

## *ASDA Report*

# EEG Arousals: Scoring Rules and Examples

This is a portion of the Atlas which is being created under the auspices of the American Sleep Disorders Association. This section of the Atlas was also presented to the membership at the 1991 APSS national meeting. It gives a preview of the way the Atlas is being composed, and feedback from the membership is welcome.

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# EEG Arousals: Scoring Rules and Examples

## A Preliminary Report from the Sleep Disorders Atlas Task Force of the American Sleep Disorders Association

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Sleep in patients with a number of sleep disorders and in some elderly is punctuated with frequent, brief arousals. The arousals are transient and generally do not result in behavioral awakening, reoccurring in some conditions as often as once per minute. The arousing stimulus differs in the various disorders and can be identified in some cases (i.e. apnea, leg movements, pain), whereas in other cases (i.e. "normal" sleep of elderly, some insomnias) it is idiopathic. The important fact is that the arousals result in fragmented sleep rather than shortened sleep. Just as with shortened sleep, it now is clear that sleep fragmentation leads to increased daytime sleepiness.

These brief arousals can be identified on the standard polysomnogram and are characterized by abrupt changes in electroencephalographic (EEG) frequency (suggestive of an awake state) and/or brief increases in electromyographic (EMG) amplitude. The transient nature of these arousals leads to their being overlooked or to decisional uncertainties in the standard 20- or 30-second epoch sleep stage scoring system. Standard sleep stage scoring systems are intended to identify state [i.e. wake, rapid eye movement (REM) and non-rapid eye movement (NREM) sleep] and not transient interruptions in state. Hence, a set of criteria to specifically and reliably identify the occurrence of transient arousals would be very useful for both clinical and theoretical purposes. The following rules with illustrations were developed by the Sleep Disorders Atlas Task Force of the American Sleep Disorders Association.

### EEG AROUSAL SCORING

#### Recommended polygraphic parameters for arousal scoring

The standard Rechtschaffen and Kales bipolar submental EMG and referential electrooculograms (EOGs) (LOC/A1 and ROC/A2) are used, as is the referential

central EEG obtained from C4/A1 or C3/A2 placements. In addition an occipital referential EEG derivation (O1/A2, O2/A1 or OZ/A1 or A2) is recommended. Arousals can be scored from either the central or occipital derivation EEG.

#### An EEG arousal is:

An abrupt shift in EEG frequency, which may include theta, alpha and/or frequencies greater than 16 Hz but not spindles, subject to the following rules and conditions.

#### EEG arousal scoring rules

1. Subjects must be asleep, defined as 10 continuous seconds or more of the indications of any stage of sleep, before an EEG arousal can be scored (Figs. 1 and 2). Arousal scoring is independent of Rechtschaffen and Kales epoch scoring (i.e. an arousal can be scored in an epoch of recording, which would be classified as wake by Rechtschaffen and Kales criteria).
2. A minimum of 10 continuous seconds of intervening sleep is necessary to score a second arousal (see Rationale section for discussion of 10 seconds as minimum sleep between arousals) (Figs. 3 and 4).
3. The EEG frequency shift must be 3 seconds or greater in duration to be scored as an arousal (see Rationale section for discussion of 3 seconds as the arousal duration criteria) (Figs. 1, 5 and 6).
4. Arousals in NREM sleep may occur without concurrent increases in submental EMG amplitude (Fig. 7).
5. Arousals are scored in REM sleep only when accompanied by concurrent increases in submental EMG amplitude (Figs. 8 and 9).
6. Arousals cannot be scored based on changes in submental EMG amplitude alone.
7. Artifacts, K complexes or delta waves are not scored as arousals unless accompanied by an EEG

frequency shift (as previously defined) in at least one derivation. If such activity precedes an EEG frequency shift, it is *not* included in reaching the 3-second duration criteria. When occurring within the EEG frequency shift, artifacts or delta wave activity are included in meeting duration criteria (see Rationale section for discussion of delta wave activity as an indicant of arousal) (Figs. 10–12).

8. The occurrence of pen blocking artifact should be considered an arousal only if an EEG arousal pattern is contiguous. The pen blocking event can be included in reaching duration criteria (Figs. 13–15).
9. Noncurrent, but contiguous, EEG and EMG changes, which were individually less than 3 seconds but together greater than 3 seconds in duration, are not scored as arousals (Fig. 16).
10. Intrusion of alpha activity of less than 3 seconds duration into NREM sleep at a rate greater than one burst per 10 seconds is not scored as an EEG arousal. Three seconds of alpha sleep is not scored as an arousal unless a 10-second episode of alpha-free sleep precedes (Figs. 17 and 18).
11. Transitions from one stage of sleep to another are not sufficient of themselves to be scored as EEG arousals unless they meet the criteria indicated above.

#### Rationale for various criteria

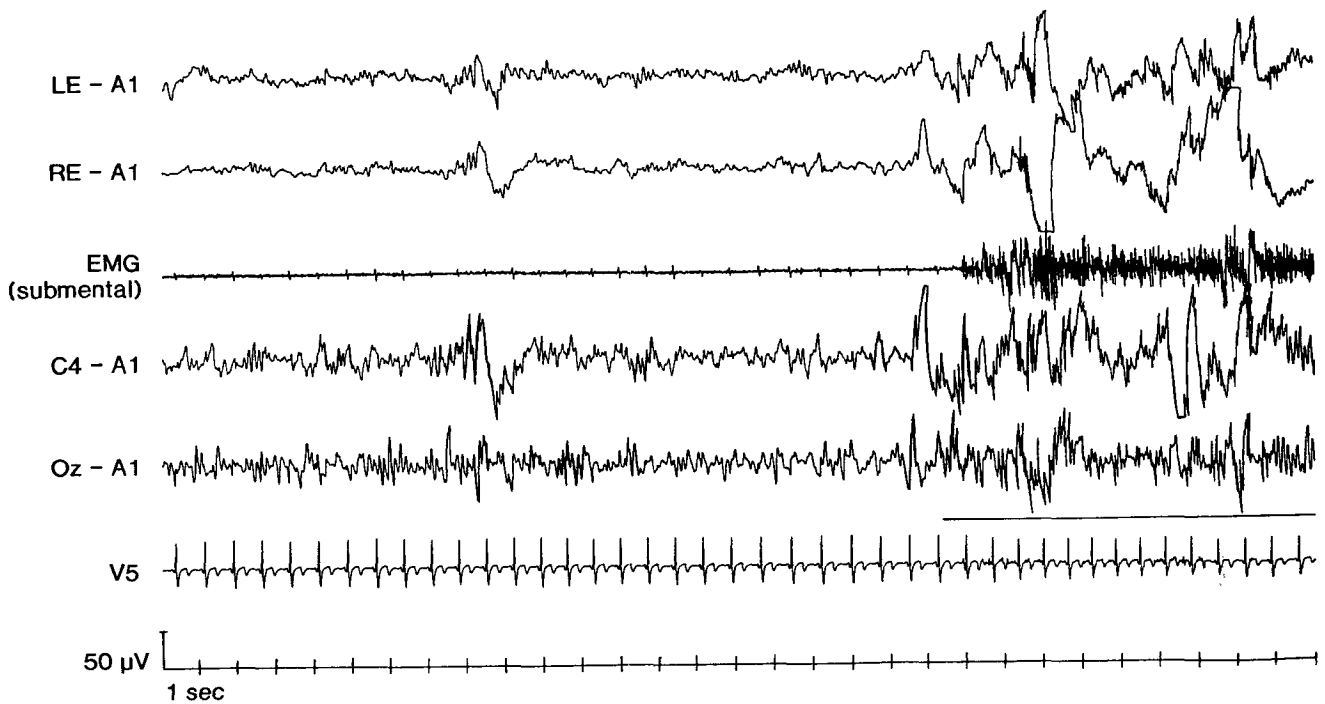
The scoring criteria are based on the EEG derivation alone with only one exception. Scoring of EEG arousal from REM sleep requires the presence of a simultaneous increase in the submental EMG amplitude. The presence of bursts of alpha or theta activity in REM sleep EEG are common phenomena. These events may or may not reflect physiological arousal from REM

sleep. However, reliable scoring of arousal from REM sleep is best achieved with the additional requirement of EMG amplitude increases. The significance of submental EMG amplitude changes in the absence of EEG changes is not fully understood and as such is not presently identified as an arousal.

