991), in time, therefore, these cues should acquire positive affective tone.

Although intervention studies typically report reductions in crying and tantrums during the sleep-onset period (e.g., Adams & Rickert, 1989; Lawton et al., 1991; C. Williams, 1959), no direct test of this habituation hypothesis has yet been conducted. Physiological measures of responses to bed-associated cues (e.g., dim light) might track habituation, although such measures would need to be taken under circumstances that did not evoke overt distress. Consistent with the view that both parts of the parent–infant dyad have to adjust to permit sleep to mature, Chadez and Nuris (1987) discussed the covert, distress-evoking responses of parents, and suggested ways of helping parents deal with these. More research into parents' emotional responses to ISD is clearly warranted.

A further aspect of the discriminative control of sleep initiation is provided by self-produced comfort cues, the use of which increases with age (Anders et al., 1992). Research has shown that children with ISD differ from those whose sleep is normal in that they less frequently use self-produced comfort sources and continue to rely on parent-supplied comforting (Holliday, Sibbald, & Tooley, 1987). These self-produced comfort behaviors include the use of soft toys or bedding and thumb sucking.

The exact mechanisms by which self-produced comfort cues facilitate sleep have not been delineated (Anders et al., 1992). Some activities, such as sucking, may evoke respondent behaviors that facilitate sleep, whereas others may help sleep onset by assisting in the achievement of behavioral quietude. All the objects and activities involved in self-comforting have the potential to become effective SDs for falling asleep because they occur reliably before and temporally close to sleep onset. Thus

they too may become powerful conditioned reinforcers.

The capacity to self-initiate comforting behavior is important to the quality of infant sleep. In 3-month-old infants, those who had learned to self-soothe had much longer continuous sleep times and longer total sleep times and spent much longer periods in their cribs than did the non-self-soothers (Anders et al., 1992). Continued supply of parent-mediated comfort may block the development of self-supplied comforting activities, but this hypothesis has not yet been tested. It is established, however, that parental presence at the time the infant goes to sleep is associated with persistent night waking in 8- to 12-month-old children (Adair, Bauchner, Philipp, Levenson, & Zuckerman, 1991).

Despite this finding, it has been suggested, from an attachment theory perspective, that the physical presence of a parent (especially the mother) may have the effect of calming the infant and promoting sleep, independent of any activities the parent may engage in (Sadeh & Levie, 1991). This might be studied by having a parent remain physically in the room with the child without interaction (e.g., while feigning sleep). If compared with conventional extinction procedures, in which both parental presence and activity are withdrawn, this might separate the reinforcing component of parental presence from the stimulus component.

Parent behaviors such as bedtime feeding or prebed and presleep rituals may easily be established (see below). When these occur they supply inappropriate SDs for initially falling asleep; once habitual, they promote sleep-onset delay, because the ritual stimuli have to be provided each night in order to get the child into bed and ultimately to sleep (Adair et al., 1991).

A key assumption of the stimulus control analysis of ISD is that resumption of sleep following an arousal will be facilitated to the degree that the stimuli associated with initially falling asleep are encountered upon subsequent arousal (Ferber, 1985, 1990a). If the SDs controlling initial sleep onset are provided directly by the child's sleeping environment and possibly by self-produced comfort cues, these stimuli will be present if and when the child wakes later in the night. They then will again set the occasion for falling asleep, and the child's sleep will be normal. These partial arousals will not lead to sleep-initiation difficulties, despite being a regular feature of each night's sleep. Interference from competing behavior (distress expression) or substitution of parent-mediated SDs, having prevented the development of appropriate stimulus control, may thus lead to recurrent night waking.

Contingencies for Sleep-Compatible and Incompatible Behavior

The child who exhibits bed refusal and/or sleep-onset delay with concomitant parental attention, and/or who wakes and cries during the night, also exhibits a second problem disclosed by behavioral analysis, namely response competition from behavior incompatible with going to bed and falling asleep. The persistence of this competing behavior in the child's (and the parents') repertoire can be explained by analysis of the contingencies of positive and negative reinforcement experienced by both parents and child.

We have assumed that parental attention, and the warmth, comfort, nourishment, and entertainment it mediates, is a powerful natural reinforcer for children, and one that may well be more immediate, and therefore more potent, than the reinforcer of sleep. Having a child stop crying and go to sleep during the hours of the night is likely to be a powerful negative reinforcer for parents. These mutually reinforcing consequences can interact to maintain sleep disturbance through the operation of a coercive behavior trap (Patterson, 1982; Patterson & Reid, 1973).

