

# Impact of 5G Mobile Phone Exposure on EEG and Heart Rate Variability (HRV)

## Client

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„Quantum Upgrade®“

Study was conducted from 16/12-19/12/2024

## iPhone 15 Pro

IMEI1: 35 857131 564276 7

IMEI2: 35 857131 471142 3

Handover of the study on 13 January 2025



# 1. Summary

Current scientific studies show a systematic effect of electromagnetic radiation emitted by mobile communications on the human brain and the cardiovascular system. The present study tested whether the Quantum Upgrade® intervention mitigates the effects of 5G mobile phone exposure on the brain and cardiovascular system. For this purpose, N = 10 subjects were tested during a 30-minute 5G cell phone call with the Apple iPhone 15 Pro. The smartphone was placed on a tripod at a distance of 1.0 cm from the left ear of the test subjects.

The study followed a randomized experimental design with three conditions:

1. Baseline measurement (no mobile phone exposure)
2. 5G exposure with Quantum Upgrade®
3. 5G exposure without Quantum Upgrade®

A high-density electroencephalogram (EEG) for recording electrical brain activity was recorded from 256 electrodes attached to the surface of the head according to the international 10/5 system. Heart rate variability (HRV) was recorded via an electrocardiogram (ECG) with recording from seven electrodes. The power densities for the theta, alpha, beta and gamma frequency bands were determined for the EEG data. In a further step, the activation sources in the brain were calculated. In the HRV analysis, the parameters mean HR, SDNN, SDANN, RMSSD, pNN50, HF, LF, LF/HF ratio, VLF and total power were determined.

The results of the EEG measurements show a significant increase in EEG beta and gamma activity in the frontal, central, temporal, parietal and occipital brain areas as well as in the limbic system with a significant reduction in EEG theta and alpha activity during 5G mobile phone exposure with the iPhone 15 Pro. In HRV, there is a significant reduction in the time-related HRV parameters SDNN, SDANN, RMSSD, pNN50, HF, LF and LF/HF ratio under 5G mobile phone exposure compared to the baseline measurement without EMF exposure. When using the Quantum Upgrade® during the 5G cell phone call with the iPhone 15 Pro, the EEG parameters beta and gamma activity in the central, temporal, parietal and occipital brain areas as well as in the limbic system are significantly reduced compared to the iPhone 15 Pro test condition without Quantum Upgrade®, EEG theta activity in the central and occipital brain areas as well as in the limbic system and EEG alpha activity in the central, temporal, parietal and occipital brain areas as well as in the limbic system significantly increased. During the 5G phone call with the iPhone 15 Pro without Quantum Upgrade®, the HRV parameters SDNN, SDANN, RMSSD, pNN50, HF and LF/HF ratio are significantly reduced compared to the baseline measurement without 5G mobile phone exposure. The HRV parameters SDNN, SDANN, RMSSD, pNN50, HF and LF/HF ratio are at comparable levels when using the Quantum Upgrade® during the 5G phone call with the iPhone 15 Pro.



## 2. Research Method

In the present study, ten subjects (nine of whom were male; average age 60.1 years; age range 35-78 years) were tested. The electroencephalogram (EEG) testing took place in a seated position over a period of 30 minutes per experimental condition. The smartphone was positioned 1.0 cm from the left ear in each experimental condition. After a 10-minute baseline measurement without mobile phone exposure, the iPhone 15 Pro smartphone (manufacturer: Apple, Cupertino, CA, USA) was switched on for 30 minutes in 5G mode. In a second test condition, the Quantum Upgrade® (manufacturer: Quantum Upgrade®, USA) was switched on via app and the iPhone 15 Pro was tested for 30 minutes in 5G mode. The test conditions were randomized across participants to eliminate sequence effects. Electrical brain activity was recorded using a mobile ultra-high-density EEG (ANT neuro) from 256 electrodes attached to the head surface according to the international 10/5 system with a readout rate of 512 Hz. The electrooculographic (vertical and horizontal eye movements) and electromyographic (muscular potentials) data were recorded as control variables from two electrodes each with a readout rate of 512 Hz.

In addition, heart rate variability (HRV) was recorded from seven electrodes using the medilog® AR mobile ECG system (manufacturer: Schiller Medizintechnik GmbH, Feldkirchen, Germany). After removing electrooculographic (EOG) and electromyographic (EMG) artifacts, EEG data underwent Fast Fourier Transformation (FFT), followed by frequency-specific analysis of the theta (3.5-7.5 Hz), alpha (8.0-12.5 Hz), beta (13.0-30.0 Hz), and gamma (31.0-100.0 Hz) bands. The individual frequency bands indicate different psychophysiological states of alertness and activation (relaxation/fatigue/stress etc.) of the brain and show specific frequency changes during 5G exposure. In a further step, the EEG activation sources were localized, which can be used to make statements about the origin of the EEG signal measured on the head surface. For the ECG data, after artifact correction, an analysis was performed to determine the mean heart rate (HR) and the HRV parameters standard deviation of the NN interval (SDNN), standard deviation of the mean value of the NN intervals in all 5-minute intervals (SDANN), Root mean sum of squared distance (RMSSD), percentage of intervals with at least 50 ms deviation from the preceding interval (pNN50), low frequency (LF), high frequency (HF), ratio of low frequency and high frequency (LF/HF ratio), very low frequency (VLF), total power (TP).

The EEG data of the power density spectra for the frequency bands theta, alpha, beta and gamma were subjected to inferential statistical procedures. For this purpose, repeated measures analyses of variance were performed for the experimental condition factor for each brain region (frontal, central, temporal, parietal, occipital, limbic system) and the effect sizes (partial Eta-squared  $\eta^2$ ) were calculated. For the HR and HRV parameters SDNN, SDANN, RMSSD, pNN50, LF, HF, LF/HF ratio, VLF, TP, analyses of variance with repeated measures were

also calculated for the experimental condition factor as well as the effect sizes (partial eta squared  $\eta^2$ ). A significance level of  $p = 0.05$  was set for all statistical tests.



