

No Effect of Mobile Phone-Like RF Exposure on Patients With Atopic Dermatitis

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This study investigates the effect of exposure to a mobile phone-like radiofrequency (RF) electromagnetic field on people with atopic dermatitis (AD). Fifteen subjects with AD were recruited and matched with 15 controls without AD. The subjects were exposed for 30 min to an RF field at 1 W/kg via an indoor base station antenna attached to a 900 MHz GSM mobile phone. Blood samples for ELISA analysis of the concentration of substance P (SP), tumor necrosis factor receptor 1 (TNF R1), and brain derived neurotrophic factor (BDNF) in serum were drawn before and after the provocation (exposure/sham). Baseline heart rate and heart rate variability, local blood flow, and electrodermal activity were also recorded. No significant differences between the subject groups were found for baseline neurophysiological data. The cases displayed a serum concentration of TNF R1 significantly higher than the control subjects and a significantly lower serum concentration of BDNF in the baseline condition. For SP there was no difference between groups. However, no effects related to RF exposure condition were encountered for any of the measured substances. As to symptoms, a possible correlation with exposure could not be evaluated, due to too few symptom reports. The result of the study does not support the hypothesis of an effect of mobile phone-like RF exposure on serum levels of SP, TNF R1, and BDNF in persons with AD. *Bioelectromagnetics*, 2008.

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INTRODUCTION

The question whether the exposure to radiofrequency (RF) fields from mobile phones may give rise to symptoms has been subject to debate. Epidemiological studies report that some persons experience symptoms that they relate to their use of mobile phones (MPs), among which headaches and skin symptoms such as burning sensations in the facial skin and warmth sensations on and around the ear are the most common [Sandström et al., 2001; Seitz et al., 2005]. However, it has been impossible to establish a causal relationship between exposure and symptoms in provocation studies [Haarala et al., 2004; Rubin et al., 2005]. The question has been raised whether there are particularly sensitive people who may be affected by RF exposure at levels below the limits of internationally accepted guidelines [ICNIRP, 1998; EU, 2004; WHO, 2004].

Since skin symptoms are among the symptoms most commonly reported in relation to MP use, people with atopic dermatitis (AD) may constitute a group sensitive to MP exposure. AD is a common condition that usually begins in early childhood and is the result of

abnormal inflammatory processes in the skin. The inflammation is the result of a complex mechanism involving non-specific as well as specific immunological processes. Patients with AD often have allergic rhinitis, asthma or food allergies, and a family history of allergy. Dry skin is another common feature. When the itching is severe, scratching causes skin damage and entry of irritant substances and microbes into viable cell

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layers, where an inflammatory response is induced, further aggravating the dermatitis. The condition tends to improve with age, but a considerable proportion of people with childhood eczema have relapses in adult life and the tendency to dry skin usually persists [Leung et al., 2004].

In a Japanese study from 2002, enhanced skin wheal responses and increased plasma levels of the neuropeptides substance P (SP) and vasoactive intestinal peptide (VIP) were observed in subjects with AD [Kimata, 2002] after MP provocation. The substances investigated are known to be involved in inflammatory processes. SP has been shown to exert proinflammatory effects and to stimulate the release of other proinflammatory substances, such as the cytokine tumor necrosis factor alpha (TNF- α) [Collins, 1996; Cuesta et al., 2002], whereas VIP has anti-inflammatory effects and inhibits the production of TNF- α [Kim et al., 2000]. Proinflammatory cytokines—such as TNF- α —may increase the production of neurotrophins such as brain derived neurotrophic factor (BDNF) [Schulte-Herbrüggen et al., 2005]. Neurotrophins are important for the proliferation and growth of neurons [Linnarsson et al., 2000], and they are known to be involved in inflammatory processes [Halliday et al., 1998] as well as in wound healing and in the reparation of tissue damage caused by UV-radiation [Shi et al., 2003]. Neuropeptides also have trophic effects [Goll et al., 1994]. The levels of expression of SP and TNF- α are known to be affected by exposure to ionizing radiation, for example, radiotherapy [Forsgren et al., 2000]. Indications of an effect of non-ionizing radiation on the release of TNF- α and other cytokines have been reported [Chang et al., 2003], but results from other studies contradict this [Ikeda et al., 2003]. Non-ionizing radiation has also been shown to affect the concentration and activity of BDNF after sciatic nerve transection in the rat [Longo et al., 1999]. Interactions between SP, TNF- α , and BDNF have been demonstrated [Kim et al., 2000; Joachim et al., 2001; Bracci-Laudiero et al., 2002; Cuesta et al., 2002].