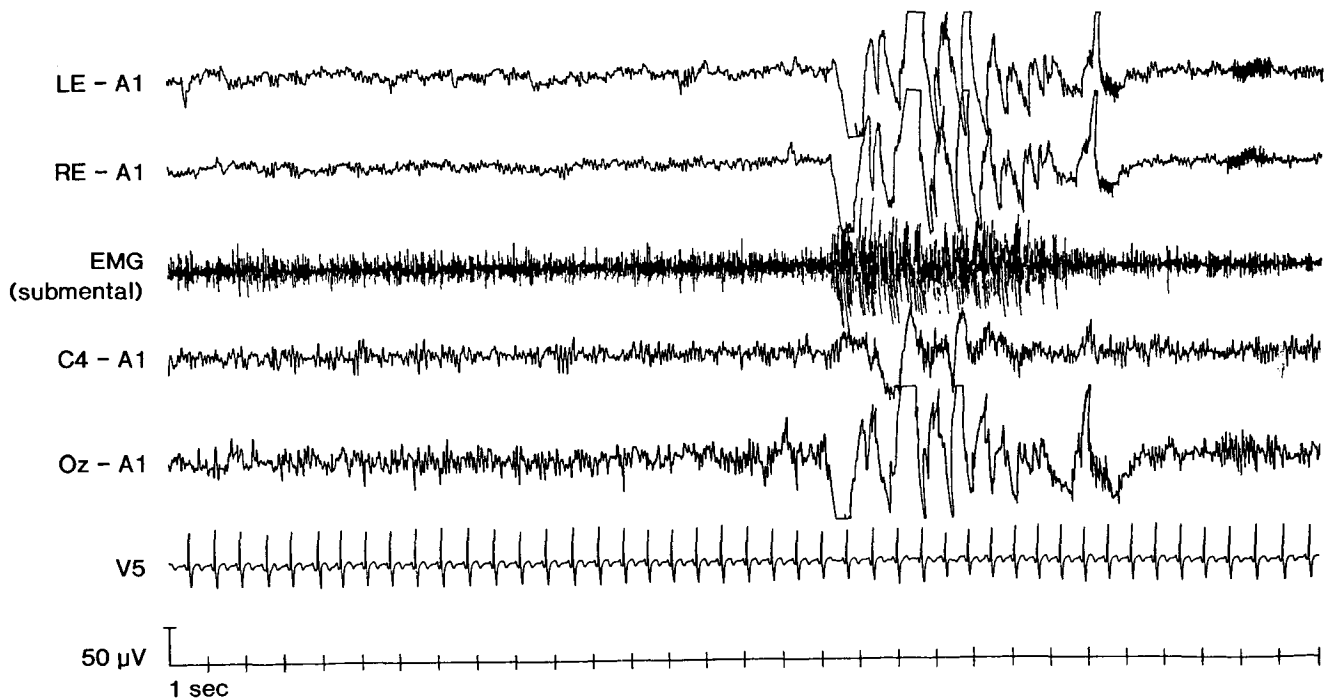
The criteria of defining an arousal as being 3 seconds or greater in duration is a methodological as opposed to a physiological decision. Identification and agreement on events of shorter duration are difficult to achieve. It should also be noted that no terminal criteria are established. An arousal can proceed to a wake score by Rechtschaffen and Kales criteria (i.e. greater than one-half of the epoch) or can be followed by a return to a lighter or the same sleep stage.

Arousals are considered periodic phenomena disrupting sleep. The minimum amount of intervening sleep necessary to score independent arousals will depend on the background EEG. Generally, 10 seconds of continuous sleep based on standard Rechtschaffen and Kales criteria is sufficient to score independent arousals. Ten seconds is chosen as the criterion because determination of sleep versus wake over an interval of less than 10 seconds becomes less reliable within and between scorers. The 10-second criterion also helps distinguish arousals from the residual effects of prior arousals or from other more continuous phenomena such as alpha sleep.

The present EEG arousal scoring rules do not provide for the scoring of delta wave bursts as arousals when they occur independent of EEG frequency shifts as defined by these scoring criteria. These events, delta wave bursts, may be indicants of arousal, but empirical evidence at this time is limited. Reliable scoring of such events may be difficult without the use of additional polygraphic parameters (i.e. respiratory tracings) to achieve reliable scoring.



**FIG. 1.** This is a greater than 3-second EEG change with frequencies greater than 16 Hz and alpha activity. This EEG arousal also has increased EMG amplitude. There are greater than 10 seconds of sleep preceding this event, and it is scored as an arousal.



**FIG. 2.** There is no sleep preceding this event and it is not scored as an arousal.

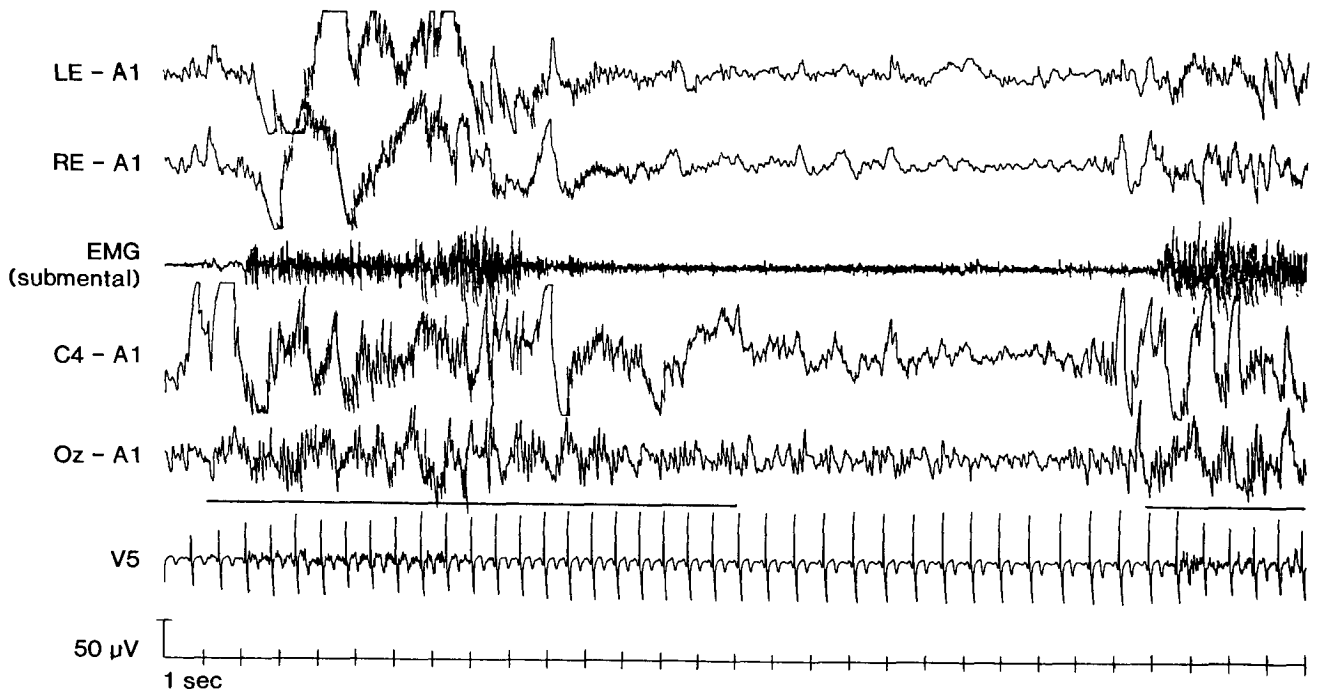


FIG. 3. Two arousals are scored on this epoch as there are 10 seconds of sleep between the arousals.