## 3. Results

### 3.1 EEG

The results of the EEG measurements are shown in Figures 1-6 and Tables 1-4. The results of the EEG source activations in the brain show strong activations in the beta and gamma frequency spectrum during 5G exposure to the iPhone 15 Pro without using the Quantum Upgrade®, including in the deeper layers of the brain (especially the limbic system: hypothalamus, pineal gland, hippocampus) with a simultaneous reduction in EEG activity in the theta and alpha frequency bands. The activations in the beta and gamma bands began after just two to three minutes of exposure to 5G via the iPhone 15 Pro, and in four of the test subjects immediately at the start of 5G exposure. Six out of ten participants reported experiencing head pressure or headaches during the 5G phone call using the iPhone 15 Pro.

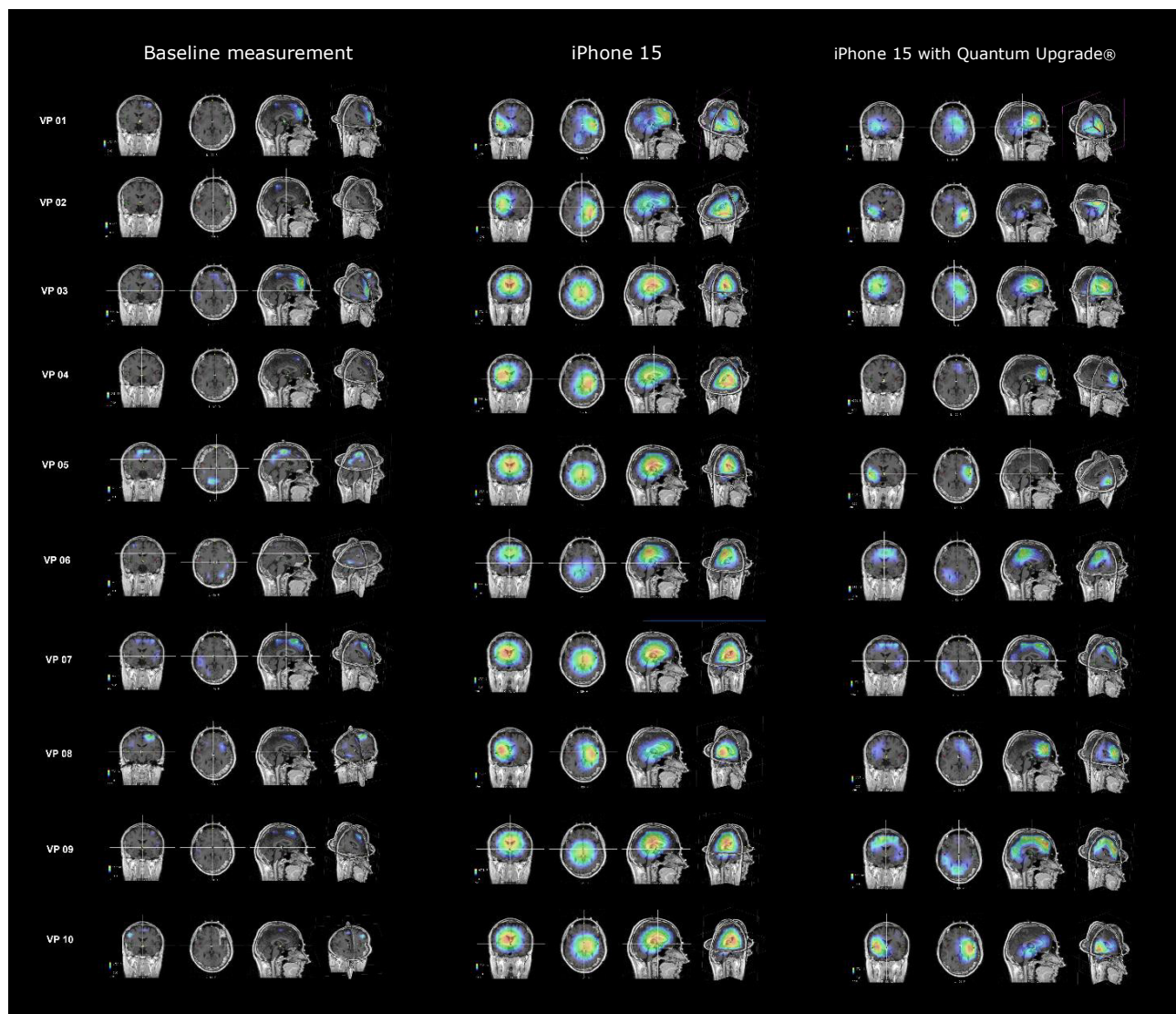
When using the Quantum Upgrade®, the stress activations in the beta and gamma bands caused by the 5G exposure decrease significantly with the onset of the intervention in the central, temporal, parietal and occipital brain areas as well as in the limbic system (see Fig. 1). At the same time, a statistically significant increase in alpha synchronization can be observed in the central, temporal, parietal and occipital brain areas as well as in the limbic system during 5G exposure to the iPhone 15 Pro with Quantum Upgrade® compared to the iPhone 15 Pro test condition without Quantum Upgrade® (see Fig. 2).