This study investigates whether the exposure to an isolated, pulsed RF field similar to that from a GSM mobile phone would affect symptoms or the levels in serum of SP, Tumor necrosis factor receptor 1 (TNF R1), or BDNF in subjects with AD. TNF R1 levels were analyzed instead of TNF- α because TNF R1 is more reliably measured in blood. To exclude potential effects of the extremely low frequency (ELF) field emitted by an ordinary MP and/or the differences in energy deposition between MP models, a controlled RF exposure system with a mobile phone-like RF signal emitted via indoor base station antennas was used.

METHODS

Subjects

Fifteen subjects with atopic dermatitis (AD) (eight males, seven females) were recruited from the Department of Dermatology at Umeå University Hospital. People with AD (according to the diagnostic criteria by Hanifin and Rajka [1980]) were consecutively asked whether they were allergic to birch pollen and if they were interested in taking part in the study. Consenting patients with confirmed allergy to birch pollen (history of rhino-conjunctivitis during birch pollen season and positive prick test or serology) were included. A study group selected on the basis of the phenotype (the presence of eczema) alone will be composed of a majority of subjects with atopy and a minority without atopy, and the subject groups may respond differently to provocation. Due to this, confirmed pollen allergy was used as a criterion to ensure a subject group consisting of truly atopic individuals only. This approach was also chosen by Kimata [2002] who used cedar pollen allergy as the selection criterion. In our study, however, we used birch pollen rather than cedar pollen because birch pollen is a more common allergen in Sweden. Fifteen control subjects without atopic disease, matched to the cases with respect to age and sex, were also recruited. The study was conducted according to the principles of the Declaration of Helsinki of the World Medical Association and the study protocols were approved by the Ethical Committee for research at Umeå University. Informed consent was obtained from all participants.

Experimental Procedure

For each subject, one provocation with sham exposure and one with true exposure was performed, in random order. The provocations were performed a week apart, at the same time of day—either a.m. or p.m. The matched pairs of case and control subjects were tested roughly at the same time of day (a.m. or p.m.), which was the closest time correspondence achievable. The experiments were performed for approximately 6 months with a 3-month break during the pollen season. The subjects were reimbursed for their participation (Fig. 1).

After an introduction to the experiment, a pre-exposure blood sample for the ELISA analyses was collected (see “ELISA analyses”). Electrodes and sensors for the registration of base line physiological parameters (see “Physiological measurements”) were attached and the subject was left alone in the exposure chamber for a 10-min adaptation period. After the adaptation period, the antennas were correctly positioned and the subject was exposed/sham exposed for

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Adaptation	Blood sample 1	Exposure/Sham	Blood sample 2
10 min		30 min	

Fig. 1. Schematic drawing of the experimental procedure during Days 1 and 2.

30 min, during which time a film was shown on an LCD computer screen ("The Blue Planet", BBC). The exposure condition (on/off) was assigned randomly by the responsible technician and was not known by the experimenter or the subjects. It was not possible to keep the study completely double blind because the physiological recordings were distorted by the RF signal during exposure in a mode clearly visible to the experimenter. However, there were no cues—for example, visible, auditory, or vibratory—through which the subjects could detect the exposure conditions. A second (post-exposure) blood sample was collected immediately after the provocation.

