

FEATURE ARTICLE

Keep Cell Phones and PDAs Away From EMG Sensors and the Human Body to Prevent Electromagnetic Interference Artifacts and Cancer

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Keywords: electromyography, artifact, cancer, cell phones, electromagnetic interference

Cell phones produce electromagnetic interference (EMI), which can cause artifacts in physiological recordings and be misinterpreted by the clinician. This study investigated the possible effect of EMI (electrical artifact) on physiological recordings when cell phones are activated/ringing. The procedure consisted of placing the cell phone at varying distances from surface electromyographic sensors. Depending on the orientation of the cell phone's antenna, the EMI produced an artifact in the physiological signal for up to 175 cm (6 ft) that can be misinterpreted by the therapist. To avoid EMI artifacts, clients and therapists should turn off their cell phones when recording physiological signals. This means turning the cell phone off and not just switching it to vibrate. In addition, recent epidemiological studies suggest that long-term intensive cell phone use may increase the risk of gliomas, auditory tumors, and salivary tumors on the side of the head to which the person places the cell phone. Thus, to reduce artifacts and biological harm, the authors recommend keeping the cell phone away from the body and the biofeedback equipment.

Introduction

The surface electromyographic signal (SEMG) recorded from the upper trapezius increased and the therapist asked, "What did you just experience? What thoughts did you have?" These questions were based on the psychophysiological principle that every thought has a corresponding physiological activity and every physiological response a corresponding emotional/cognitive activity (Green & Green, 1977). Before leaping to the conclusion that movements, emotions, or thoughts increased the SEMG or changed the electroencephalogram (EEG) signal, the biofeedback instrument user must eliminate the possibility that the signal was produced by an externally generated electromagnetic signal. This article explores an unrecognized source of artifacts that is becoming omnipresent: the electromagnetic interference (EMI) produced by cell phones (Peper, Tylova, Gibney, Harvey, & Combatalade, 2008).

Over the past 10 to 15 years, cell phones have gone from large, bricklike wireless devices to easily hidden devices, with some as small as a pack of chewing gum. These personal digital assistants (PDAs), also known as palmtop computers, keep us connected by allowing us to talk, email, and surf the Web. We can now be connected 24 hours a day, and PDAs such as the BlackBerry[®] let us continuously check for email. Cell phones and their digital Internet-connected clones are ubiquitous and increasing in use.

The worldwide mobile subscriber base crossed the 3 billion mark in late 2007 and is now expected to cross 5.5 billion by the end of 2013. A new report from Portio Research reveals that more than half of the world now uses a mobile phone and predicts that 80% of the world's population will be doing so by the end of 2013—a staggering 5.8 billion people. China wins the top spot, just ahead of India, and is expected to contribute more than 1 billion additional subscribers during this time. Brazil comes in a distant third with 132 million additional subscribers over the same period. Africa, the Middle East, and Latin America are also expected to experience high growth estimated at 13.3%, 10.7%, and 9.9%, respectively (Williams, 2008). In many instances, the person shuts off the ring and switches to vibrate to signal inbound calls or emails. Thus, it's easy to forget to turn the cell phone off and leave it on vibrate.

The effect of EMI from cell phones has been reported and is the basis for turning cell phones off in planes and many medical settings where physiological monitoring is performed. Research by Tri, Severson, Firl, Hayes, and Abenstein (2005) found that cell phones may interfere with medical equipment. In that study, six mobile devices were tested with 16 medical devices; this study demonstrated that most affect the electrocardiogram (ECG) recordings if the phones were closer than 17 inches. If the EMI can produce an artifact in medical recording, may it also have health implications beyond producing artifacts? This study investigated the effect of EMI from cell phones during SEMG recording. The purpose of this study was to determine

whether EMI affects physiological electromyographic recording and, if yes, identify the safe distance for cell phone use.

