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# MOBILE PHONE USE AND TEMPORAL SKIN HEAT SENSATION

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## Abstract

Epidemiological investigation of mobile phone (MP) users reported symptoms of discomfort feeling, warmth behind/around or on the ear and heat sensation of the cheek. These symptoms may be due to thermal insulation, conduction of the heat produced in the phone by the battery currents and running of the radiofrequency (RF) electronic circuits, and electromagnetic field (EMF) energy absorbed by the user's head. Using a Luxtron 790 fiberoptic thermometer we measured the temperature of the temporal skin due to GSM 1800 MHz MP radiated power (125 mW). We suppressed the EMF exposure by switching the RF signal from the antenna to a 50  $\Omega$  load. The ambient air temperature was 23°C and the MP was held in the normal position of use for 30 minutes to reach the thermal steady state. With a switched off MP, the increase in skin temperature was statistically significant 1.88°C. When MP was switched on, the increase was 2.93°C in reception mode, 3.29°C in emission mode without load and 3.31°C in emission mode with load. The temperature difference with or without load was not significant ( $t_{17} = 0.707$ ;  $p = 0.489$ ), which means that the contribution of EMF absorption to skin heating is negligible. The result suggests that the heat sensations reported by the MP users are exclusively caused by thermal insulation and heat conduction from MP associated with long calling time.

## Keywords

Mobile phone, electromagnetic field, biological effects, heat, skin temperature

## Introduction

Mobile phone "cell phone" use has dramatically increased over the last decade, but doubts remain over its safety. Many epidemiological investigations of MP users [1, 2] reported symptoms of discomfort feeling, warmth behind/around or on the ear and heat sensation of the cheek. These symptoms may be due to changes in the thermal exchange between the skin and the air due to the contact between the phone and the skin (thermal insulation), conduction of the heat produced in the phone by the battery currents and running of the radiofrequency (RF) electronic circuits transmitted to the tissue, and of a part electromagnetic field (EMF) energy absorbed by the user's head. The head exposure to EMF presents particular problems due to the close proximity between the source of emission (MP antenna) and the head of the user. A major part between 40-50 % of MP EMF energy is absorbed by user's head [3] and the absorption is highest in the skin ~ 38.5 % [4].

The aim of this study is to quantify the temporal skin warming of the MP user in the normal position of use and to investigate the contribution of different parameters to skin increase temperature especially EMF energy.

## Methods

The mobile phone used in this study was a GSM 1800 MHz Motorola mr 20 with a test card to control the use mode of the MP. It was used at maximal power during emission and their batteries allowed continuous emission without loss of power for the whole duration of the experiment. The emission parameters were as following: frequency: 1800 MHz; frequency of repetition of impulses: 217 Hz; duty cycle: 1/8; peak power/average power: 1 W / 125 mW.

We suppressed the EMF exposure by switching the RF signal from the antenna to a 50  $\Omega$  load. During experiments the MP was: switched off; switched on in reception mode, in emission mode without load and in emission mode with load.

Temperature was measured using a fiberoptic thermometer (Luxtron 790) with 4 SFF-5 surface temperature sensors which can be used in normal listening conditions. The temperature was measured every minute during the experiment until thermal steady state was reached and the data automatically recorded on a computer. The accuracy of measures was  $\pm 0.1^\circ\text{C}$ .

The sensors were calibrated at the beginning of each experiment in a water bath at ambient temperature (controlled by a mercury thermometer). For each volunteer, three sensors were used, one placed on the temple of the subject (skin sensor), another on the mobile phone surface in contact with the temple (phone sensor) and the last measures air temperature (air sensor). The 'skin sensor' was placed perpendicular to the line starting from the tragus in alignment with the lip edge, at the level of the temporo-mandibular joint, and held in position with porous adhesive tape (Figure 1a). The 'phone sensor' was placed on the flat surface between the screen and the keypad on the middle line using adhesive tape (Figure 1b). When the phone was in the normal using position, the two sensors were both parallel and contiguous. The use of these two sensors allowed the measurement of the kinetics of the raise in temperature at the skin-telephone interface until thermal equilibrium was reached.



**Figure 1:** Skin (a) and phone sensor (b) positioning.

After calibration, the sensors were placed on the skin and MP in their reference positions. The temperatures of skin and MP surface switched off at room temperature were measured before beginning measurement at normal using position of MP. Then mobile phone switched off was held in the normal using position and the variations in temperature recorded until temperature equilibrium was reached (approximately 30 minutes). The same experiment was done with switched on MP: in reception mode in emission mode without load and in emission mode with load suppressing EMF exposure.

