Differences between olfactory thresholds in two sleep states in the newborn infant[1]

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Olfactory thresholds–measured by startles and/or disturbances of respiration–were established in newborn infants. In regular sleep, the threshold was substantially higher than it was in irregular, or REM, sleep. This result illustrates the role of state in studies of infants.

The concept of "state" has recently generated experimentation and discussion in relation to the human neonate. The concept refers to relatively stable response patterns that can be observed at different times in the same individual and in different babies. State has been shown to affect the outcome of experiments in several areas of neonatal research.

Most workers, following Aserinsky & Kleitman (1955), have distinguished two major sleep states in human infants–regular and irregular (REM) sleep–as well as several waking and transitional states (cf. Parmelee et al, 1967; Prechtl & Bientema, 1964; Hutt et al, 1968a). Prechtl et al (1967) demonstrated that the strength of reflexive responses may be influenced by the state variable; the results depend in part on the type of reflex (Lenard et al, 1968). Sensory thresholds also may be a function of state. Hutt et al (1968a, b) discovered that the probability of electromyographic response to auditory stimulation was in part a function of state. In a study of habituation, they found that "response decrement and recovery are primarily functions of state-changes." Within one state, there was no evidence of habituation with repeated stimulation; they suggested habituation may be an "epiphenomenon of endogenous changes of state, each having its own associated level of responsiveness." This result shows it is necessary either to monitor state changes or to provide controls [perhaps along the lines suggested by Sharpless & Jasper (1956)] for the study of habituation in neonates. This paper presents data on the effect of state upon responses to olfactory stimuli. The experiment was designed to show variations of olfactory threshold with changes in state as a preliminary step to looking at habituation to olfactory stimulation in the human neonate.

The question of the effect of state on threshold has implications beyond the interpretation of habituation studies. Several studies (Lipsitt & Levy, 1959; Lipsitt et al, 1963; Kaye & Lipsitt, 1964) have examined change in sensory thresholds over the first few days of life. If state has an effect on threshold, some of the effect may be a result of differences in the time spent in each state over these days or changes in the states themselves, perhaps as a result of the effect of anesthetics, or the delivery (Brazleton, 1962).

SUBJECTS

Twenty full-term 3-day-old infants were seen. Infants with a Prechtl score (1967) of 8 or greater were eliminated, reducing the number of available Ss by about 15%.

APPARATUS

The Ss were placed on their sides in a stabilimeter crib in a temperature-controlled (72°F) and well ventilated room. Activity was monitored by a movement-sensing device put in the mattress (Griffiths, Chapman, & Campbell, 1967). Respiratory movements were recorded using an infant pneumograph connected to a Grass PT5 pressure transducer. Signals were recorded on a Beckman Type R polygraph, with paper speed of 5 mm/sec.

Olfactory stimuli, freshly prepared every 2 or 3 days, were presented on a piece of cotton soaked with the odorant on the end of a glass rod. The stimuli consisted of a geometrical progression of concentrations of amyl acetate (1.56, 3.12, 6.25 ... 100%) in a virtually nonodorous diluent (diethyl phthalate) and a control, the diluent alone. The stimuli were stored in clean test tubes stoppered with corks wrapped in aluminum foil.

PROCEDURE

Two Es were present: one to administer stimuli and to observe and record S's reactions and the other to monitor the polygraph and to control the timing of stimuli.

The Ss were assigned randomly to one of two groups of 10 Ss, one group to be tested in regular sleep and the other in irregular sleep. Ss were tested the first time after feeding that they reached the required state. Regular sleep was defined as regular respiration, eyes closed, and no movement outside of the occasional startle. This state corresponds to the State 1 described by Hutt et al (1968a). Irregular sleep was characterized by irregular respiration, body movements, and eyes closed with rapid eye movements; it corresponds to Hutt's State 2. There are transitional and waking states in addition to the two states examined.

Threshold for response was determined by presenting the stimuli in order of increasing concentration of odorant. At the start, presentation of the odorants was alternated with presentation of the nonodorous control; such a series sometimes took too long, and S changed states. This procedure tends to eliminate Ss that have higher thresholds (which would take longer to reach). Therefore, after the first two odorant-control pairs, the odorants were presented without the diluent controls. Each stimulus presentation was of 10 sec duration; for odorants with no corresponding presentation of the control, the 10 sec previous to stimulus presentation served as the control. Interstimulus interval was 60 sec, or longer if S was not in the proper condition as, for example, when a startle occurred spontaneously before the presentation of a stimulus, or if S moved a hand over or in front of his nostrils. The odorant-soaked cotton was held on the glass rod in a position between and about 1 cm from S's nostrils. Stimulus presentations were marked in the polygraph record by means of a pen controlled by a foot switch.