Consider first the problem of sleep-onset delay. If normal undisturbed sleep patterns are to be learned, the child must learn to tolerate being alone in bed, with minimal stimulation and activity. Then naturally occurring bed cues can, in the absence of response competition, control the emission of falling asleep, to be reinforced by sleep. Expression of distress, if it is effective in gaining parental attention, is doubly reinforced—negatively by escape from the aversiveness of being alone and positively by parental attention—and is thereby strengthened

by a powerful double reinforcement contingency. But the distress behavior and subsequent interaction with the parent compete with falling asleep under natural stimulus control, exacerbating the problem.

Furthermore, as a result of the child's escape from being alone and the parents' escape from hearing their child cry, both child and parent may learn to anticipate each other's behavior and act to avoid the aversive state (Overmier, 1979). The child's behavior engages and holds parental attention earlier and earlier, while parents respond with the provision of more and more immediate, often ritualized, attention in order to prevent distress. In this way, elaborate and prolonged bedtime tantrums and rituals (e.g., Durand & Mindell, 1990; Sanger, Weir, & Churchill, 1981; Weissbluth, 1982; C. Williams, 1959) may be shaped inadvertently, and sleep-onset delay may merge with bed refusal. Longitudinal data from children aged 1 to 5 years have shown that problems such as prolonged bedtime routines, recurrent demands for parent attention after being put to bed, and sleep-onset delay increase over time (Beltramini & Hertzig, 1983), consistent with the view that these behaviors are shaped by parent–child interaction.

In older children, bed refusal also may be part of a general pattern of noncompliance with parental instructions. It may, therefore, share features associated with noncompliance, such as vague and unclear instructions, threats not followed by stated consequences, and noncontingent or inappropriately contingent parental attention (see Sanders & Dadds, 1993, for a review). Furthermore, the natural reinforcer for completing the going-to-bed-and-falling-asleep sequence (sleep) is necessarily delayed while the behavior sequence is completed. Competing activities that engage the parent or other family members may provide more immediate reinforcement than is received for compliance with bedtime instructions.

Continued activity may postpone sleep in children, but eventually, bed-refusing children will inexorably fall asleep, often after a period of brief quietude on the periphery of family activities, or while held by a parent (e.g., Jones & Verduyn, 1983; Sanger et al., 1981). One strategy used by parents of children who exhibit bed refusal is to wait until the child has fallen asleep before putting him or her to bed, thereby avoiding prebed conflict (Keener, Zeanah, & Anders, 1988). These children, therefore, may not experience the appropriate going-to-bed-and-falling-asleep sequence necessary for their sleep initiation to come under the control of bedtime and bedroom cues, thus perpetuating their sleep difficulties.

Contingencies of positive and negative reinforcement also operate to maintain cosleeping, where the child is allowed to go to sleep in the parents' bed or is transferred there upon awakening (e.g., Chadez & Nuris, 1987). This practice also blocks the development of appropriate stimulus control and prevents the development of appropriate sleep. Cosleeping is known to be associated with other forms of ISD (Lee, 1992; Lozoff, Wolf, & Davis, 1985; Madansky & Edelbrock, 1990), and instructing parents to stop cosleeping is associated with improvements in their children's sleep (Adair, Zuckerman, Bauchner, Philipp, & Levinson, 1992).

Similar contingencies may also maintain night waking. The developing infant is likely to have a history of crying in response to waking, with this crying engaging parental attention. If this continues beyond a developmentally appropriate age, or if it is reinstated following a period of illness or other disruption in the child's life or the family's circumstances, parents may need to withhold attention in order for the crying to undergo extinction. Parents, however, will have had many opportunities to learn that prompt attention to incipient or early expressions of infant distress may prevent or shorten their infant's crying. Because of this history of negative reinforcement, it may be very difficult for parents to withhold or attenuate well-practiced and relatively intense forms of attention in order for their child to learn to resume sleep without parental attention.

There is some evidence that the reinforcing potency of parental attention varies on a continuum from negligible to very great (Pritchard & Appleton, 1988; Rickert & Johnson, 1988). Parents who alleviate sources of nocturnal distress in low-key and minimally intrusive ways may supply little

reinforcement for night waking, whereas actions such as feeding or removing the child to the parents' bed have high reinforcing potential. Lawton et al. (1991) documented quantitative and qualitative changes in parental activities in the course of graduated extinction, with these changes associated with improvements in the child's sleep. Procedures such as systematic ignoring (Rickert & Johnson, 1988), in which parents are trained to check their child in a minimally intrusive way and to interact more intensely only if they detect a genuine need, may effectively exploit this decrement in reinforcing potential.

The quality, frequency, and developmental history of parental (especially maternal) checking of infants need more investigation. Anders et al. (1992) have shown that a complex relationship exists between maternal checking and infant sleep. We speculate that mothers who check their infants at a high rate may be more vulnerable to inadvertently reinforcing the signaling accompanying REM arousals, thus contributing to the development of ISD.

