New Zealand Psychologist, 1979, *8,* 28-30.

Technical Note: The Measurement of Electroencephalographic Functioning During Motor Activity

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Modifications to a standard EEG Telementary unit are described which enable the unit to be operated with a range of up to 900 meters in adverse conditions. This is illustrated by records of the EEG of a skier, made with all equipment outdoors on a base of snow. Implications for the use of telemetry in field studies and its use in combination with behavioural measures are noted.

Electroencephalographic (EEG) activity has conventionally been measured in the immobile, and usually resting, subject; a condition which prompted Callaway's (1975) comment that we know more about the brain when it is not functioning than when it is functioning. But with increasing sophistication of EEG equipment, immobility is no longer a necessary constraint. As a case study, we report on the development and use of a system which has successfully telemetered and recorded EEG functioning of a subject while skiing. This particular activity imposes potentially severe performance demands on the system.

The utility of telemetered EEG activity has been demonstrated or advocated in several areas. Psychopharmacological evaluation of centrally acting drugs has been facilitated by telemetered EEG techniques, leaving the subject fully mobile, and allowing behavioural measures (Simard, Schneider, & Turbes, 1978; Willey, Roos, & Hunt, 1975). Mischel (1971) has suggested that such a combination of measures is useful as a tool in clinical assessment of behaviour disorders. An appropriate application arises in the detection of epilepsy, since seizures tend to occur more readily in freely moving patients (Geier & Bancaud, 1973). Telemetered EEG thus enables us to observe behavioural factors and central nervous system changes simultaneously and is consequently a powerful assessment technique.

Major problems associated with the use of telemetry arise from the interference of artifactual signals (noise) with the desired signal (EEG). Since the EEG signal is of the order of 20 to 100 millivolts any comparable electrical potential generated in the vicinity of the electrodes or transmitting equipment is likely to be superimposed noise but is recorded as spurious signals. Sources of noise are in the electrical circuits, the transmission and reception of the signal, the movement of electrodes and transmitter, and neuronal potentials from sources other than the cortex (such as cranial muscles). While technical advances have minimized noise from electronic circuits, and have minimized transmission and reception noise in stable atmospheric conditions, other sources of noise are still troublesome.

This paper reports a field study testing equipment modifications to improve the quality and range of recording EEG activity of a physically active subject. It was conjectured that if the equipment could function in the open air, on a base of snow, next to a building containing a large unscreened generator and a ski tow drive motor, then it could be expected to operate in most real situations. The activity of skiing was chosen since it provides a wide range of muscle involvement for a comparable range of velocities and is more continuous than the activity transmission from walking to running in usual human locomotion.

Method

Apparatus

The EEG was recorded by a modified single channel Biosentry telemetry unit. The principal modification was the addition of a Galbraith R.F. preamplifier to the receiving aerial to increase the range of operation beyond the recommended 15 meters (Figure 1). The transmitter was mounted inside a construction worker's helmet, giving protection to the apparatus and supporting the mounting of a transmitting aerial. Previously the transmitter had been carried on a belt or in a pocket (Wellkowitz & Deutsch, 1976), although Andersson (1976) has used a head mounting. The head mounting has the advantage of reducing the distance from electrode to preamplifier, which is crucial for the reduction of artifact, keeps electrode and carrier leads away from muscles likely

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This work was supported by grants to the second author from the Scientific Lottery Profits Distribution Committee, and the New Zealand Neurological Institute. Particular thanks are due to Mr Winton Bell for interfacing the system.