Exposure

The RF signal was generated by a test GSM 900 MP (Ericsson GH 337, DC power supply Mascot 719) and emitted via indoor base station antennas (Allgon 7336) to expose the whole area where ordinary MPs are likely to deposit the RF energy. The signal was amplified (Ophir 5802064) and fed to a power attenuator unit (Radiall attenuator, -30 dB). From there, it was directed to a power divider (MCLI CI-20), allowing it to reach a power meter (HP 437B) and the left or right antenna or a dummy load (Thermaline 8080; 25 W, 50 W) via a remotely controlled selector. A schematic circuit diagram is shown in Figure 2. The frequency of the signal was 890 MHz, with pulse repetition time of 4.61 ms (217 Hz) and a pulse duration of 0.577 ms. The DTX function was turned off during the provocation (for further details on the exposure system, see Wilén et al. [2006]).

The provocation experiments were performed in a specially designed exposure chamber in which background levels of both power frequency and radio frequency fields were low enough to be considered negligible. The subjects were seated in a semi-reclining chair in front of an LCD computer screen and the two antennas were mounted on each side of the chair, on an adjustable wooden framework. The antennas were placed one on each side of the subject's head at a distance of 8.5 cm and the head was positioned between two wooden bars to ensure a well-defined location during the provocation (exposure/sham). RF exposure was applied from the right side only. The exposure set up was adjusted to give a rather homogenous SAR distribution in the parietal area of the head with a $SAR_{1g} = 1.0$ W/kg as measured with a DASY 3 system at AMC Centurion AB, Åkersberga, Sweden (for details on the SAR distribution, see Wilén et al. [2006]). The exposure was kept below the limits of internationally accepted guidelines of 2 W/kg [ICNIRP, 1998].

Questionnaires

The subjects were asked about, for example, health status, work situation, MP use, symptoms experienced in general, and symptoms that occurred or were aggravated in connection with the use of a MP or in connection with visual display terminal (VDT) work by a questionnaire. An individual was defined as having one of the following symptoms if the symptom occurred at least once a week: *dizziness, feelings of discomfort, difficulties concentrating, memory loss, unusual fatigue, headaches, sensations of warmth*

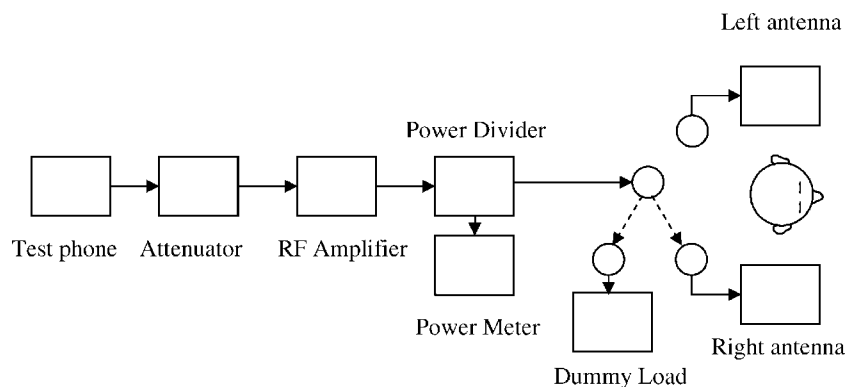


Fig. 2. Circuit diagram of the exposure system.

behind/around the ear, sensations of warmth on the ear, burning sensations in the facial skin, tingling/tightness in the facial skin, sleep disturbances, numbness, tinnitus, itching in the face/on the trunk/on the arms/on the hands/on the legs, eczema in the face/on the trunk/on the arms/on the hands/on the legs, and other symptoms. The list of symptoms was based on earlier studies on MP-related symptoms [Hansson Mild et al., 1998] with addition of typical AD symptoms.