Parents of children with ISD often attempt to solve the problem by physical or other punishments or threats of punishment (Johnson, 1991), by using prescription and nonprescription medications, and by using extinction (ignoring) for bedtime tantrums or night waking (e.g., Rickert & Johnson, 1988). However, this is not often successful (Chavin & Tinson, 1980). Extinction may fail because of the occurrence of a response burst (France & Hudson, 1990; France et al., 1991; Lawton et al., 1991; Seymour, 1987, C. Williams, 1959). Unsuccessful attempts to use extinction may inadvertently make the problem worse, because reinforcement is resumed when the behavior has reached new levels of intensity and persistence, and the experience of partial, intermittent reinforcement should increase future resistance to extinction (Nation & Woods, 1980).

Nevin (1988) has recently challenged the conventional view on the strengthening of behavior by intermittent reinforcement. He suggests that the strength of a response, measured as its resistance to change (its momentum), is increased by richer rather than leaner schedules of reinforcement (see Nevin, 1993, for a review of evidence from clinical contexts). However, in the case of resumption of attention following a failed attempt to extinguish ISD, both conventional partial-reinforcement effect theories and Nevin's momentum account seem to predict that failed attempts at extinction may make ISD worse. The duration of the failed attempts are typically short (1 night or less), and the duration and the quality of parental attention finally given to the extremely distressed child may well exceed normal levels. If this is so, then the extinction episode may end with an equal or even greater overall amount of reinforcement than normal. This would increase, or at least maintain, the momentum of the behavior. Given the ethical difficulties (France, 1991, 1992) of studying failed extinction attempts, this will probably remain a speculation.

Nevin's analysis suggests that although the rate of responding depends on response–reinforcer relations, its momentum depends on stimulus–reinforcer relations (Nevin, 1988, 1993). If this is so, then the instigation of procedures to change problem behaviors should be associated with a marked change in the environment normally associated with the behavior, in order to weaken the momentum of the behavior. For ISD, this might mean having the father substitute for the mother in dealing with bedtime, moving the bed to a different location, or altering the environment in some other distinctive way. Such proposals have not yet been systematically investigated.

Behavioral Analysis and Interventions for ISD

Beginning with C. Williams's (1959) case study of the use of extinction to treat bed refusal and sleep-onset delay, there have been an increasing number of intervention studies for ISD. In recent years, uncontrolled case studies have been largely replaced by controlled-outcome research using both between-group and single-case designs. Extinction and its variants, positive routines, and scheduled awakenings are demonstrably effective methods (see France & Hudson, in press, for a review).

The success of extinction (e.g., France & Hudson, 1990; France et al., 1991; Lawton et al., 1991;

Rickert & Johnson, 1988; Seymour, 1987) is clearly unsurprising. However, although the effectiveness of extinction tends to confirm the validity of the identification of parent attention as a critical reinforcer maintaining ISD it does not provide direct evidence as to the processes by which ISD develops.

As a number of authors have noted, extinction is often impractical because of objections from parents and others (France, 1991; Lawton et al., 1991; Rickert & Johnson, 1988). This has led to the investigation of modifications of extinction that preserve the critical contingency manipulation while making the procedure more acceptable to parents. The continued importance of a careful analysis of the contingencies being manipulated in interventions can be illustrated by considering the various procedures labeled *graduated extinction*. Variants of this procedure have been derived from Ferber's original "progressive approach" (Ferber, 1985). They involve parents waiting a progressively longer and longer time before attending to the child. Ferber (1985) recommends a standard schedule, beginning with a waiting time of 5 min and increasing by 5 min each successive night. Rolider and Van Houten (1984) set the initial delay equal to the average delay observed during baseline, and Durand and Mindell (1990) instructed the parents to initially respond immediately and then increase the delay over successive nights. Adams and Rickert (1989) prescribed an individual initial delay and progression for each family.

Lawton et al. (1991) noted that these procedures are very similar to progressive-ratio or progressive-interval schedules (Findley, 1958) and, therefore, may run the risk of prolonging or maintaining the behavior rather than eliminating it. Lawton et al. (1991), therefore, developed an alternative graduated extinction procedure, based on the view that each episode of waking and crying with subsequent parental attention was a two-link behavior chain, with the terminal link being a period of dense, variable reinforcement, delivered on a variety of ratio schedules. Following this analysis, they instructed parents to begin attending for as long as their average duration during baseline, and then to reduce this gradually until attention was faded altogether. This was viewed as equivalent to instating extinction by systematically reducing the magnitude of the reinforcer, rather than delaying the reinforcer for longer and longer periods of time.

Despite this careful fading, Lawton et al. (1991) observed postextinction response bursts in some children, perhaps indicating a high level of sensitivity to the prevailing contingencies, or possibly sudden shifts in the quality of parental attention. More research is needed to examine these possibilities and other issues, such as the most appropriate fading rate. A more systematic investigation of the postextinction response burst is also needed, such effects having been more often warned of than researched (Kazdin, 1984).