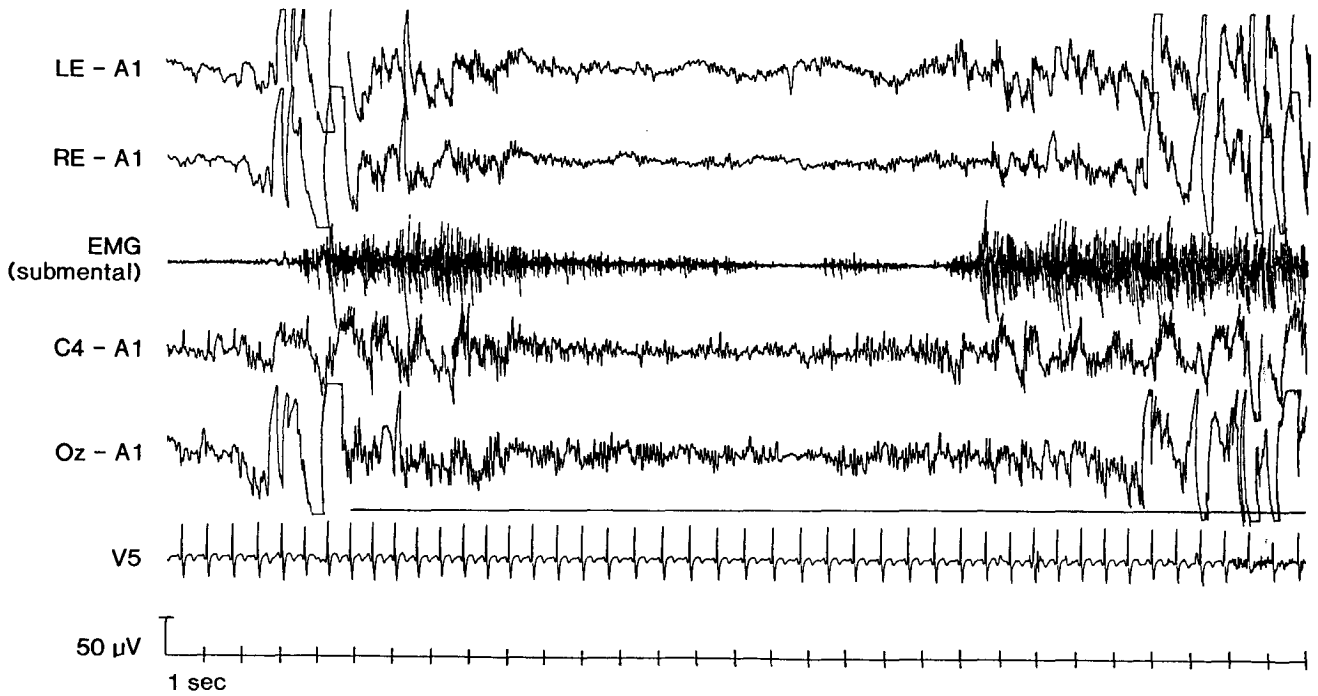
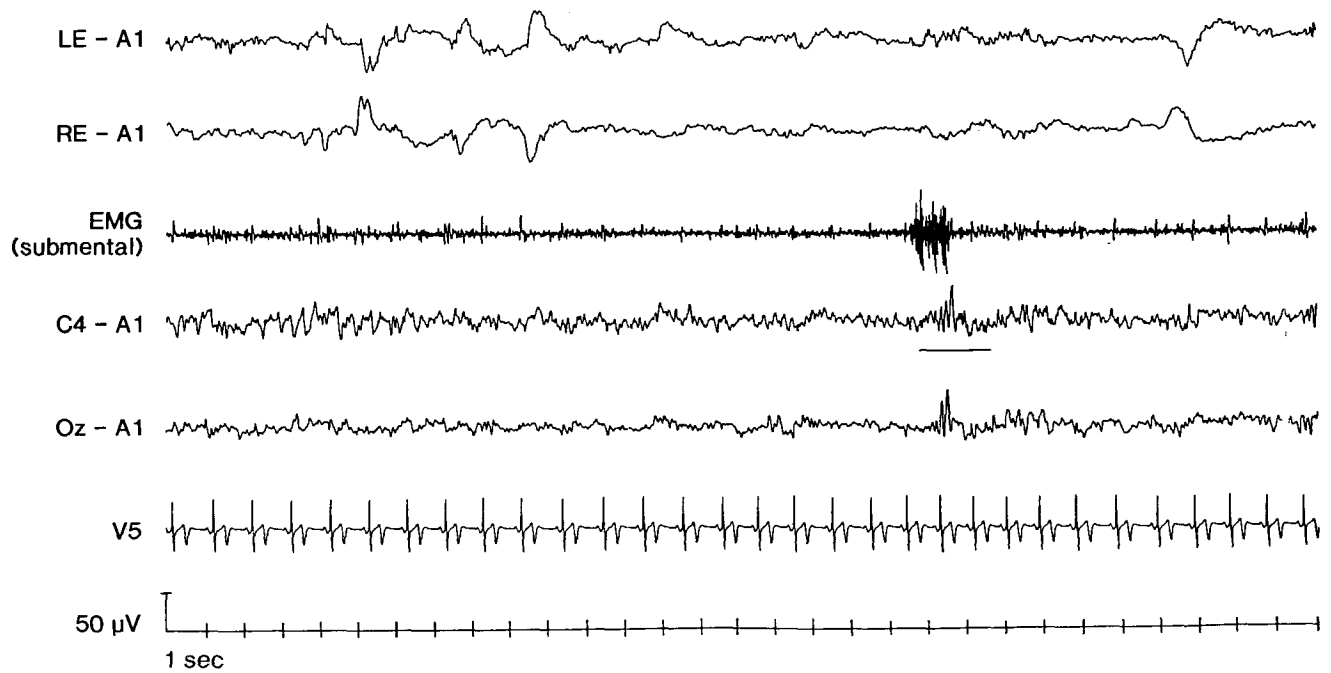
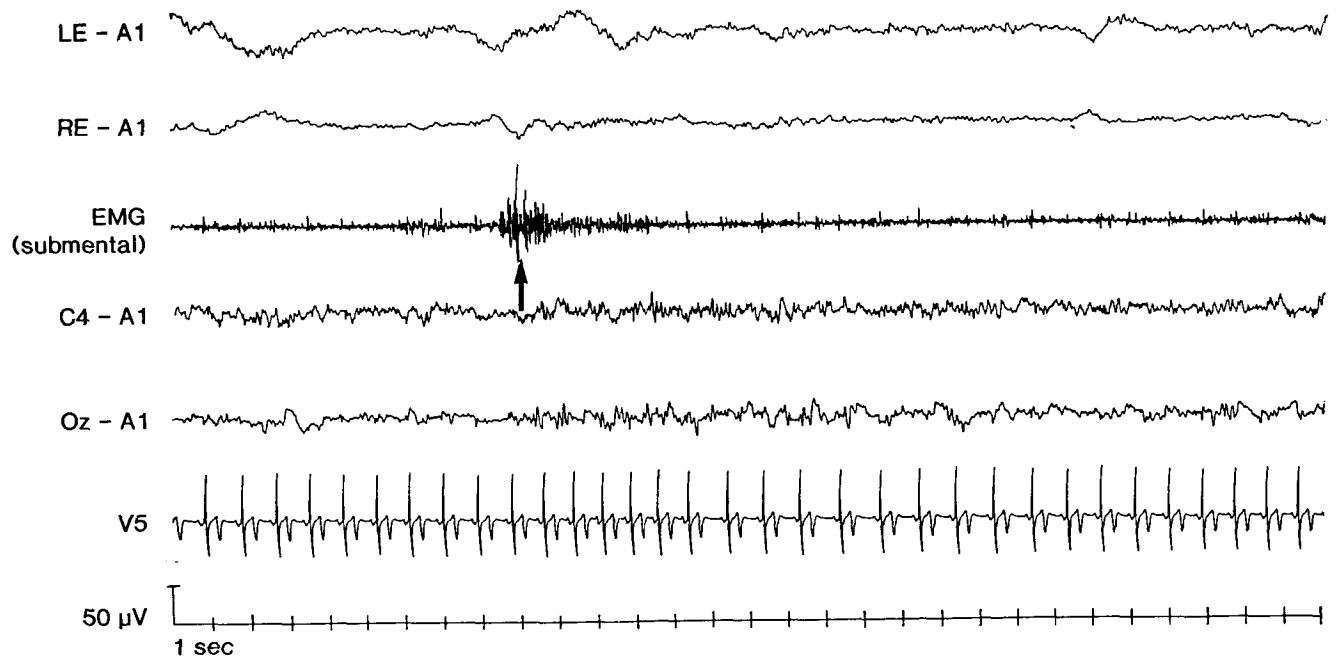