Inferential statistical analysis revealed significant effects of Quantum Upgrade® application compared to 5G exposure without Quantum Upgrade®, across theta, alpha, beta, and gamma frequency bands. The analysis of variance shows significant effects for the theta band [ $F(2, 28) = 3.96$ ;  $p = 0.04$ ;  $\eta^2 = 0.06$ ]. The post-hoc tests show significant changes in the theta band in the central ( $p = 0.04$ ) and occipital ( $p = 0.04$ ) brain areas as well as in the limbic system ( $p = 0.03$ ). Furthermore, the effects of using the Quantum Upgrade® are significant for the alpha band, [ $F(2, 28) = 5.18$ ;  $p = 0.02$ ;  $\eta^2 = 0.14$ ]. Post hoc tests show significant changes for the alpha band in the central ( $p = 0.03$ ), temporal ( $p = 0.02$ ), parietal ( $p = 0.02$ ) and occipital ( $p = 0.02$ ) areas of the brain as well as in the limbic system ( $p = 0.01$ ). For the beta band, the effects of using the Quantum Upgrade® are highly significant, [ $F(2, 28) = 5.69$ ;  $p = 0.01$ ;  $\eta^2 = 0.22$ ]. Post-hoc tests show highly significant effects for the central ( $p = 0.01$ ), temporal ( $p = 0.01$ ), parietal ( $p = 0.01$ ) and occipital ( $p = 0.01$ ) brain areas as well as in the limbic system ( $p = 0.009$ ). Highly significant effects of the Quantum Upgrade® were also shown for the gamma band [ $F(2, 28) = 5.83$ ;  $p = 0.01$ ;  $\eta^2 = 0.25$ ]. The post-hoc tests show changes in the central ( $p = 0.01$ ), temporal ( $p = 0.009$ ), parietal ( $p = 0.01$ ) and occipital brain areas ( $p = 0.01$ ) as well as for the limbic system ( $p = 0.009$ ). A detailed presentation of the inferential statistical testing can be found in Table 1-4.





The results of the present EEG measurements indicate an effect of the Quantum Upgrade® application, which significantly reduces the beta and gamma activations in the brain that occur during 5G exposure to the Apple iPhone 15 Pro in the central, temporal, parietal and occipital brain areas as well as in the limbic system and promotes alpha activity in the central, temporal, parietal and occipital brain areas as well as in the limbic system. Theta activation is also promoted by Quantum Upgrade® in the central and occipital areas of the brain and in the limbic system.



*Fig. 1:* EEG source activations in the baseline measurement without EMF exposure (left column), with 5G exposure via the iPhone 15 Pro (middle column) and with the Quantum Upgrade® applied during 5G exposure via the iPhone 15 Pro (right column). Red = very strong activation, blue = very low activation.

The results show very strong activation when exposed to 5G by the iPhone 15 Pro without using Quantum Upgrade®, especially in the deeper regions of the brain (limbic system).

When Quantum Upgrade® is used, there is a significant reduction in stress activation in the brain triggered by 5G exposure in the central, temporal, parietal and occipital areas of the brain as well as in the limbic system.