The Swedish AMY classification of occupations (which is based on ISCO-88) was used to classify different occupations into four categories—*management, professional, intermediate* and *other*—to enable comparison between the subject groups [Arbetsmarknadsstyrelsen, 1996]. To estimate the psychosocial workload of a subject, an index was computed based on four commonly used questions related to workload, influence on working conditions, support from colleagues, and whether the work was experienced as stimulating and interesting [Hansson Mild et al., 1998]. A follow-up questionnaire was handed out after each session (real/sham provocation) to record symptoms perceived during or after the provocation and the subject's experience of the experimental situation.

Physiological Measurements

To estimate the subject's stress level, heart rate, heart rate variability (HRV), local blood flow, and electrodermal activity (EDA) of the subjects were recorded during the initial 10 min of each session (adaptation) using a method used in previous studies [Lyskov et al., 2001; Wilén et al., 2006]. This test battery may be used to describe the activity of the autonomic nervous system and to evaluate the level of acute stress [The European Society of Cardiology and The North American Society of Pacing and Electrophysiology, 1996]. The data recorded during adaptation were considered as resting values (relaxed state) and later used for comparing the baseline physiological characteristics of cases and controls. All variables were amplified and recorded using an MP100 data acquisition unit (Biopac Systems, Inc., Goleta, CA) and analyzed using ACQKnowledge III (Biopac Systems, Inc.) and Matlab 6.0 (Mathworks, Inc., Natick, MA) software. The variables were continuously recorded during the experiment.

The heart rate was recorded using standard ECG electrodes placed on the chest and on the forearm and elbow (reference) of the left arm. The HRV recordings were digitalized, visually inspected for artifacts, and analyzed both in the time domain and in the frequency domain. The power spectral analysis was performed by Fast Fourier Transformation, using standard ranges for the very low (VLF), low (LF), and high frequency (HF)

bands ($VLF \leq 0.04 \text{ Hz} < LF \leq 0.15 \text{ Hz} < HF \leq 0.4 \text{ Hz}$) [The European Society of Cardiology and The North American Society of Pacing and Electrophysiology, 1996]. The normalized power in the LF and HF bands was computed ($LF_n = LF / (\text{Total power} - VLF) \times 100$; $HF_n = HF / (\text{Total power} - VLF) \times 100$) as well as the LF/HF-ratio.

ELISA Analyses

The blood samples were centrifuged for 10 min and the sera were frozen and stored at -80°C until assay. Because the TNF receptor TNF R1 is reliably measured in blood, the levels of TNF R1 were analyzed instead of TNF- α levels. TNF R1 levels were measured using a Human Quantikine TNF R1 kit (R&D Systems, Wiesbaden-Nordenstadt, Germany), with a minimum detectable level of 0.77 pg/ml, $\pm < 5\%$. The serum levels of BDNF were measured with a ChemiKine BDNF Sandwich Elisa Kit (Chemicon International, Inc., Temecula, CA) with a minimum detectable level of 7.8 pg/ml, $\pm < 4\%$. The levels of SP were measured using a substance P Enzyme Immunoassay kit (Phoenix Pharmaceuticals Inc., Belmont, CA), with a minimum detectable level of 0.04 ng/ml, $\pm < 5\%$.

Statistical Analysis

The statistical processing and analysis were performed using SPSS 11.0 for Windows (SPSS, Inc., Chicago, IL). All variables were normally distributed (Kolmogorov-Smirnov test, $P > 0.05$) except SP serum levels. However, after logarithmic transformation, they too satisfied the criterion of normal distribution. Therefore, the transformed SP values were used for the statistical analysis, but the results are presented in original units for ease of understanding.

The effects of exposure on serum concentrations were evaluated using a multivariate repeated-measures analysis of variance with exposure (exposure, sham) as within-subjects variable, and sequence of exposure (exposure first, exposure last) and group (case, control) as between-subjects variables. The significance level was set at 0.05. Differences between cases and controls regarding experience of symptoms during exposure/sham could not be evaluated statistically because too few symptoms were reported.