FIG. 4. A single arousal, at the far left of the page, is scored on this epoch as there is no sleep intervening between the initial arousal and the EMG and alpha burst on the right side of the page.



**FIG. 5.** The instance of EEG frequency change and EMG amplitude increase in this REM epoch is not long enough in duration to score as an arousal.



**FIG. 6.** While the EMG amplitude is briefly elevated, there is no EEG frequency change and this event is not scored as an arousal.

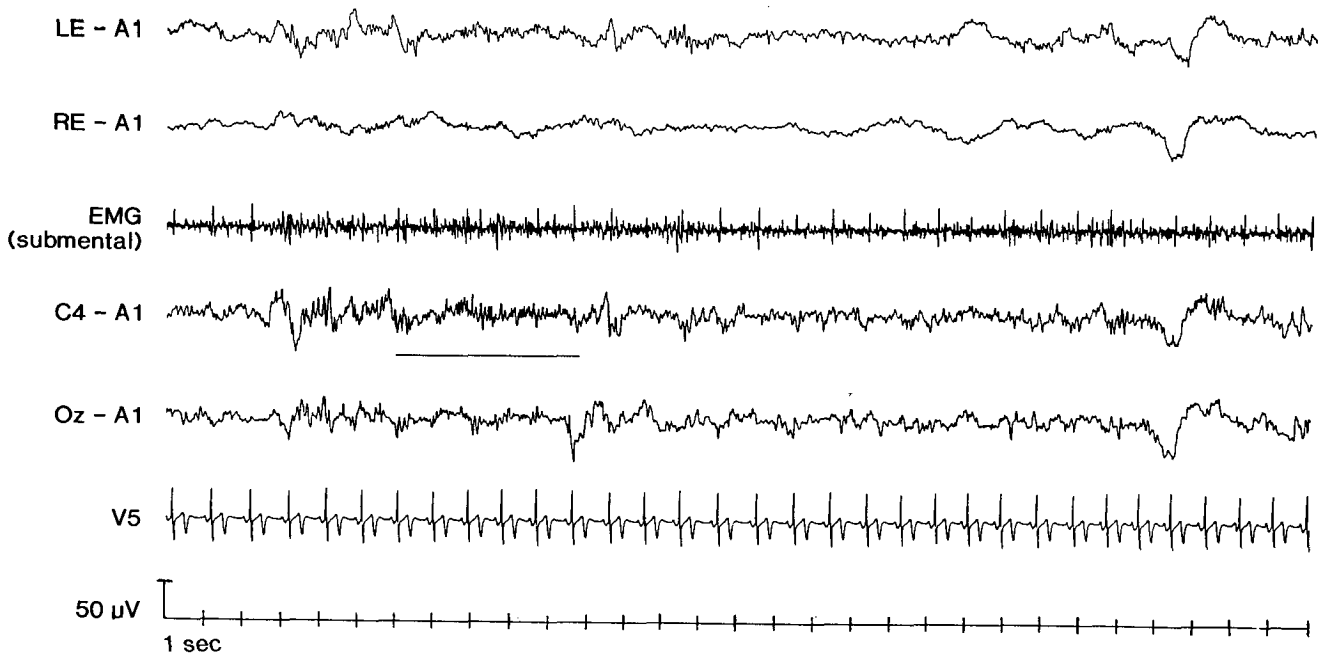


FIG. 7. The EEG frequency change in this epoch of NREM is scored as an arousal despite the absence of an EMG amplitude increase.

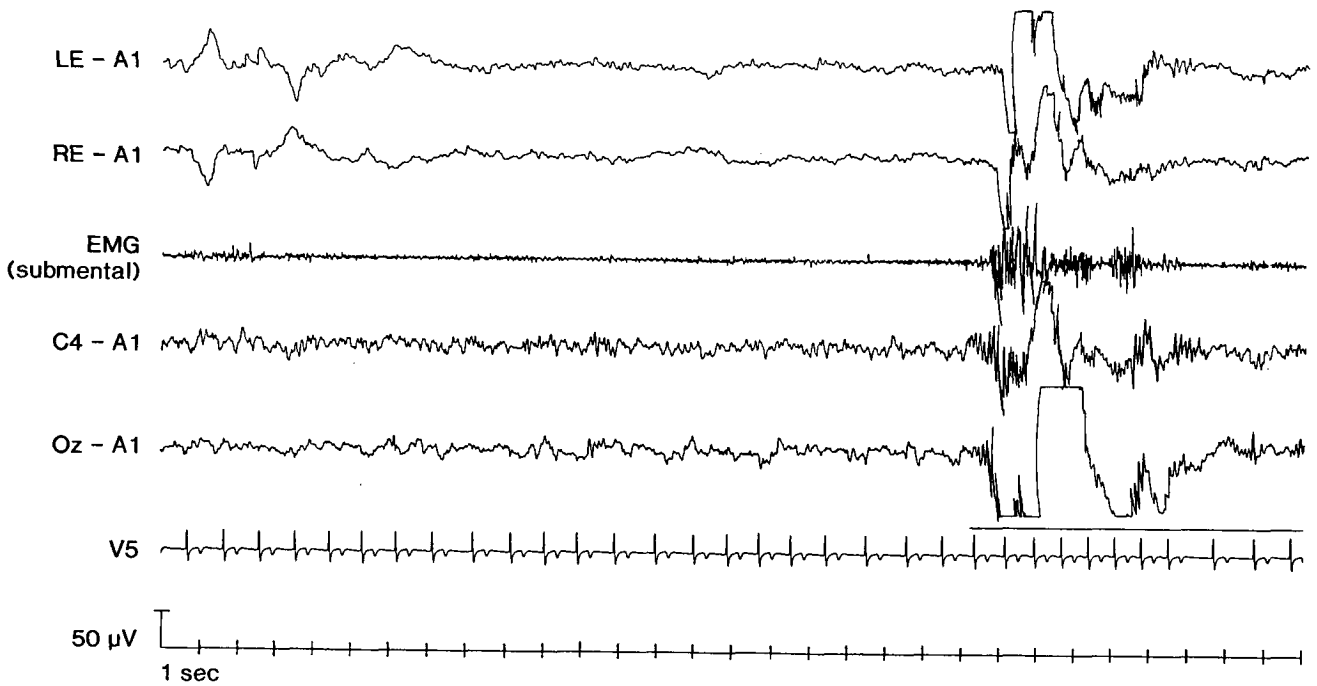


FIG. 8. The EEG frequency change in this epoch of REM sleep is scored as an arousal as there is both an EMG amplitude increase and EEG change of greater than 3 seconds duration.