The MP was held in the normal using position "Cheek position" (CENELEC Standard 50361) to have the maximal contact between the MP surface and the skin of the MP user (Figure 2). This position may modify heat exchange between the skin and the ambient air and make the MP and the antenna close to the head of the MP user.



**Figure 2:** Phone held by the hand in normal user position "Cheek position".

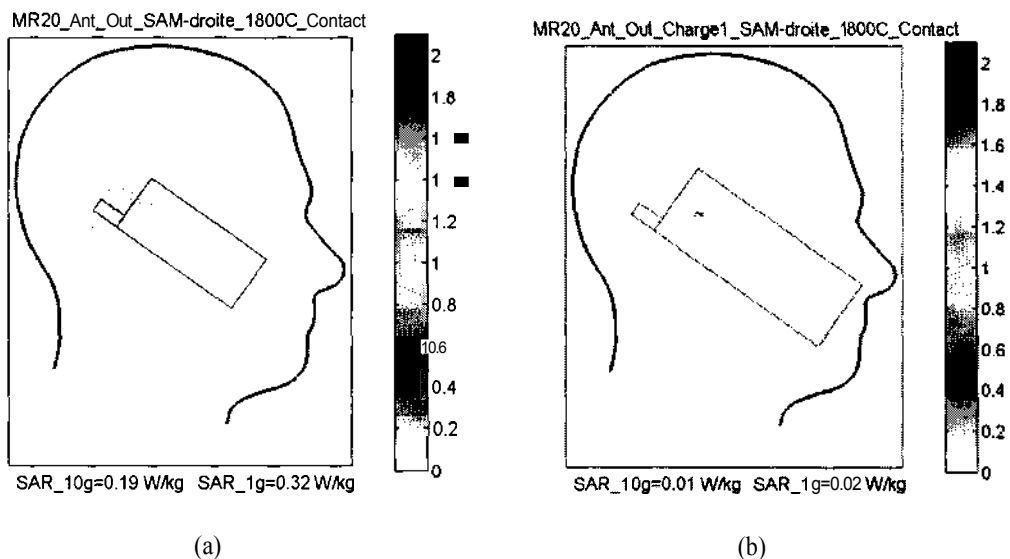
Three healthy male volunteers 25, 26 and 30 years old have participated for this study. For each trial 18 measurements were made to assess the repeatability of the measures. The mean values are given with one standard deviation ( $\pm 1$  SD). The difference between experimental conditions was computed by Student's *t*-tests. The *t*-values are given with their corresponding degrees of freedom (subscripts beneath *t*-values). The accepted level of significance was  $p < 0.05$ .

In all experiments, the mean value of ambient air temperature ( $T_{air}$ ) was  $23.0 \pm 0.8^\circ\text{C}$ , the relative humidity was  $50 \pm 10\%$ , the air flow rate in the room was  $0.01 \text{ m}\cdot\text{s}^{-1}$  (natural convection) and the MP was held in the normal position of use for at least 30 minutes to reach the thermal steady state.

## Results

### Load EMF suppress efficacy:

To test the efficacy of the EMF suppress by switching the RF signal from the antenna to a 50  $\Omega$  load the SAR of the MP was measured by the SAM phantom (Figure 3).



**Figure 3:** SAR measurements ( $\text{W}\cdot\text{kg}^{-1}$ ) averaged over tissue masses of 1 and 10 g using SAM phantom with mobile phone in emission mode without (a) and with load (b).

Using the MP connected to the load, the maximal value of SAR ( $SAR_{10\text{ g max}} = 0.01\text{ W.kg}^{-1}$ ;  $SAR_{1\text{ g max}} = 0.02\text{ W.kg}^{-1}$ ) was 15 to 19 times less when compared to the SAR using the MP without load ( $SAR_{10\text{ g max}} = 0.19\text{ W.kg}^{-1}$ ;  $SAR_{1\text{ g max}} = 0.32\text{ W.kg}^{-1}$ ). A commonly accepted SAR limit is:  $SAR_{10\text{ g max}} = 2\text{ W.kg}^{-1}$ .

We can conclude that using this load is efficient to suppress the head EMF exposure from the MP antenna. This load can then be used in this study for testing the possible EMF effect on the heat sensation and skin temperature increase on the cheek.

### Temperature measurements:

Temperature is recorded until equilibrium was reached around 30 min after the beginning of the experiment. The mean value of temperature measurement concerns the steady state period.