RESULTS

A description of the subjects is given in Table 1. Case subjects reported more symptoms not related to MP or VDT than controls (average number of symptoms reported, cases: 4.6, SD: 3.7; average, controls: 0.5, SD: 0.8). Five cases reported experiencing 0–3 symptoms at least once a week, six reported 4–6

TABLE 1. Description of Subjects

	Case (n = 15)	Control (n = 15)
Age (mean + SD)	30.5 (9.7)	28.9 (9.3)
Sex		
Male	8	8
Female	7	7
Smoking		
Yes	2	1
No	13	14
Exercise		
Yes	10	13
No	5	2
Exercise activity		
0–2 times/week	1	0
3–4 times/week	7	10
>4 times/week	7	5
Clinically diagnosed headaches		
Yes	3	2
No	12	13
Occupation		
Management	0	0
Professional	11	8
Intermediate	1	1
Other	3	5
Employment ^a		
Full time	11	11
Part time	2	4
Unemployed	1	1
VDT-work ^a		
None	2	4
<1 h/day	5	2
1–4 h/day	5	3
>4 h/day	2	4
MP use ^a		
Yes	13	13
No	1	0
Number of calls/day		
<2 calls/day	2	4
2–4 calls/day	7	7
5–8 calls/day	3	0
>9 calls/day	1	2
Calling time/day		
<2 min/day	1	2
2–15 min/day	8	7
15–60 min/day	4	4
>60 min/day	0	0
Use of hands-free equipment		
Yes	4	4
No	9	9
Index of psychosocial workload ^a		
Low	3	3
Medium	10	6
High	1	2
Work capability (self-assessed) ^a		
Good	12	12
Moderate	3	0
Not so good	0	0

^aMissing values.

TABLE 2. Symptoms Reported at Least Once a Week (Not Related to the Use of MP or VDT)

	Case (n = 15)	Control (n = 15)
Feelings of discomfort	1	0
Difficulties concentrating	3	0
Memory loss	2	0
Fatigue	3	1
Headaches	2	2
Sensations of warmth behind/around/on the ear	1	1
Burning sensations/tingling/tightness in the facial skin	4	0
Sleep disturbances	2	1
Tinnitus	2	1
Itching face	7	0
Itching trunk/arms/hands/legs/feet	10	0
Eczema in the face	6	0
Eczema on the trunk/arms/hand/legs/feet	8	0
Other symptoms	0	2
Sum	51	8

No subjects reported dizziness or numbness.

symptoms, and four reported more than six symptoms. In the control group, no subject reported experiencing more than three symptoms. Skin symptoms—such as burning sensations or tingling/tightness of the facial skin, itching, and eczema—were the symptoms most frequently reported (Table 2). None of the subjects reported dizziness or numbness. There was no significant difference regarding number of symptoms related to the use of MP and/or VDT (average number of MP- or VDT-related symptoms, cases: 1.3, SD: 2.2; average controls: 1.1, SD: 1.6). However, the controls reported sensations of warmth on and around the ear in connection with MP use to a greater extent than did the cases. The most common symptoms were sensations of warmth on or around the ear in connection with MP use and headaches and burning sensations in the facial skin with VDT use (Table 3). Dizziness, memory loss, tinnitus, or itching trunk/arms/hands were not reported

as related to MP or VDT use. Some of those experiencing symptoms had taken measures to reduce the symptoms, mainly reduction of VDT use, reduction of MP use, and/or use of hands-free equipment. No significant differences between the subject groups in baseline heart rate, HRV, blood flow, or EDA were encountered (Table 4).