The demonstrated success of positive prebed routines (Adams & Rickert, 1989) is evidence of the major role played by discriminative stimuli in controlling the presleep behavior chain, but although these procedures emphasize stimulus control, they are not free of contingency manipulations. Unlike extinction procedures, which may be applied to inappropriate behavior at any point in the chain, positive routines are applicable only to the problems of bed refusal and sleep-onset delay. However, given that they were as effective as graduated extinction and were highly acceptable to parents (Adams & Rickert, 1989), positive routines warrant further investigation to determine their full utility.

Accounting for the success of scheduled awakenings (Rickert & Johnson, 1988) poses greater problems for our behavioral account. This procedure involves using baseline data to predict the usual times of spontaneous night waking, waking the child 15 to 60 min before this time, and then systematically extending the waking time closer and closer to the morning waking time. On scheduled awakening, the parents do whatever they normally would do for a spontaneous awakening. As originally presented, scheduled awakenings were justified as accomplishing the "shaping and reinforcing of behavior incompatible with the undesirable behavior," that is, reinforcing sleep as the response incompatible with waking (McGarr & Hovell, 1980, p. 176). This assumes that sleep is an operant,

although no argument for this assumption was presented and is contrary to the conclusion we reached earlier.

This initial, single-case study of a 3-month-old infant could support only limited conclusions about scheduled awakenings. However, in a controlled study, Rickert and Johnson (1988) compared scheduled awakenings, systematic ignoring, or no-treatment groups. The number of spontaneous awakenings was reduced over time, more for the two treatment groups than for the control group. Daily mean numbers of spontaneous awakenings were always lower with systematic ignoring than with scheduled awakenings, but this difference was not statistically significant.

Rickert and Johnson (1988) acknowledge that the mechanism for the effect of scheduled awakenings is obscure. They present three possibilities: shaping and reinforcement of sleep, as hypothesized by McGarr and Hovell (1980); resetting of the child's circadian clock; and transfer of the control of waking from endogenous to exogenous (parental) stimuli. If, following a scheduled awakening, parents left the room before the child went back to sleep, the procedure could be viewed as giving the child multiple opportunities to learn to resume sleep under bed-supplied SDs. Requiring parents to do this might enhance the effectiveness of scheduled awakenings.

This uncertainty about the mechanism of scheduled awakenings points to an issue that we have not yet commented upon, namely the need to consider possible interactions between behavior changes and changes in sleep organization and maturation. We have stressed the role that maturational features of infant sleep plays in rendering infants and their parents vulnerable to chronic night waking. Only the most indirect and speculative data (e.g., the cross-cultural comparisons mentioned above) exist on the possible effects of behavior on sleep and its development. For instance, does the development of chronic night waking lead to slower maturational change in the NREM:REM proportion? Does sleep-onset delay affect the REM-NREM sequence, and does the development of chronic night waking lead to awakenings at times other than REM-associated arousals? Conversely, does effective intervention facilitate sleep maturation? These questions all require further research.

CONCLUSION

The emergence and maintenance of sleep disturbances in infants and preschool children provide an interesting setting in which to study the processes of biological maturation in combination with the psychosocial processes of parent–child interaction (France & Blampied, 1993). The analysis presented above suggests that all infants are vulnerable to developing sleep disturbances because of the frequency with which they cycle through the REM and NREM phases of sleep. Whether or not this vulnerability becomes expressed in actuality depends on whether or not their sleep comes under appropriate or inappropriate stimulus control and whether or not infants and their parents make contact with latent contingencies of reinforcement that may shape and maintain the behavioral manifestations of ISD. Direct evidence of the history of parent–child interaction suggested by the behavioral account to cause the emergence of ISD awaits further research. By its nature, such research is difficult to do, not only because it would require extensive observations of family interaction throughout the night, but also because it would need to be prospective, undertaken before the ISD became manifest. Nevertheless, despite the absence of direct confirmatory evidence, indirect evidence from interventions incorporating behavioral principles supports the analysis, because behavioral interventions such as extinction, graduated extinction, and positive routines are demonstrably effective in remedying ISD. The success of scheduled awakenings remains theoretically unaccounted for.

As the various clinical investigations have demonstrated, parents can be trained relatively easily to change the ways they interact with their sleep-disturbed children so as to instate or reinstate acceptable sleep. This suggests that appropriate education given to parents during the first 3 to 6 months of their child's life may prevent ISD. This may also be needed when there is a heightened risk

of developing ISD (e.g., during periods of childhood illness or stressful disruptions in family circumstances). Both studies that have examined early intervention through parent training to prevent ISD have reported positive results (Adair et al., 1992; Wolfson, Lacks, & Futterman, 1992). Prevention of ISD remains, however, an area needing further investigation.

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