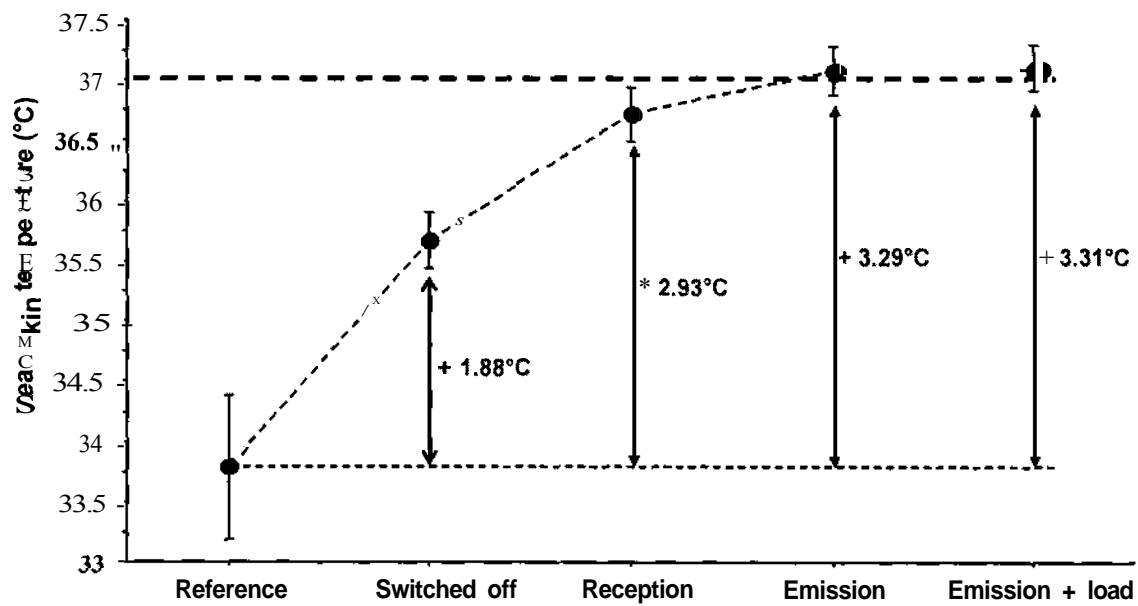
The initial mean skin temperature ( $T_{\text{skin}}$ ) of volunteers at normal room temperature ( $23.0 \pm 0.8^\circ\text{C}$ ) was  $33.8 \pm 0.6^\circ\text{C}$  (reference). The study of the raise in skin temperature due to the physical contact with the phone showed that the equilibrium temperature at the 'skin-phone' interface was  $35.7 \pm 0.2^\circ\text{C}$ . This was due to the decrease of the skin heat loss with the environment (Table 1). The mobile phone contact causes heat insulation of the skin surface. The temperature increase is equal to  $+1.88^\circ\text{C}$  (Figure 4).

The mobile phone temperature -as the skin temperature- increases when the MP is in contact with the skin surface. The skin and the phone sensor were face to face and give the same value at thermal equilibrium at skin-phone interface.

**Table 1:** Equilibrium mean values ( $\pm 1\text{ SD}$ ) 'n= 18' of air temperature ( $T_{\text{air}}$ ,  $^\circ\text{C}$ ), skin temperature ( $T_{\text{skin}}$ ,  $^\circ\text{C}$ ) and mobile phone surface temperature ( $T_{\text{mp}}$ ,  $^\circ\text{C}$ ), in the different experimental conditions (reference, skin-phone interface: MP switched off, switched on in reception mode, in emission mode without load, in emission mode with load).

	Experimental conditions				
	Reference	Skin-phone interface			
		Switched off	Reception	Emission	Emission + load
$T_{\text{air}}\text{ (}^\circ\text{C)}$	$22.6 \pm 0.7$	$22.9 \pm 0.8$	$23.1 \pm 0.7$	$23.2 \pm 0.8$	$23.4 \pm 0.7$
$T_{\text{skin}}\text{ (}^\circ\text{C)}$	$33.8 \pm 0.6$	$35.7 \pm 0.2$	$36.7 \pm 0.2$	$37.1 \pm 0.2$	$37.1 \pm 0.2$
$T_{\text{mp}}\text{ (}^\circ\text{C)}$	$22.8 \pm 0.8$	$35.3 \pm 0.4$	$36.7 \pm 0.2$	$37.2 \pm 0.20$	$37.4 \pm 0.2$

When MP was switched on, the increase in skin temperature from the initial value was  $2.93^\circ\text{C}$  in reception mode,  $3.29^\circ\text{C}$  in emission mode without load and  $3.31^\circ\text{C}$  in emission mode with load.