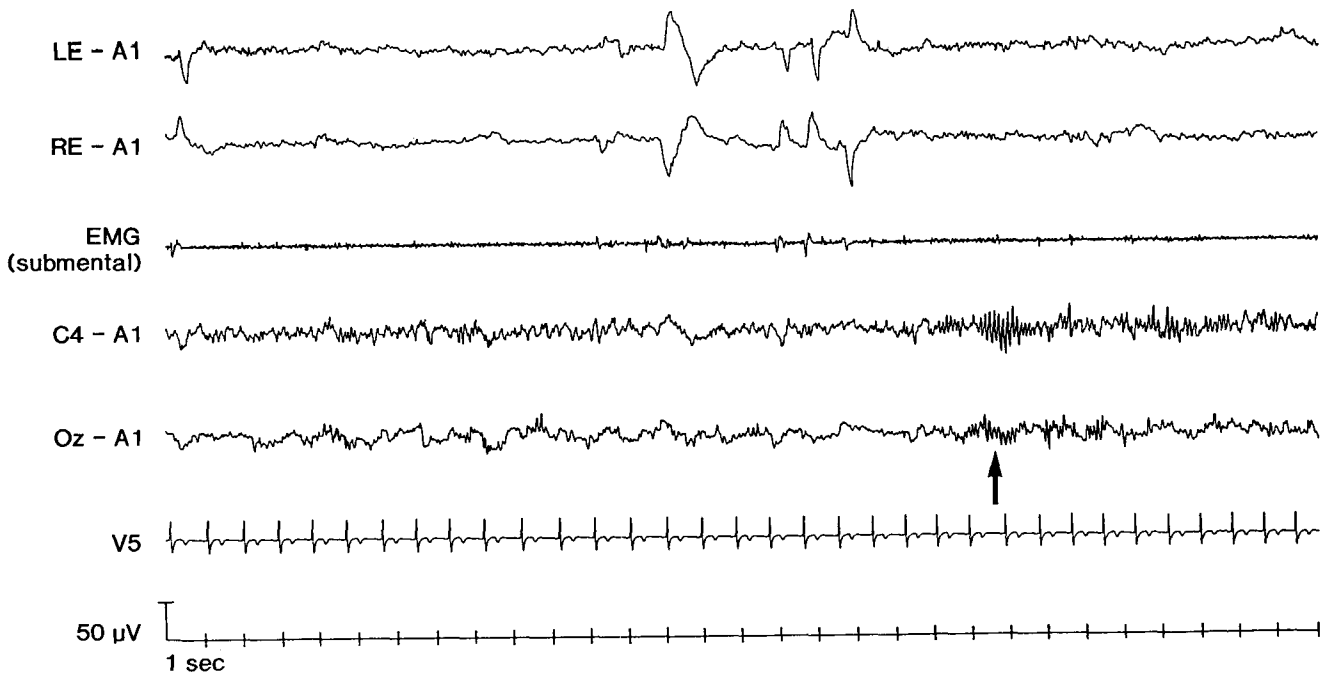


FIG. 9. The EEG frequency change on this epoch of REM sleep is not accompanied by an increase in EMG amplitude and thus is not scored as an arousal.

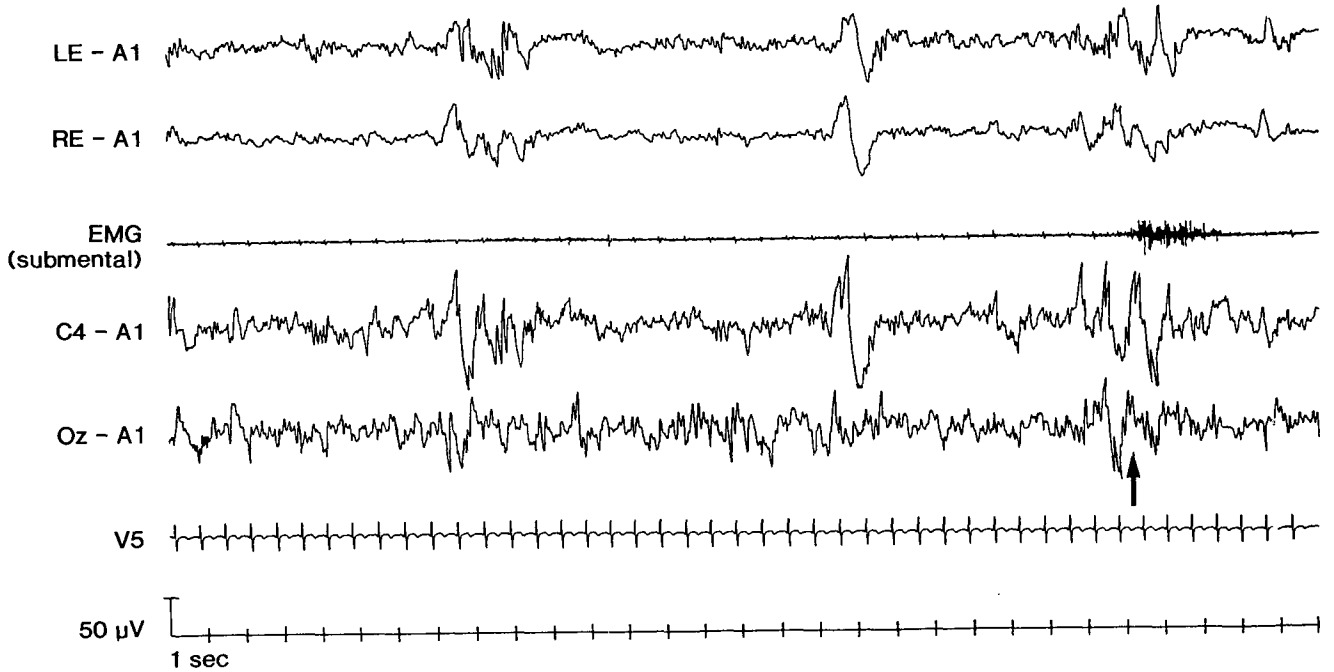


FIG. 10. The delta burst of this example is not scored as an arousal as there is no arousal-type EEG, although there is an EMG amplitude increase.