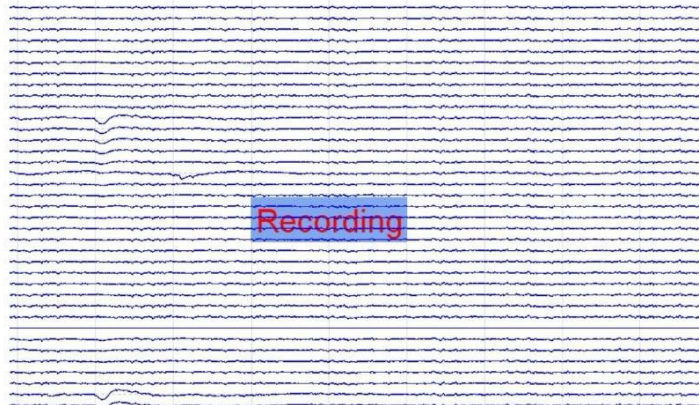
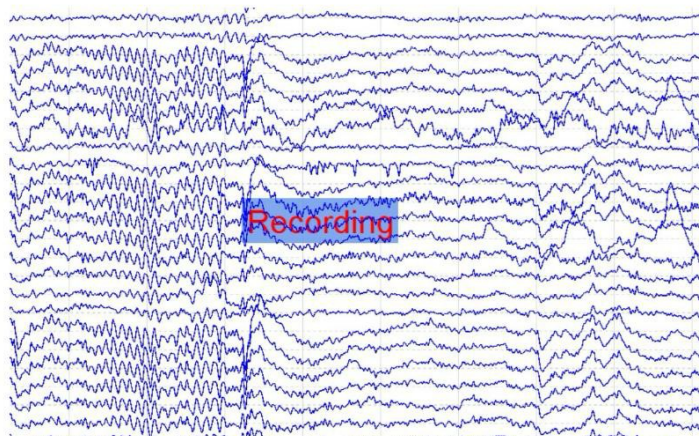
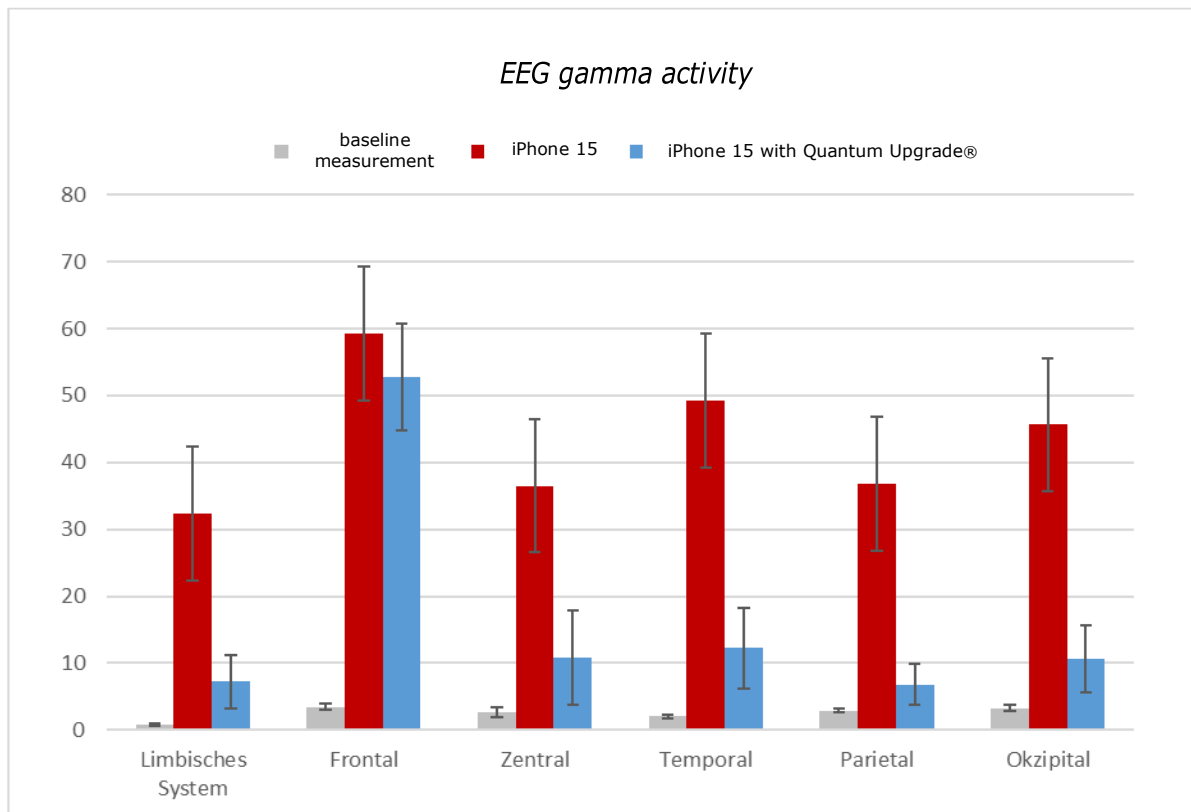
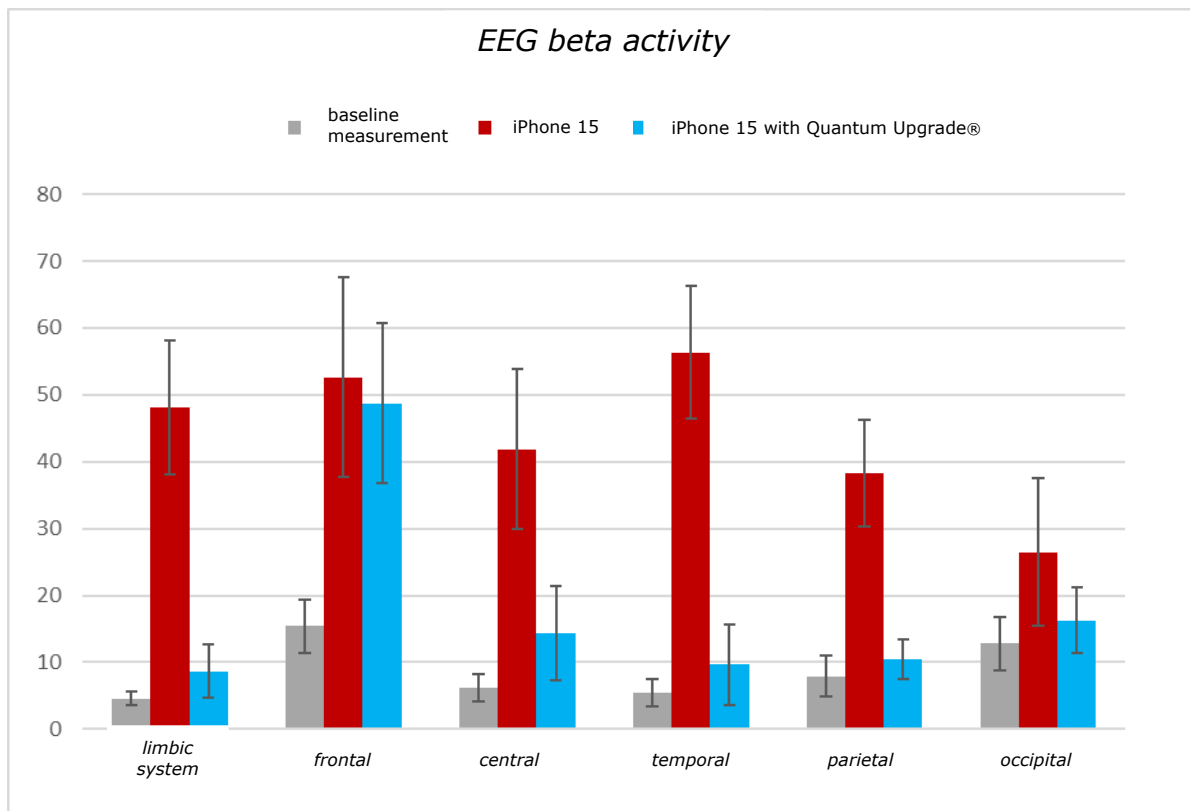
**iPhone 15 Call****iPhone 15 Call  
with Quantum  
Upgrade®**

Fig. 2. EEG alpha synchronization and increased frequency variability of the EEG signal by using the Quantum Upgrade® during a 5G phone call with the iPhone 15 Pro. EEG alpha synchronization is statistically significantly increased in the central, temporal, parietal and occipital brain areas as well as in the limbic system when using the iPhone 15 Pro with the Quantum Upgrade® compared to the iPhone 15 Pro test condition without the Quantum Upgrade® (see Table 3).