Method

The subject was seated, and SEMG surface electrodes were placed on the skin over the opponens pollicis and abductor pollicis brevis with reference electrode placed on the radius. The SEMG was amplified with a Myoscan Pro sensor (model N2124), narrow-band filter set between 100 and 200 Hz, and recorded with BioGraph ProCompVersion 2.1 (Thought Technology, Ltd., Canada). A cell phone (Samsung model SGH-D807) was placed at varying distances between 1 cm and 225 cm from the sensor and/or encoder. At each of the distances, an inbound call was made to make the phone ring.

Results

The results indicated that significant EMI during cell phone activation (ringing/sending) produced large EMG changes (electrical artifacts) when the cell phone was placed near the sensor. The EMI signal totally overwhelmed the physiological recording when the cell phone was in close proximity to the electrodes and sensor. Each time the cell phone rang (inbound call), it was preceded by significant artifact ($>400 \mu\text{V}$) in the recording, as shown in Figure 1.

The EMI artifact was still $92 \mu\text{V}$ when the cell phone was held 30 cm (11.8 inches) from the sensors, as shown in Figure 2.

The amplitude of the artifact was dependent on the distance from the electrode and EMG sensor, as shown in Figure 3. The effect disappeared at distances greater than 175 cm (6 ft), as shown in Figure 3.

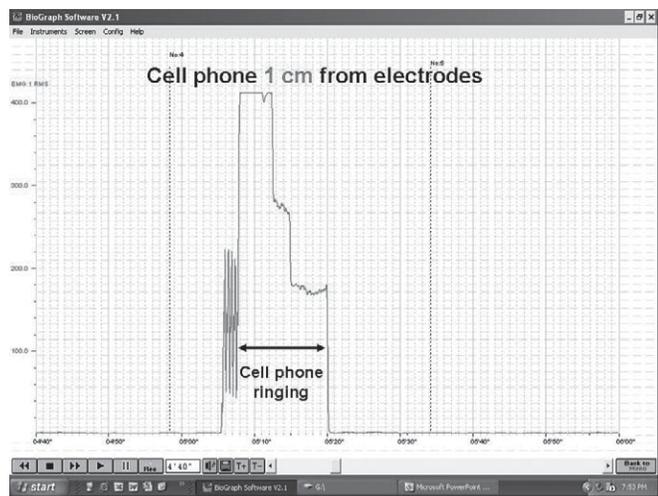


Figure 1. Surface electromyographic recording showing the effects of a cell phone located 1 cm (0.4 inches) away from the electrodes.

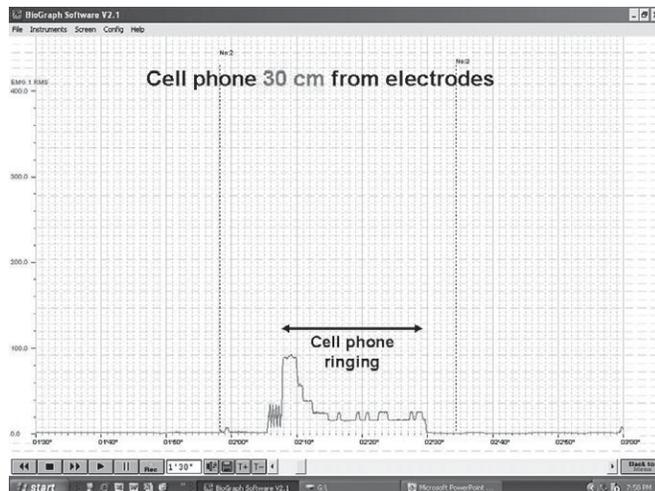


Figure 2. Surface electromyographic recording showing the effects of a cell phone located 30 cm (11.8 inches) away from the electrodes.