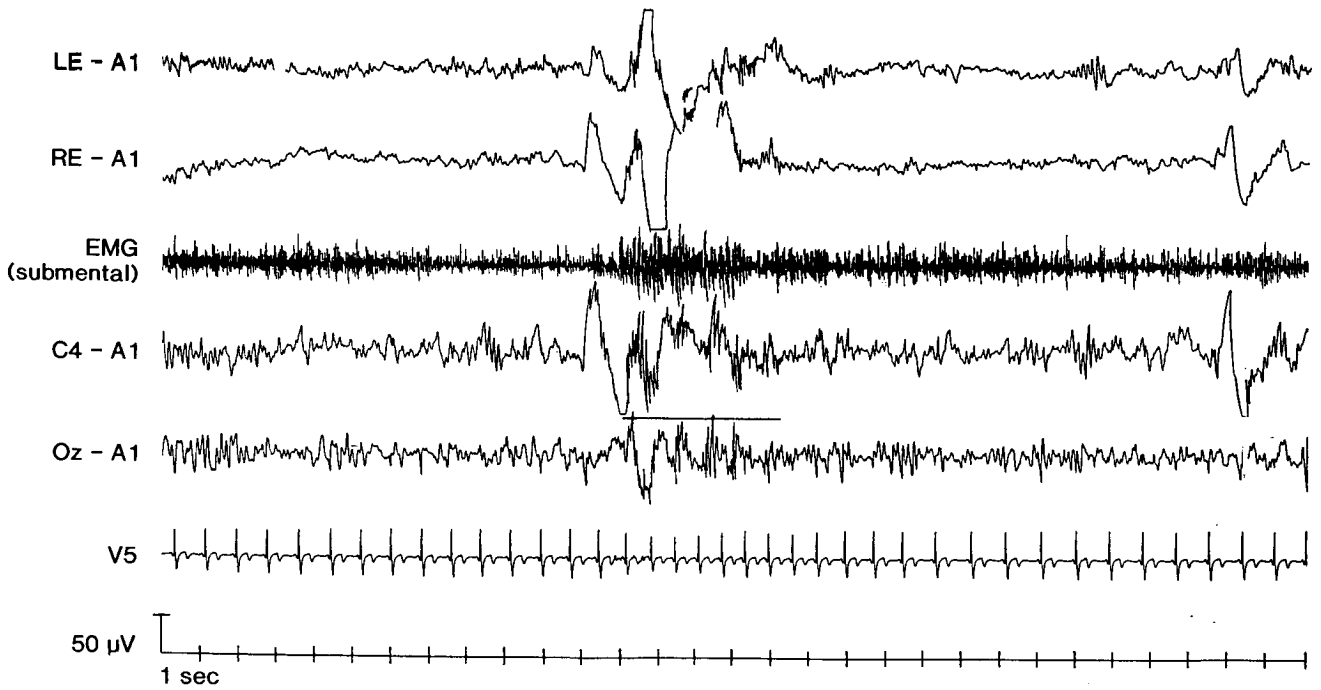


FIG. 11. The artifact in this example precedes the EEG arousal and is not included in making the 3-second duration criteria.

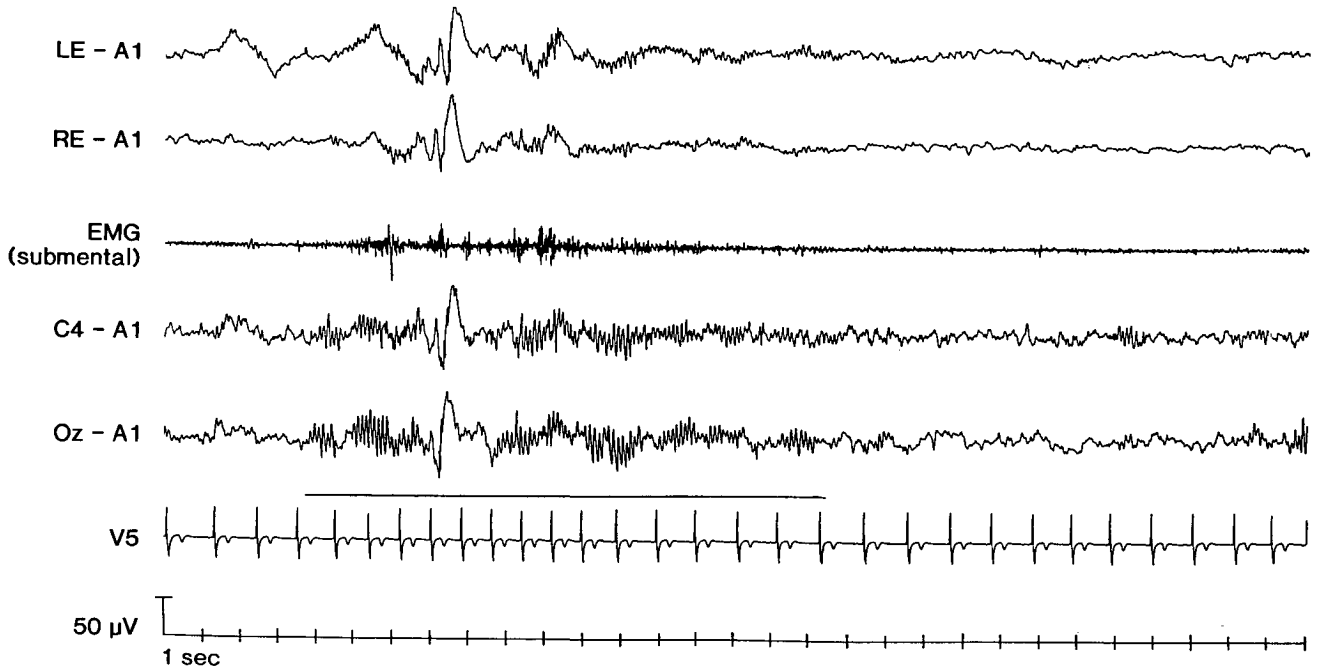
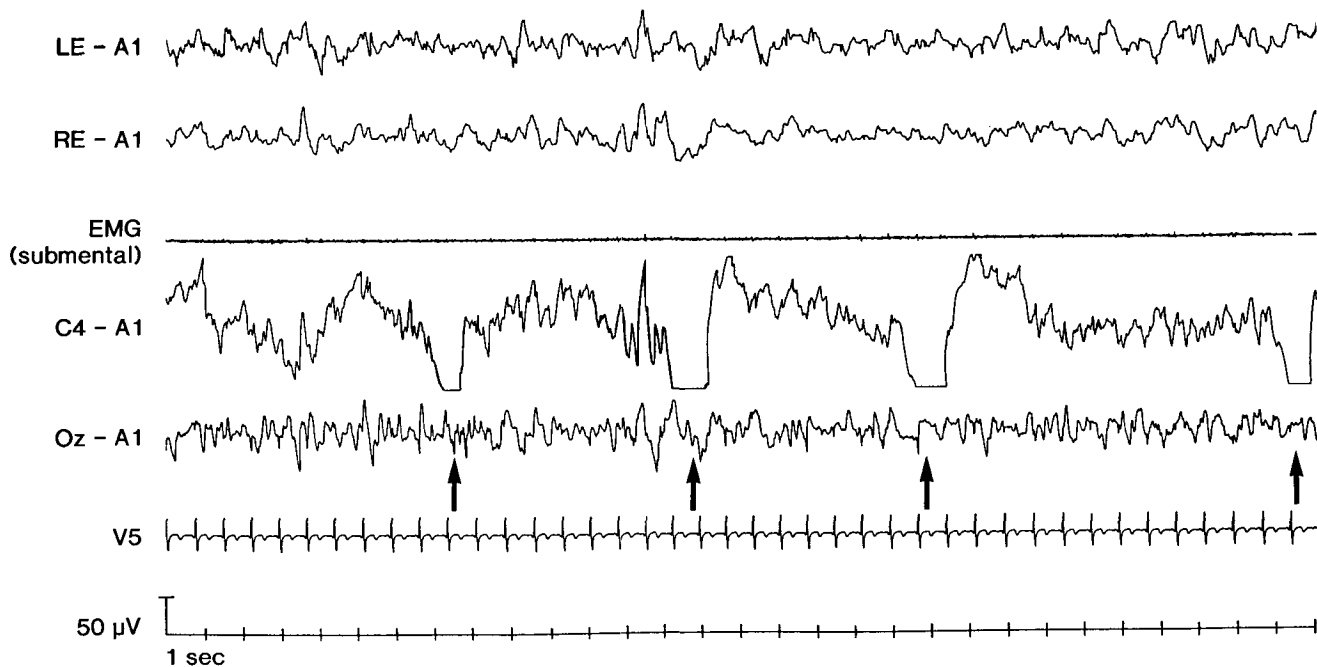
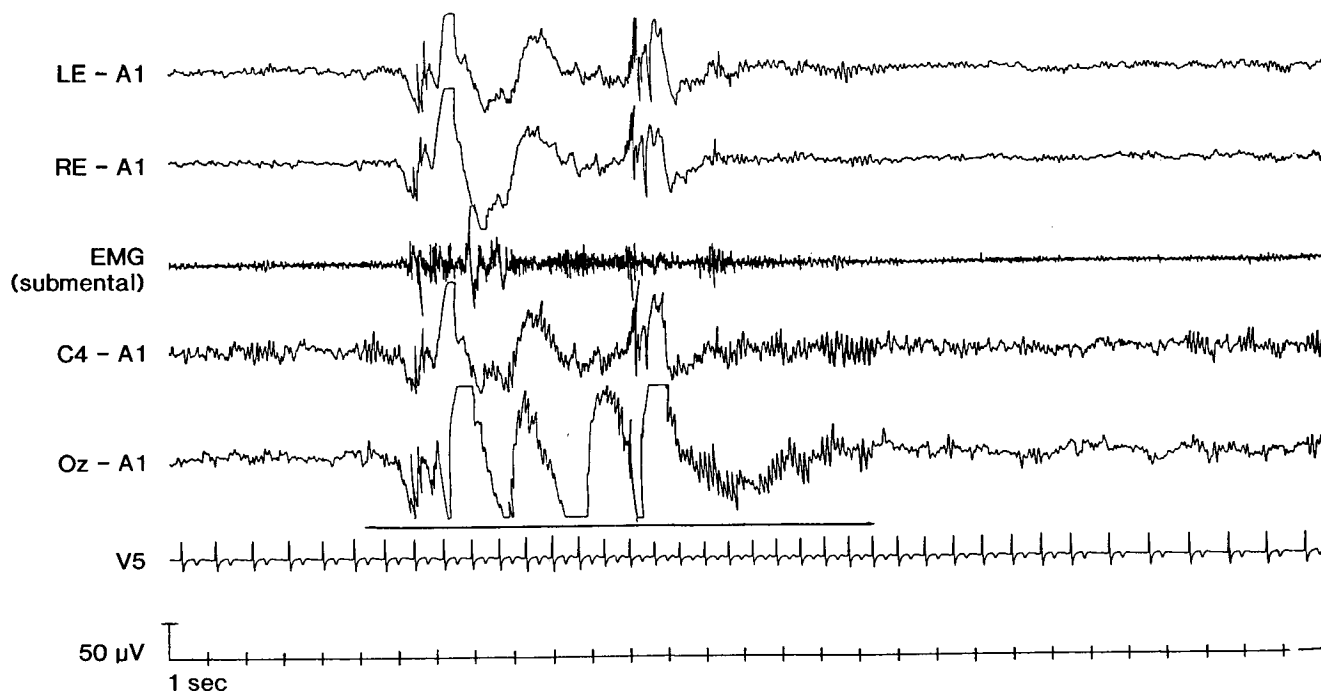