*Fig. 3 EEG gamma activity (mean values, standard deviations, in  $\mu V^2/Hz$ ) during the baseline measurement without mobile phone exposure, during a 30-minute 5G phone call with the iPhone 15 Pro and during the application of Quantum Upgrade® during the 5G phone call with the iPhone 15 Pro. The results show strong gamma activations during the 5G call without using Quantum Upgrade® in all tested brain areas.*

*When using the iPhone 15 Pro with the Quantum Upgrade®, the gamma activations in the central, temporal, parietal and occipital brain areas as well as in the limbic system are significantly reduced compared to the iPhone 15 Pro test condition without the Quantum Upgrade®.*



*Fig. 4: EEG beta activity (mean values, standard deviations, in  $\mu V^2/Hz$ ) during the baseline measurement without mobile phone exposure, during a 30-minute 5G phone call with the iPhone 15 Pro and during the application of the Quantum Upgrade® during the 5G phone call with the iPhone 15 Pro.*

*The results show strong beta activations during the 5G call without using Quantum Upgrade® in all tested brain areas.*

*When using the iPhone 15 Pro with the Quantum Upgrade®, the beta activations in the central, temporal, parietal and occipital brain areas as well as in the limbic system are significantly reduced compared to the iPhone 15 Pro test condition without the Quantum Upgrade®.*

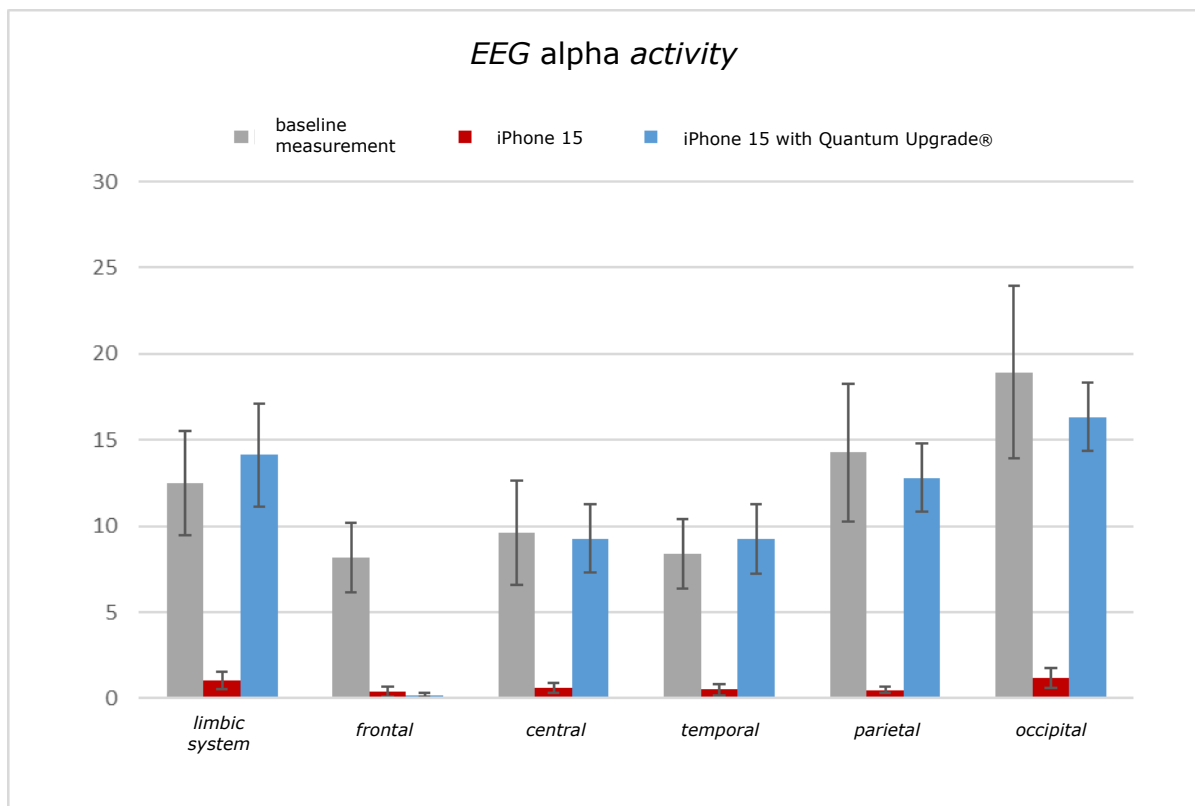


Fig. 5: EEG alpha activity (mean values, standard deviations, in  $\mu V^2/Hz$ ) during the baseline measurement without mobile phone exposure, during a 30-minute 5G phone call with the iPhone 15 Pro and during the application of Quantum Upgrade® during the 5G phone call with the iPhone 15 Pro.

The results show a significant decrease in alpha activations during the 5G call without using Quantum Upgrade® in all tested brain areas.

When the Quantum Upgrade® is used with the iPhone 15 Pro, the alpha activations in the central, temporal, parietal and occipital brain areas as well as in the limbic system are significantly increased compared to the iPhone 15 Pro test condition without the application and are at a comparable level to the baseline measurement without EMF exposure. When using the Quantum Upgrade® with the iPhone 15 Pro, the alpha activations in the frontal brain areas are significantly reduced compared to the baseline measurement without EMF exposure.