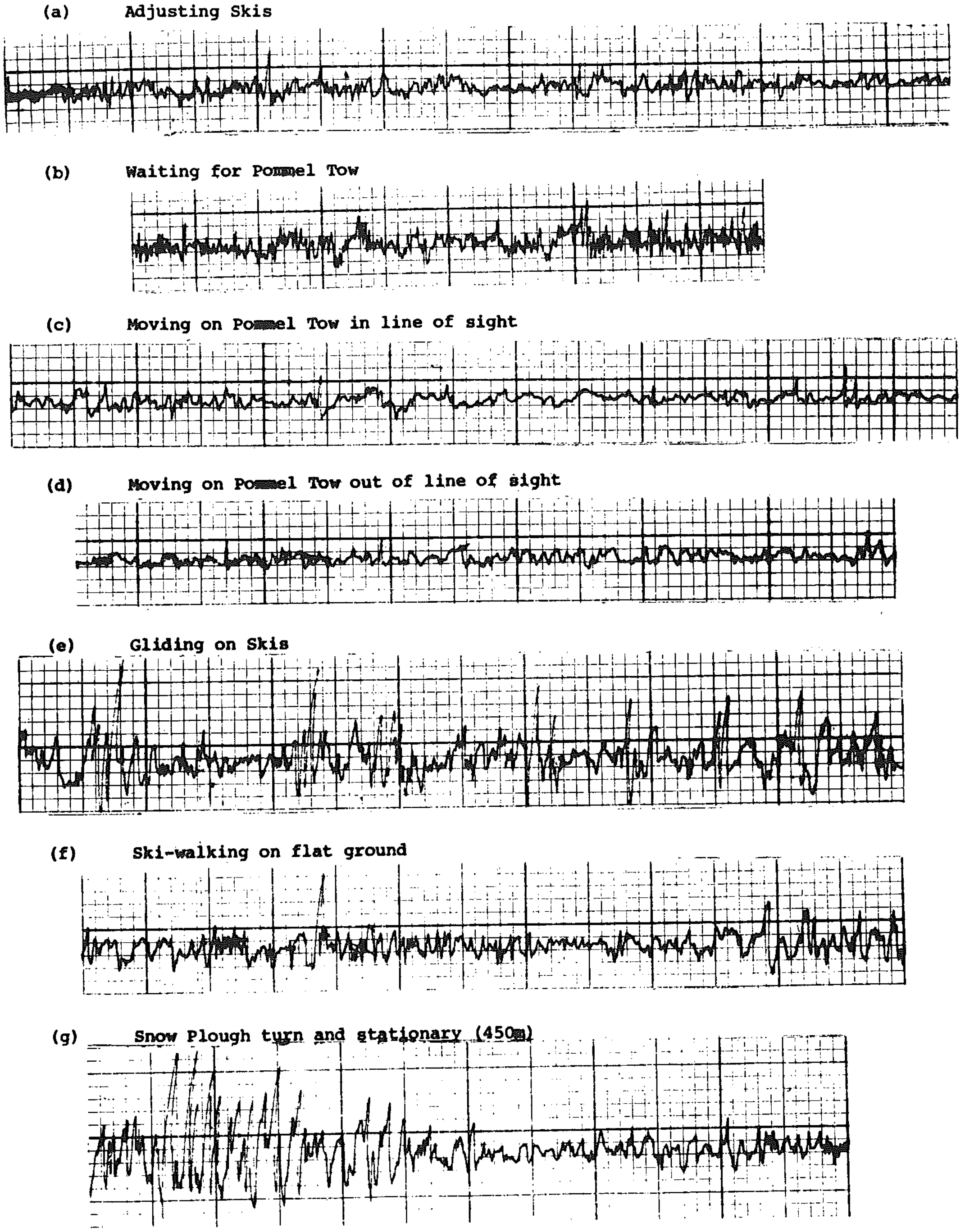

Figure 3. Epochs of recorded EEG for different mobility conditions. (Scale: each division = 1/10 inch; paper speed: 3 cm/sec; amplitude of signal: 1 cm = 100 mv.)

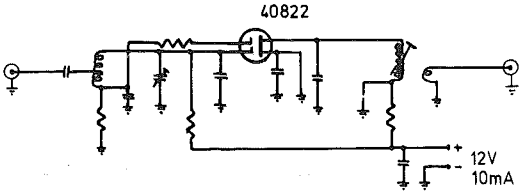

Figure 1. Circuit diagram of the 6 pre-amplifiers fitted to the receiving aerial to increase the range of reception.

to cause artifact, and is the most stable position during skiing movement. The output of the receiver was further amplified for recording purposes through a modified Lafayette EEG/EKG pen drive amplifier and recorded on paper chart at 100 millivolts/cm.