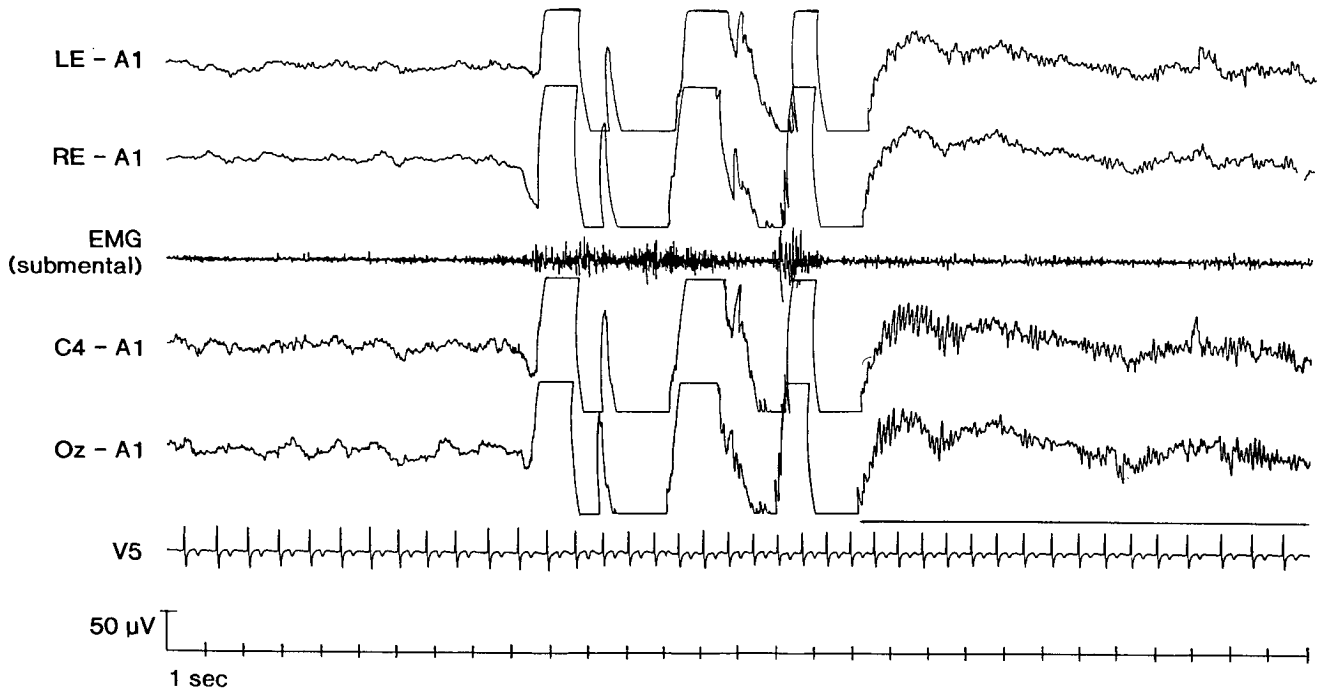
FIG. 12. The artifact in this example is embedded in the EEG arousal and is included in making the 3-second duration criteria.



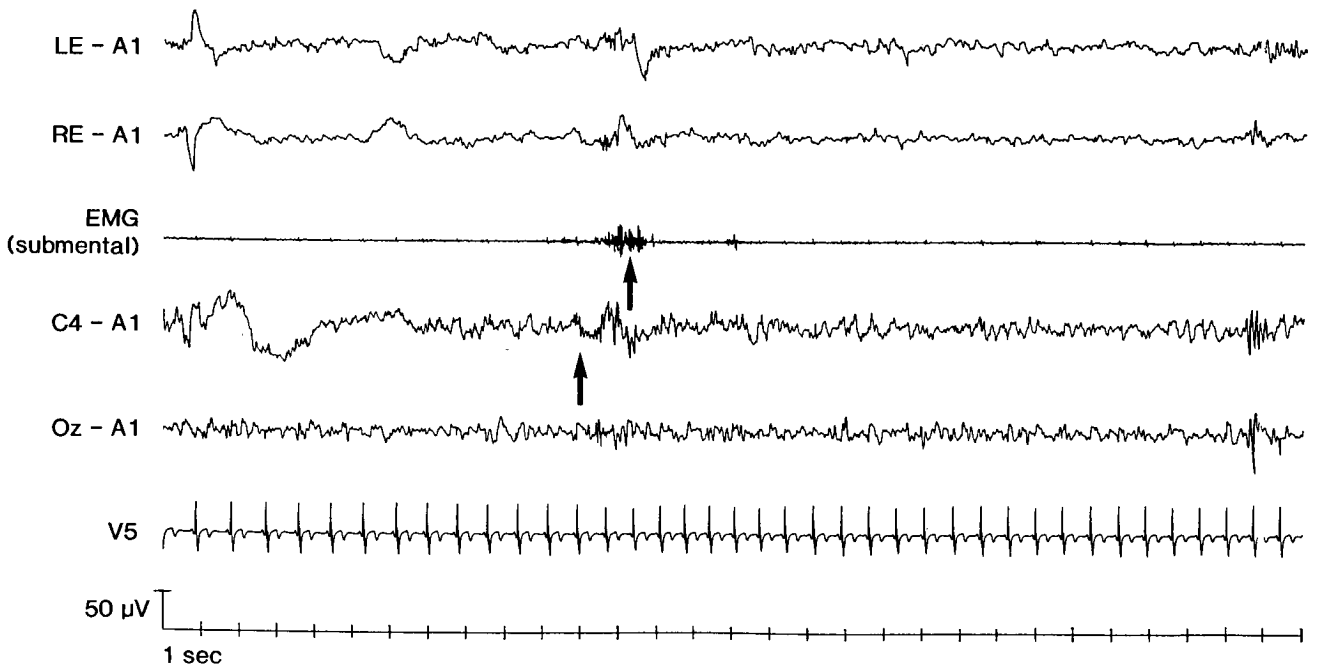
**FIG. 13.** The repetitive instances of pen blocking artifact in the central lead of this example are not scored as arousals as there is no arousal-type EEG in either derivation. Given the pen blocking artifact in this epoch, the electrode integrity should be checked.