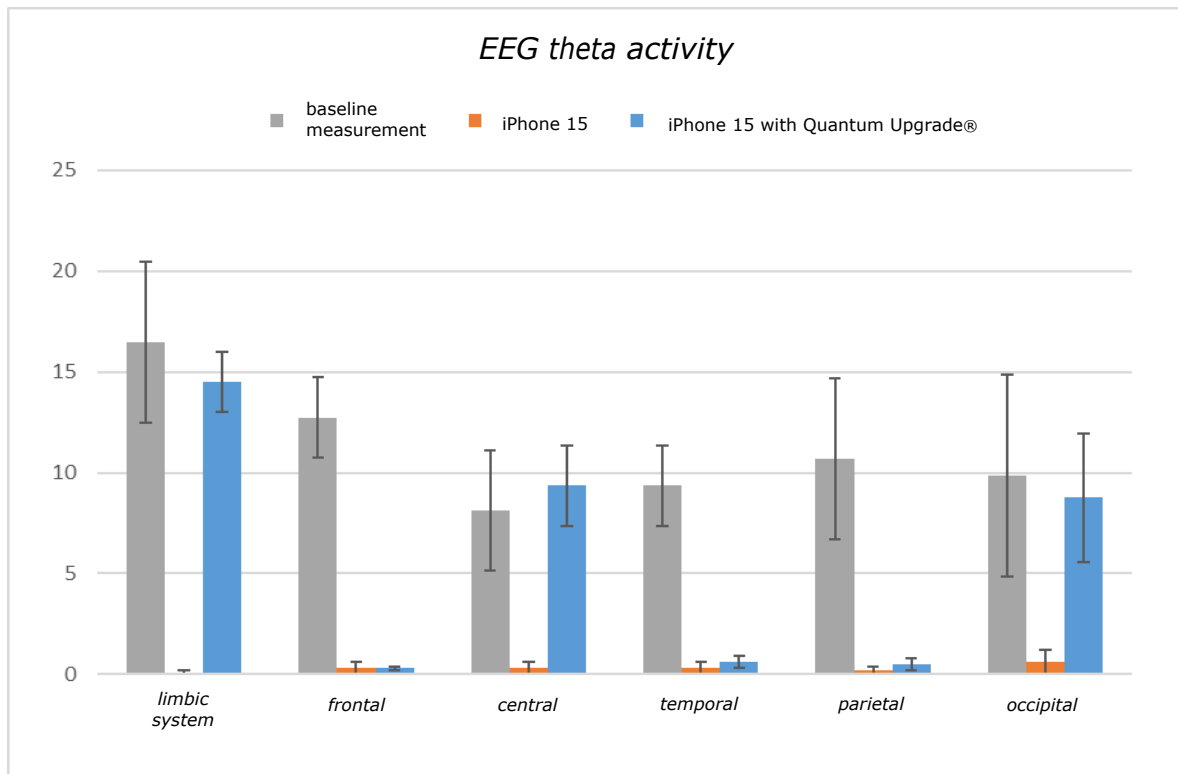


Fig. 6: EEG theta activity (mean values, standard deviations, in  $\mu V^2/Hz$ ) during the baseline measurement without mobile phone exposure, during a 30-minute 5G phone call with the iPhone 15 Pro and during the application of Quantum Upgrade® during the 5G phone call with the iPhone 15 Pro.

The results show a significant decrease in theta activations during the 5G call without using Quantum Upgrade® in all tested brain areas.

When using the Quantum Upgrade® with the iPhone 15 Pro, the theta activations in the central and occipital brain areas as well as in the limbic system are significantly increased compared to the iPhone 15 Pro test condition without application and are at a comparable level with the baseline measurement without EMF exposure. When using the Quantum Upgrade® with the iPhone 15 Pro, the theta activations in the frontal, temporal and parietal brain areas are significantly reduced compared to the baseline measurement without EMF exposure.



EEG Gamma Activity	Limbic system	Frontal	Central	Temporal	Parietal	Occipital
Baseline Measurement	0,87	3,46	2,69	2,07	2,92	3,28
iPhone 15 Pro	32,41 <sup>a</sup>	59,18 <sup>a</sup>	36,50 <sup>a</sup>	49,29 <sup>a</sup>	36,74 <sup>a</sup>	45,62 <sup>a</sup>
iPhone 15 Pro with Quantum Upgrade®	7,25 <sup>d</sup>	52,73 <sup>b</sup>	10,85 <sup>d</sup>	12,26 <sup>c,d</sup>	6,82 <sup>d</sup>	10,65 <sup>d</sup>

<sup>a</sup> statistical significance level  $p < .01$  in comparison (post-hoc test) of test condition iPhone 15 Pro without application versus baseline measurement without EMF exposure

<sup>b</sup> statistical significance level  $p < .01$  in comparison (post-hoc test) of test condition iPhone 15 Pro with Quantum Upgrade® compared to baseline measurement without EMF exposure

<sup>c</sup> statistical significance level  $p < .05$  in comparison (post-hoc test) of test condition iPhone 15 Pro with Quantum Upgrade® compared to baseline measurement without EMF exposure

<sup>d</sup> statistical significance level  $p < .05$  in comparison (post-hoc test) of test condition iPhone 15 Pro with Quantum Upgrade® compared to test condition iPhone 15 Pro without application

**Table 1:** Mean power densities in  $\mu V^2/Hz$  of the EEG activations in the gamma band (31-100 Hz) due to 5G exposure for the test conditions iPhone 15 Pro without application and iPhone 15 Pro with application of the Quantum Upgrade® as well as for the control condition (baseline measurement without EMF exposure).

The results show significant increases in the activations in the gamma band in all tested brain areas when using the iPhone 15 Pro compared to the baseline measurement without EMF exposure.

When the Quantum Upgrade® is used with the iPhone 15 Pro, the gamma activations in the central, parietal, temporal and occipital brain areas as well as in the limbic system are significantly reduced compared to the iPhone 15 Pro test condition without application. When using the Quantum Upgrade®, the activations in the gamma band in the central, parietal and occipital brain areas as well as in the limbic system are at a comparable level compared to the baseline measurement without EMF exposure. In the frontal and temporal brain areas, the activations in the gamma band are significantly increased when using the Quantum Upgrade® compared to the baseline measurement.