Nine out of 13 cases and 4 out of 15 controls reported symptoms during or after the experiment on any day (Table 5). Both the cases and controls reported more symptoms on the day with true exposure than on the day with sham exposure; however, the number of symptoms was not sufficient for a statistical evaluation of the relation between experienced symptoms and exposure condition. The most common symptoms were fatigue, headache, and itching and burning sensations of the facial skin. Skin symptoms were mainly reported by the cases. Two of the 15 cases were excluded from this

TABLE 3. Symptoms Related to the Use of MP or VDT

	Case (n = 15)			Control (n = 15)		
	None	MP	VDT	None	MP	VDT
Feelings of discomfort	14	1	0	13	1	1
Difficulties concentrating	14	0	1	14	0	1
Fatigue	13	0	2	14	0	1
Headaches	12	1	2	14	0	1
Sensations of warmth behind/around/on the ear	12	2	1	9	6	0
Burning sensations/tingling/tightness in the facial skin	14	0	1	12	1	2
Sleep disturbances	15	0	0	14	0	1
Numbness	14	0	1	14	0	0
Itching face	13	1	1	15	0	0

No subjects reported dizziness, memory loss, tinnitus, itching trunk/arms/hands, or eczema related to MP or VDT use.

TABLE 4. Mean Values and Standard Deviation (in Brackets) of Heart Rate (Beats/min), Normalized Low and High Frequency Power (LFn, HFn), Low Frequency/High Frequency Ratio (LF/HF), and Electrodermal Activity (EDA; Peaks/min, Only Left Hand Shown) in the Baseline Condition (Sampled Before Exposure on Day 1)

	Case (n = 15)	Control (n = 15)	<i>P</i> *
HR	74 (6)	71 (10)	n.s.
LFn	0.54 (0.14)	0.49 (0.17)	n.s.
HFn	0.25 (0.10)	0.27 (0.11)	n.s.
LF/HF	3.5 (4.1)	3.0 (3.1)	n.s.
EDA (left)	2.3 (2.0)	2.3 (1.4)	n.s.

**P* values from MANOVA.

analysis because they did not return the follow-up questionnaire for both sessions. Four subjects (3 cases, 1 control) reported feeling stressed or anxious during the experiment. This was not related to exposure condition.

Cases displayed significantly higher serum concentrations of TNF R1 and significantly lower concentrations of BDNF in the baseline condition (sampling before exposure/sham exposure on day 1), differences that remained throughout the experiment (Table 6). There was a tendency toward a lower SP concentration in the case group, but the difference was not significant. No effect of RF exposure was found for any of the examined substances (Table 7), and there were no significant differences between subjects receiving true exposure on day 1 and those receiving true exposure on day 2. A tendency towards decreasing levels during the test session, regardless of exposure condition, was observed for all substances among controls, but not among cases (no significant differences between groups).

DISCUSSION

As expected, the cases reported more symptoms than the controls, both generally and in the test situation. However, not enough symptoms were reported to statistically evaluate a possible correlation between symptoms and exposure condition. This agrees

with clinical experience that individuals with AD do not report symptoms related to MP use to any greater extent than individuals without AD. There is, to our knowledge, no study investigating the relation of MP-related symptoms and AD, but it has been reported that individuals with AD do not exhibit VDT-related symptoms more frequently than individuals without AD [Stenberg et al., 2002].

The analysis of the baseline physiological recordings revealed no significant differences between the subject groups. The recorded values agree with values from similar examinations [Wilén et al., 2006]. This and the fact that only four subjects reported feeling stress or anxiety during the experiment indicates that there was no difference between cases and controls with respect to the level of acute stress.

A baseline difference in serum levels of TNF R1 and BDNF was encountered between the study groups. Differences are to be expected because all three substances are known to be involved in inflammation. The levels of SP in control subjects corresponded to a great extent with serum levels that have previously been reported for human subjects [Grimsholm et al., 2005]. The levels of TNF R1 were in the normal range for cases as well as for controls according to the information given by the ELISA kit manufacturer and correspond to previously obtained values [Grimsholm et al., 2005]. As to the concentration of BDNF, we have noted somewhat higher values in other studies (unpublished observations). Nevertheless, it can be concluded that the levels for all the factors analyzed are within reasonable levels. All of the analyses were performed on serum, not on plasma, as was the case in the Japanese study, since results from serum analysis have been found more reliable in other projects of our laboratory. Levels of the factors analyzed here probably reflect normal conditions for this skin disease. The subjects were not randomly selected and might not be representative of people with AD, especially as the sample size is small. However, the AD group only included subjects with the atopic genotype, as was the case in the study by Kimata [2002], and the sample size would have been large