Procedure

The EEG was transmitted from a monopolar placement of Grass gold electrodes (0_2 - A, by the 10-20 International System) fixed with collodion. The EEG signal of the subject, a proficient skier, was monitored continuously on the oscilloscope while he was skiing on the lower slopes of Mount Hutt Ski Field, at an altitude of between 1600 and 1800 meters, and a range of 5 to 1200 meters from the apparatus. Selected epochs were recorded on a Lafayette Data Graph (Figure 2).

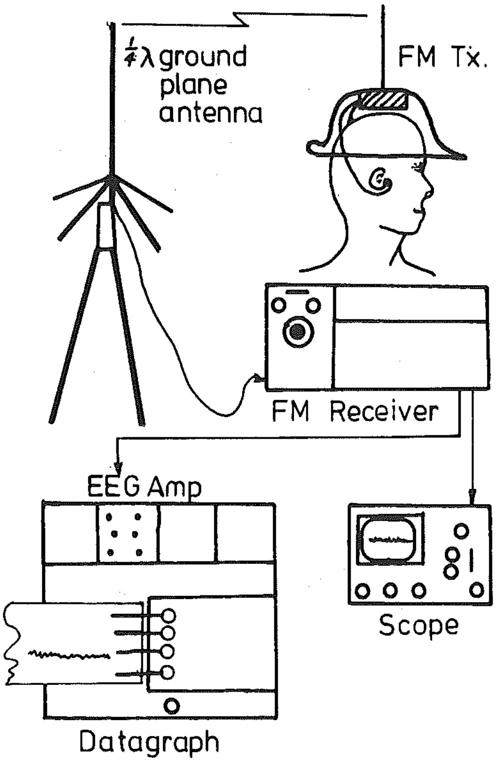

Figure 2. Schematic representation of apparatus used in the recording of the EEG.

Results and Discussion

It was found that the EEG signal could be recorded free of artifact up to 300 meters away regardless of the presence of intervening objects or terrain, and approximately 900 meters away with transmission along an undertaken line of sight. The signal varied in quality depending upon the activity of the skier (Figure 3). While stationary, (Figure 3 a, b, g) and moving on the Pommel Tow (Figure 3 c, d) the signal was of high quality. When actively skiing the signal showed artifact in proportion to the degree of vigour. Thus artifact in ski-walking (Figure 3 e) and gliding (Figure 3 f) was intermittent and may have resulted from arm movements associated with a forward thrust. For a snow plough turn (Figure 3 g) and slalom skiing disruption of the signal by artifact was complete.

It is evident that with movement of the order of 1 meter/second, the artifact was due to muscle movements. There was no artifact while on the tow but there was for similar conditions in ski-walking and gliding where arms were used. At higher speeds or in more active conditions artifact may have been due to a variety of causes.

In conclusion, it was shown that with modifications to a standard telemetry unit the EEG activity of a subject can be measured in the adverse conditions of a ski field and at some distance. It was also possible to measure this activity during some movement conditions and it was suggested that artifact during slower locomotion may have resulted from arm and upper body movements. The implications are that EEG research need no longer be confined to the stationary subject or laboratory conditions. Finally, the authors modestly suggest that this field study may set an altitude record for land-based psychological research in New Zealand.

References

Callaway, E. *Brain electrical potentials and individual psychological differences.* New York: Grune and Stratton, 1975.

Geier, S., & Bancaud, J. Etude du mode d'apparition des 159 premieres crises epileptiques partielles enregistrees en tele-EEG. *Revue d'Electronecephalographie et de Neurophysiologie Clinique de Lange Francaise,* 1973, *3,* 343-352.

Mischel, W. *Introduction to personality.* New York: Holt, Rinehart and Winston, 1971.

Simard, J.M., Schneider, G.T., & Turbes, C.C. Combined hardware-software noise rejections in the telemetry of brain wave activity. *Journal of Electrophysiological Techniques,* 1978, *6,* 24-33.

Wellkowitz, W., & Deutsch, S. *Biomedical instruments: Theory and design.* New York: Academic Press, 1976.

Willey, T.J., Roos, F., & Hunt, G.M. Computer signal processing of long duration biotelemetric brain data. *Biotelemetry,* 1975, *2,* 329-340.