EEG Beta Activity	Limbic system	Frontal	Central	Temporal	Parietal	Occipital
Baseline Measurement	4,57	15,38	6,22	5,49	7,92	12,81
iPhone 15 Pro	48,12 <sup>a</sup>	52,64 <sup>a</sup>	41,90 <sup>a</sup>	56,37 <sup>a</sup>	38,24 <sup>a</sup>	26,45 <sup>b</sup>
iPhone 15 Pro with Quantum Upgrade®	8,69 <sup>d</sup>	48,73 <sup>c</sup>	14,38 <sup>d</sup>	9,63 <sup>d</sup>	10,45 <sup>d</sup>	16,29 <sup>d</sup>

<sup>a</sup> Statistical significance level  $p < .01$  in comparison (post-hoc test) of test condition iPhone 15 Pro without application compared to the baseline measurement without EMF exposure

<sup>b</sup> Statistical significance level  $p < .05$  in comparison (post-hoc test) of test condition iPhone 15 Pro without application compared to the baseline measurement without EMF exposure

<sup>c</sup> Statistical significance level  $p < .01$  in comparison (post-hoc test) of test condition iPhone 15 Pro with Quantum Upgrade® compared to baseline measurement without EMF exposure

<sup>d</sup> Statistical significance level  $p < .05$  in comparison (post-hoc test) of test condition iPhone 15 Pro with Quantum Upgrade® compared to the test condition iPhone 15 Pro without application

**Table 2:** Mean power densities in  $\mu V^2/Hz$  of EEG activations in the beta band (14-30 Hz) due to 5G exposure for the test conditions iPhone 15 Pro without application and iPhone 15 Pro with application of the Quantum Upgrade® as well as for the control condition (baseline measurement without EMF exposure).

The results show significant increases in the activations in the beta band in all tested brain areas when using the iPhone 15 Pro compared to the baseline measurement without EMF exposure.

When the Quantum Upgrade® is used with the iPhone 15 Pro, the beta activations in the central, temporal, parietal and occipital brain areas as well as in the limbic system are significantly reduced compared to the iPhone 15 Pro test condition without application. When using the Quantum Upgrade®, the activations in the beta band in the central, temporal, parietal and occipital brain areas as well as in the limbic system are at a comparable level compared to the baseline measurement without EMF exposure. In the frontal brain areas, the activations in the beta band are significantly increased when using Quantum Upgrade® compared to the baseline measurement.

EEG Alpha Activity	Limbic system	Frontal	Central	Temporal	Parietal	Occipital
Baseline Measurement	12,48	8,15	9,60	8,37	14,26	18,91
iPhone 15 Pro	1,06 <sup>a</sup>	0,02 <sup>a</sup>	0,62 <sup>a</sup>	0,05 <sup>a</sup>	0,48 <sup>a</sup>	1,17 <sup>a</sup>
iPhone 15 Pro with Quantum Upgrade®	14,13 <sup>c</sup>	0,07 <sup>b</sup>	9,27 <sup>c</sup>	9,25 <sup>c</sup>	12,80 <sup>c</sup>	16,34 <sup>c</sup>

<sup>a</sup> statistical significance level  $p < .05$  in comparison (post-hoc test) of test condition iPhone 15 Pro without application versus baseline measurement without EMF exposure

<sup>b</sup> statistical significance level  $p < .05$  in comparison (post-hoc test) of test condition iPhone 15 Pro with Quantum Upgrade® compared to baseline measurement without EMF exposure

<sup>c</sup> statistical significance level  $p < .05$  in comparison (post-hoc test) of test condition iPhone 15 Pro with Quantum Upgrade® compared to test condition iPhone 15 Pro without application

**Table 3:** Mean power densities in  $\mu V^2/Hz$  of the EEG activations in the alpha band (8-13 Hz) due to 5G exposure for the iPhone 15 Pro and iPhone 15 Pro test conditions when using the Quantum Upgrade® and for the control condition (baseline measurement without EMF exposure).

The results show a significant reduction in activity in the alpha band in all tested brain areas when using the iPhone 15 Pro without application compared to the baseline measurement without EMF exposure.

Using the Quantum Upgrade® with the iPhone 15 Pro, the alpha activations in the central, temporal, parietal and occipital brain areas as well as in the limbic system are significantly increased compared to the iPhone 15 Pro test condition without application and are at a comparable level with the baseline measurement without EMF exposure. When using the Quantum Upgrade® with the iPhone 15 Pro, the alpha activations in the frontal brain areas are significantly reduced compared to the baseline measurement without EMF exposure.

EEG Theta Activity	Limbic system	Frontal	Central	Temporal	Parietal	Occipital
Baseline Measurement	16,47	12,73	8,13	9,36	10,68	9,87
iPhone 15 Pro	0,15 <sup>a</sup>	0,03 <sup>a</sup>	0,21 <sup>a</sup>	0,06 <sup>a</sup>	0,12 <sup>a</sup>	0,18 <sup>a</sup>
iPhone 15 Pro with Quantum Upgrade®	10,40 <sup>c</sup>	0,08 <sup>b</sup>	9,35 <sup>c</sup>	0,62 <sup>b</sup>	0,08 <sup>b</sup>	8,75 <sup>c</sup>

<sup>a</sup> statistical significance level  $p < .05$  in comparison (post-hoc test) of test condition iPhone 15 Pro without application versus baseline measurement without EMF exposure

<sup>b</sup> statistical significance level  $p < .05$  in comparison (post-hoc test) of test condition iPhone 15 Pro with Quantum Upgrade® compared to baseline measurement without EMF exposure

<sup>c</sup> statistical significance level  $p < .05$  in comparison (post-hoc test) of test condition iPhone 15 Pro with Quantum Upgrade® compared to test condition iPhone 15 Pro without application

**Table 4:** Mean power densities in  $\mu V^2/Hz$  of EEG activations in the theta band (4.0-7.5 Hz) due to 5G exposure for the iPhone 15 Pro and iPhone 15 Pro test conditions when using the Quantum Upgrade® and for the control condition (baseline measurement without EMF exposure).

The results show a significant reduction in activity in the theta band in all tested brain areas when using the iPhone 15 Pro without application compared to the baseline measurement without EMF exposure.