TABLE 5. Number of Subjects Reporting Symptoms During/After Experiment on Exposure Day, Sham Day or Both Days or None of the Days

	Case (n = 13)	Control (n = 15)
Exposure day	5	3
Sham day	3	0
Both days	1	1
None	4	11

Those who never reported any symptoms are presented as "none." Two cases were excluded due to not returning follow-up questionnaires for both sessions.

TABLE 6. Baseline Values of SP, TNF R1, and BDNF (Sampled Before Exposure/Sham Exposure on Day 1)

	Case (n = 15)		Control (n = 15)		<i>P</i> *
	Mean (ng/ml)	SD	Mean (ng/ml)	SD	
SP	0.22	0.11	0.44	0.73	0.22**
TNF R1	1.46	0.42	1.15	0.28	0.026
BDNF	21	6.3	32	9.9	0.001

**P* values from ANOVA.

***P* values from analysis of transformed values.

enough to detect changes in serum levels in the range of those reported by Kimata [2002] with a statistical power >80%.

In contrast to the study by Kimata [2002], where a GSM mobile phone attached to the subject's neck was used as the exposure source, the RF exposure used in our study was generated by a hand-held MP, but emitted via indoor base station antennas. This exposure set-up was chosen to obtain the greatest possible control of the exposure, since the energy deposition in the head during a MP call is known to differ between different MPs due to differences in antenna configuration [Wilén et al., 2003]. The GSM system also provides a battery saving function and can change the repetition frequency to 2 Hz when the user is just listening. If the user listens as much as he/she talks, this will in practice reduce the output power to half of the maximum [Hansson Mild et al., 1998]. In our study, this function was turned off during the experiment. Moreover, there is an ELF field present around an ordinary MP [Linde and Hansson Mild, 1997]. With the exposure set up used in this study only a pulsed RF field is present, and the SAR distribution (1 W/kg) is even over a large area of the head. The information about the exposure given in the Japanese study is limited.

In our study, the order of sham and true exposure was randomized to reduce possible expectancy effects. In Kimata's [2002] study, the order of the exposure conditions was the same for all subjects, with the exposure always during the first experimental session.

In conclusion, the results from our study do not support the hypothesis that exposure to mobile phone-like RF fields affects the levels of SP, TNF R1, or BDNF in serum in persons with AD, whereas the hypothesis that exposure to mobile phone-like RF fields might provoke symptoms could not be evaluated, due to too few reported symptoms.

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TABLE 7. Mean Values and Standard Deviations (in Brackets) of SP, TNF R1 and BDNF Before and After Provocation

	Case (n = 15)				Control (n = 15)			
	Sham		Exposure		Sham		Exposure	
	Before	After	Before	After	Before	After	Before	After
SP (ng/ml)	0.22 (0.11)	0.23 (0.12)	0.25 (0.16)	0.27 (0.20)	0.44 (0.73)	0.32 (0.29)	0.39 (0.52)	0.30 (0.37)
TNF R1 (ng/ml)	1.40 (0.35)	1.25 (0.37)	1.46 (0.42)	1.33 (0.34)	1.12 (0.24)	1.00 (0.31)	1.15 (0.28)	1.08 (0.34)
BDNF (ng/ml)	21.4 (6.3)	22.4 (8.2)	22.7 (7.7)	20.5 (8.1)	32.3 (9.9)	28.8 (8.3)	29.2 (8.5)	26.8 (7.5)
<i>P</i> values								
	Group	Exp/sham	Exp/sham × group					
SP	0.91*	0.11*	0.27*					
TNF R1	0.049	0.18	0.40					
BDNF	0.10	0.13	0.15					

P values from Repeated Measures ANOVA.

**P* values from analysis of transformed values.

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