Discussion

In most cases, cell phone EMI artifacts occur when the cell phone is less than 2 m (6 ft) from the sensors or encoders during the recording of signals. If the cell phone activation/ringing occurred at a distance of 50 to 150 cm, the trainee and therapist could misread the EMI artifact as an actual biological signal. This error is more likely when SEMG feedback is given during a training session without analyzing the raw SEMG signal for artifacts. The magnitude of the EMI artifact depends on the cell phone type, which should be explored in future studies.

Implication for Applied Psychophysiology

We recommend that during physiological monitoring and biofeedback training, cell phones be turned off to avoid EMI artifacts. Practitioners and trainees need to be aware of EMI

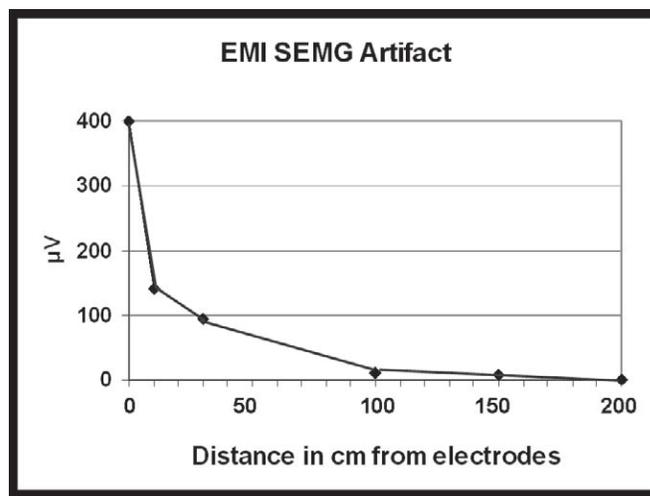


Figure 3. Surface electromyographic recording showing the effects of a cell phone ringing at different distances.

artifacts and how they may affect physiological recording of SEMG, ECG, and EEG. This would also be true for heart rate variability, when recorded from ECG but not from photoplethysmography. In addition, trainees need to be aware of this possible artifact when they are using EEG or SEMG home training units.

Check out Your Cell Phone EMI

Place the cell phone near the sensors when recording SEMG, EEG, or ECG. On another phone, dial your cell phone number and let it ring. For almost all cell phones, before the cell phone even rings or vibrates, a large EMI artifact occurs in the recording (Peper et al., 2008).

Possible Implications for Health

The large EMI signal produced when the phone rings during an inbound call illustrates that wireless devices communicate invisibly and imperceptibly through the electromagnetic spectrum. A study by Ferreri and others (2006) showed that radio frequency electromagnetic fields produced during cell phone operation penetrated 4 to 6 cm into the human brain and affected the excitability of neural activity in the area of the cortex that was closest to the phone during use, as compared with the opposite side of the head in double-blind real or sham exposure to an electromagnetic field generated by a mobile phone. After 45 minutes of exposure, it took approximately 1 hour for the affected areas to return to normal. The question as to whether such exposure could be harmful is controversial. However, in epidemiological studies, people who used cell phones for more than 10 years had twice the risk of gliomas (Schüz et al., 2006), three times the risk of auditory tumors (Hardell, Mild, & Carlberg, 2002; Lönn, Ahlbom, Hall, & Feychting, 2004), and an increased risk for salivary tumors on the side of the face to which they hold the cell phone (Sadetzki et al., 2008). These epidemiological findings suggest that long-term cell phone use may have deleterious biological effects, although no one has suggested that the EMI produced during the in-bound call is harmful. In addition, the International EMF Collaborative recently released a report showing evidence of hazard with cell phone use, and a number of scientists endorsed the report (Morgan et al., 2009). The prudent conclusion is to keep the cell phone away from both the human body and the biofeedback equipment.

Acknowledgments

We thank Marisa Cortez for her contribution to this study. This article was adapted from Lin, I. & Peper, E. (2008).

Keep your cell phone away for reducing electrical artifacts. Presented at the 39th Annual Meeting of the Association for Applied Psychophysiology and Biofeedback.

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