**FIG. 14.** This example illustrates pen blocking artifact accompanying an EEG arousal. There is initial evidence of alpha activity in the C3 derivation, and it can be assumed that the arousal continued through the artifact. Because there is alpha activity prior to and following the artifact, the artifact is included in meeting the 3-second duration criterion.



**FIG. 15.** An EEG frequency shift is not clearly evident prior to the pen blocking artifact in the center of this example, and the artifact is not scored as part of the EEG arousal. There is sufficient EEG arousal-type activity following the blocking to score an arousal. Note the rule regarding scoring of postartifact.



**FIG. 16.** The brief EEG change and the brief EMG amplitude increase in this epoch of REM sleep are not summed to reach the 3-second duration criteria. This is not scored as an arousal.

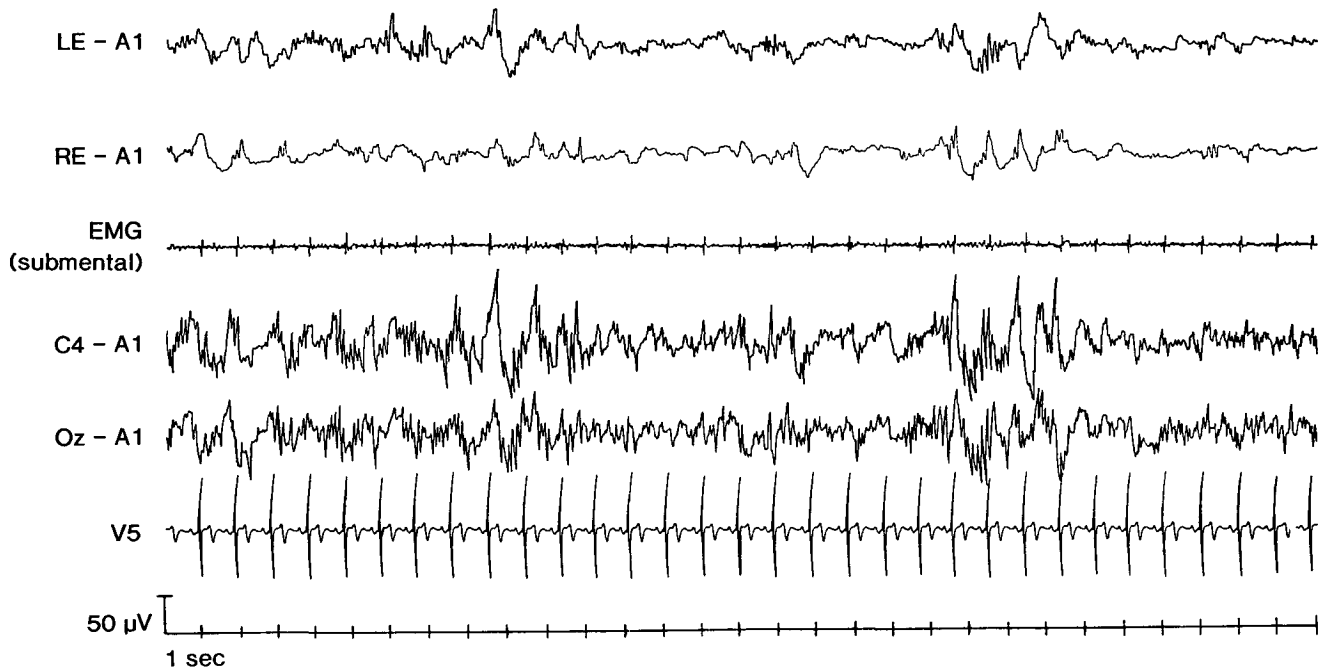


FIG. 17. This example illustrates continuous alpha intrusion into NREM sleep, which is not scored as an arousal.

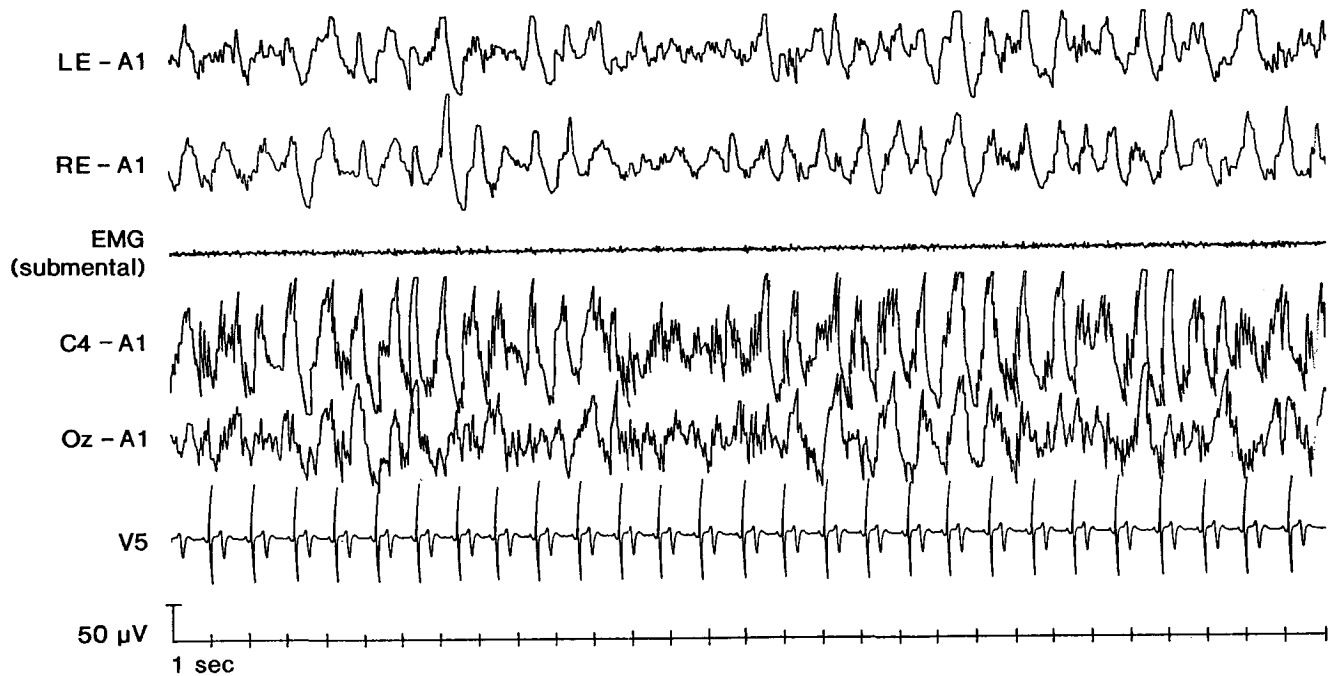


FIG. 18. This examples illustrates alpha sleep and is not scored as an arousal.