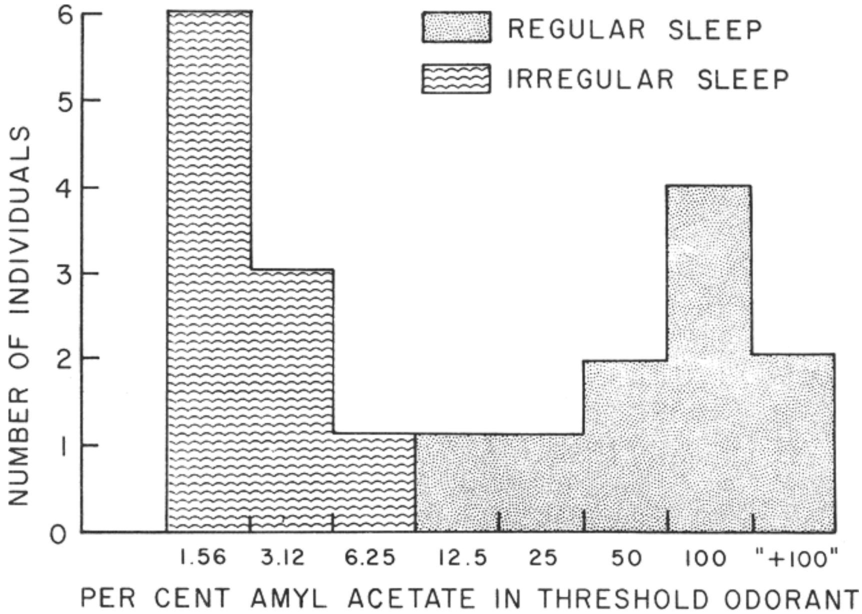
The threshold was considered to be that concentration of odorant to which S gave a greater response movement and respiratory change than was seen in the preceding control interval in the judgment of both Es. The judgment was based upon observation of S and an examination of the polygraph record. The polygraph record was subsequently checked by an E who was not allowed to see the channel recording stimulus presentations. All responses were confirmed by this individual. The problem of what to do if the Es differed did not arise.

One problem encountered was the presence of spontaneous startles. Wolff (1959) has noted that such responses occur on an average of about every 2 min in regular sleep. It was found, however, that with experience such responses were distinguishable from responses to odorants. The latter usually involved respiratory change prior to the startle, and, usually, S turned his head away from the odorant. In addition, respiration tended to remain irregular for some time after the startle. Threshold responses were confirmed by continuing to the next stimulus in the series. Only on one occasion did an S not respond to this stimulus; this S was eliminated from the study.

RESULTS

The thresholds for both groups are plotted in Fig. 1. It is evident that the threshold is much higher in regular sleep.

Fig. 1. Olfactory (amyl acetate) threshold in regular and irregular sleep.



There is, in fact, no overlap between the two groups. A majority of Ss in the irregular-sleep group responded to the first odorant. On the other hand, two Ss did not respond even to the 100% amyl acetate in regular sleep. The median test (Siegel, 1956) demonstrated that the difference between groups was significant at the .001 level of probability ($\chi^2 = 16.2$, with 1 df). The median threshold in regular sleep was 2^6 times greater than in irregular sleep.

DISCUSSION

It is apparent that sleep state greatly affects olfactory threshold as measured by behavioral startle and/or respiratory change. This is perhaps to be expected as Lenard et al (1968) have shown exteroceptive polysynaptic reflexes, of which Kretschmer's reflex (startle to strong odors) is one, are almost totally absent during regular sleep and are strong in irregular sleep.

Experimentation using olfactory stimuli with neonates therefore requires careful monitoring or control of the state variable. Unnoticed changes in state can result in large changes in reactivity to olfactory stimulation.

So far as the neonate is concerned, it appears that one should regard the sleep states as discrete, each having distinct characteristics (cf. Broughton, 1968; Parmelee et al, 1967). These states do not appear to match Lindsley's (1957) conception of a continuously graduated schema of arousal, although there conceivably may be some variation of arousal within each state. This could result in threshold differences without an apparent change in state.

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NOTE

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