THE RELATIONSHIP BETWEEN EEG AND BEHAVIOURAL MEASURES OF SLEEP ONSET

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The beginning of uninterrupted stage 1 sleep is used to calculate sleep onset latency and is included in the calculation of total sleep time in most clinical and research studies. There is, however, some controversy as to whether true sleep begins with conventionally defined stage 1 (e.g. reduction of EEG alpha). Stage 1 seems to have very little restorative value. When "awoken" from stage 1, subjects usually report not having been asleep. A more critical argument against stage 1 sleep is that subjects can continue responding to low intensity tones in this stage until about the onset of stage 2 sleep. Thus "behavioural" sleep seems to start with stage 2. There are, however, some difficulties with this latter evidence. Auditory stimuli have usually been either mildly intense, short duration, or low intensity but long duration (5-8 seconds). In both cases it would seem possible that the tone stimuli could have evoked arousal from sleep and enabled a wakeful response. The question is whether behavioural sleep onset corresponds more closely to EEG defined stage 1 sleep onset when low intensity, short duration tones (e.g. 0.2 sec) are used to test behavioural sleep onset.

Nine subjects spent three nights in the sleep laboratory (one night for adaptation and two testing nights). They were required press a switch taped to their preferred hand in response to a 1000 Hz, low intensity tone stimulus(less than 10 dB above background noise level) as they fell asleep on a series of ten trials. EEG and EOG were recorded continuously during each trial. During a trial, tone stimuli were randomly presented by computer with a mean inter-tone interval of 17 sec. Behavioural sleep onset was defined as the time of the first of two consecutively missed tones. After behavioural sleep onset the subject was awoken and started on the next trial from the same tone condition (either short duration of 0.2 sec or long, 8 sec duration). The other condition was run the next night. The order of tone conditions was balanced across subjects.

Behavioural sleep onset occurred after EEG sleep onset (stage 1) in all trials. The mean delay in minutes between the onset of stage 1 sleep and behavioural sleep onset for both tone conditions (long vs short) and in the 1st half of trials on any one night (early) and 2nd half (late) and for the total condition are shown in the table below.

	1st half	2nd half	total condition
Short tone	2.32 min	1.20 min	1.91 min
Long tone	3.63 min	1.92 min	2.47 min

There were significant differences between 1st and 2nd halves and between short and long tone conditions and no interaction. Clearly, subjects behaviourally fell asleep more quickly in the later trials. This may be due to the increased sleep propensity of a later phase of their circadian rhythms. When the short tone was used, behavioural sleep occurred sooner following stage 1 onset. However, for both tone conditions response failure occurred relatively soon after stage 1 onset. This result, as well as the finding of significant correlations between stage 1 and behavioural sleep onset latencies, suggests a fair correspondence between these measures of sleep onset. Although a few of the tone stimuli (<10% in both conditions) evoked EEG alpha return after the tone and before the response, over two-thirds of responses to tones between stage 1 and behavioural sleep onset were not accompanied by indications of EEG arousal. In conclusion, the measure of behavioural sleep onset using the short tone condition is closely coincident with conventional stage 1 sleep onset. However, for a short period following stage 1 sleep onset, simple responses to simple tone stimuli are possible without the return of EEG alpha.