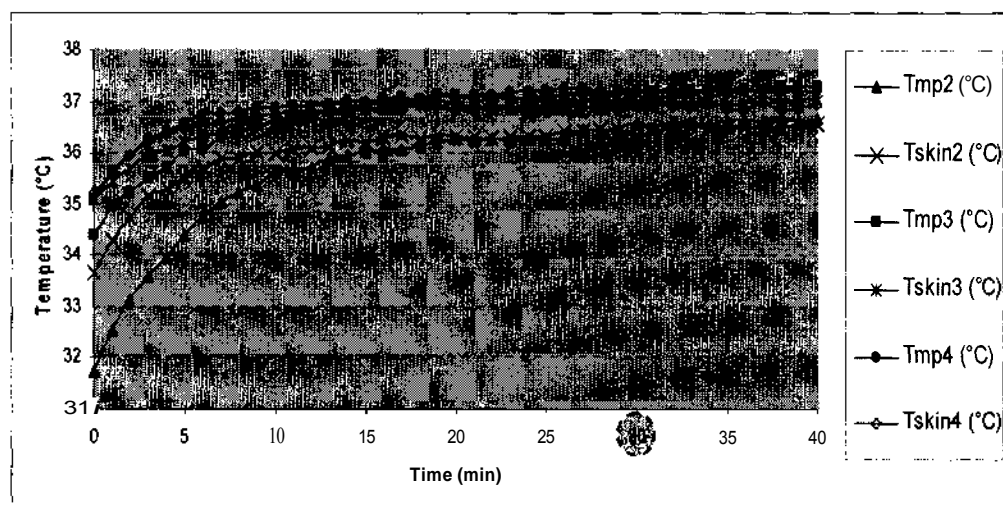


**Figure 4:** Mean skin temperature increase at thermal equilibrium in contact with mobile phone (switched off, switched on in reception mode, in emission mode without load, in emission mode with load) compared to the initial temperature of the skin surface (reference) without mobile phone skin contact.

The skin temperature difference between the mobile phone switched on in emission mode with or without load experimental condition was not significant ( $t_{17} = 0.707$ ;  $p = 0.489$ ). There is no significant supplemental skin heating due to RF emission from the MP antenna, which means that the contribution of EMF absorption to skin heating is negligible.

**Temperature increase at skin-phone interface and thermal equilibrium:**

An example of the kinetics of the raise in temperature at the skin-telephone interface is presented in Figure 5. To reach the skin-phone interface thermal equilibrium we must wait at less 30 min. The calling time is an important parameter for heat sensation and discomfort feeling. More important is the time calling with MP skin contact more is the prevalence of warmth sensation.



**Figure 5:** Skin ( $T_{skin}$ , °C) and mobile phone temperature ( $T_{mp}$ , °C) plotted against time (min), with MP switched on in reception mode (2), in emission mode without load (3) and with load (4) during one experiment. Thermal equilibrium was reached around 30 min.

### **Pain threshold:**

The highest temperature increases detected during these experiments ( $T_{\text{skin}} = 37.1^{\circ}\text{C}$ ) are in the environmental range and are experienced by the surface skin during hot summer days. No skin damage by thermal insult is experienced for  $T_{\text{skin}} < 44^{\circ}\text{C}$  [5], whereby a pain sensation replaces the feeling of temperature elevation in humans. No thermal skin damage can be suspected using MP in normal use.

### **Conclusions**

The results show that the heat sensations reported by the MP users are exclusively caused by thermal insulation and heat conduction from MP associated with long calling time. The power of EMF emitted by the MP antenna is not sufficient to cause increase in cheek skin temperature when using MP. These results suggest an awareness of the symptoms, but no damaging health problem.

### **Acknowledgements**

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### **Appendix**

MP: Mobile Phone  
EMF: Electromagnetic Field  
RF: Radiofrequency  
GSM: Global System for Mobile Communications  
SAR: Specific Absorption Rate  
 $T_{\text{air}}$ : mean air temperature  
 $T_{\text{skin}}$ : mean skin temperature  
SAM: Specific Anthropomorphic Manikin  
CENELEC: European Committee for Electrotechnical Standardization