When Quantum Upgrade® is used with the iPhone 15 Pro, theta activations in the central and occipital brain areas as well as in the limbic system are significantly increased compared to the iPhone 15 Pro without application test condition and are at a comparable level to the baseline measurement without EMF exposure. When using the Quantum Upgrade® with the iPhone 15 Pro, the theta activations in the frontal, temporal and parietal brain areas are significantly reduced compared to the baseline measurement without EMF exposure.



### 3.2 HRV

The results of the HRV measurements are shown in Table 5 and Fig. 7-15. The results of the HRV analyses show a reduction in heart rate variability in the time-related parameters SDNN, SDANN, RMSSD, pNN50 and in the frequency-related parameters HF and LF/HF ratio during exposure to 5G via the iPhone 15 Pro. These parameters reflect the adaptability and regenerative capacity of the cardiovascular system under stress, e.g. due to mobile phone exposure. When using the iPhone 15 Pro with the Quantum Upgrade®, the HRV parameters SDNN, SDANN, RMSSD, pNN50, HF and LF/HF ratio are highly significantly increased compared to the iPhone 15 Pro test condition without Quantum Upgrade® and are at a comparable level to the baseline measurement without EMF exposure.

Inferential statistical analysis of HRV data demonstrated highly significant effects of the Quantum Upgrade® application compared to 5G exposure without Quantum Upgrade®. The analysis of variance shows highly significant effects for the parameter SDNN, [ $F(2, 28) = 5.81$ ;  $p = 0.008$ ;  $\eta^2 = 0.27$ ]. The post-hoc test shows a highly significant reduction when using the iPhone 15 Pro without Quantum Upgrade® compared to the baseline measurement ( $p = 0.006$ ) and iPhone 15 Pro without Quantum Upgrade® ( $p = 0.008$ ). There were also highly significant effects for the SDANN parameter [ $F(2, 28) = 5.76$ ;  $p = 0.009$ ;  $\eta^2 = 0.30$ ]. The post-hoc test shows a highly significant reduction when using the iPhone 15 Pro without Quantum Upgrade® compared to the baseline measurement ( $p = 0.007$ ) and iPhone 15 Pro without Quantum Upgrade® ( $p = 0.008$ ). A highly significant effect can also be demonstrated for the RMSSD parameter, [ $F(2, 28) = 10.24$ ;  $p = 0.0008$ ;  $\eta^2 = 0.35$ ]. The post-hoc test shows a highly significant reduction when using the iPhone 15 Pro without Quantum Upgrade® compared to the baseline measurement ( $p = 0.0007$ ) and iPhone 15 Pro without Quantum Upgrade® ( $p = 0.0008$ ); also highly significant effect for pNN50, [ $F(2, 28) = 11.45$ ;  $p = 0.0006$ ;  $\eta^2 = 0.33$ ]. The post-hoc test shows a highly significant reduction when using the iPhone 15 Pro without Quantum Upgrade® compared to the baseline measurement ( $p = 0.0006$ ) and iPhone 15 Pro without Quantum Upgrade® ( $p = 0.0006$ ). Highly significant effects were found for the frequency-related parameters HF and LF/HF ratio: HF, [ $F(2, 28) = 9.63$ ;  $p = 0.0007$ ;  $\eta^2 = 0.31$ ], with post-hoc test iPhone 15 Pro without Quantum Upgrade® versus baseline measurement ( $p = 0.0006$ ) and iPhone 15 Pro without Quantum Upgrade® ( $p = 0.0007$ ), and LF/HF ratio, [ $F(2, 28) = 9.40$ ;  $p = 0.0008$ ;  $\eta^2 = 0.25$ ], with post-hoc test iPhone 15 Pro without Quantum Upgrade® compared to the baseline measurement ( $p = 0.0008$ ) and iPhone 15 Pro without Quantum Upgrade® ( $p = 0.0008$ ).

The results of the present HRV analyses indicate a positive effect of the use of the Quantum Upgrade® during 5G mobile radio exposure by the iPhone 15 Pro on HRV in the sense of an improvement in HRV, i.e. the adaptability of the cardiovascular system and thus also the ability to regenerate.



HRV	Baseline Measurement	iPhone 15 Pro without Quantum Upgrade®	iPhone 15 Pro with Quantum Upgrade®	Statistical Significance P
SDNN	147,2 (118,0-175,2)	112,7 (85,4-166,1) <sup>a</sup>	142,5 (111,2-161,7)	0,008
SDANN	133,6 (104,4-162,0)	105,5 (82,2-128,7) <sup>a</sup>	126,1 (92,2-143,5)	0,009
RMSSD	37,1 (26,3-48,6)	23,4 (17,0-31,4) <sup>b</sup>	37,6 (27,3-48,8)	0,001
pNN50	16,8 (6,4-23,9)	7,5 (2,0-21,3) <sup>b</sup>	13,2 (8,1-22,6)	0,001
Mean HR	78,2 (71,5-82,6)	79,6 (73,7-84,4)	77,1 (70,5-84,3)	0,578
LF	876,2 (576,3-1353,6)	754,3 (453,1-1147,4)	858,1 (501,5-1216,8)	0,425
HF	406,7 (233,2-640,5)	142,6 (70,2-241,9) <sup>b</sup>	390,8 (243,7-598,4)	0,001
LF/HF ratio	1,9 (1,6-2,7)	5,6 (3,2-7,9) <sup>b</sup>	1,7 (1,5-2,5)	0,001
VLF	3048,2 (1678,3-3819,4)	2616,0 (1630,9-3587,8)	2773,4 (1658,9-3735,3)	0,287
Total power	3744,9 (2632,4-5892,2)	3126,8 (2116,3-4195,3)	3623,5 (2652,1-5680,3)	0,189

<sup>a</sup> statistical significance level  $p < .01$  in comparison (post-hoc test) of test condition iPhone 15 Pro without application versus baseline measurement without EMF exposure

<sup>b</sup> statistical significance level  $p < .001$  in comparison (post-hoc test) of test condition iPhone 15 Pro without application versus baseline measurement without EMF exposure

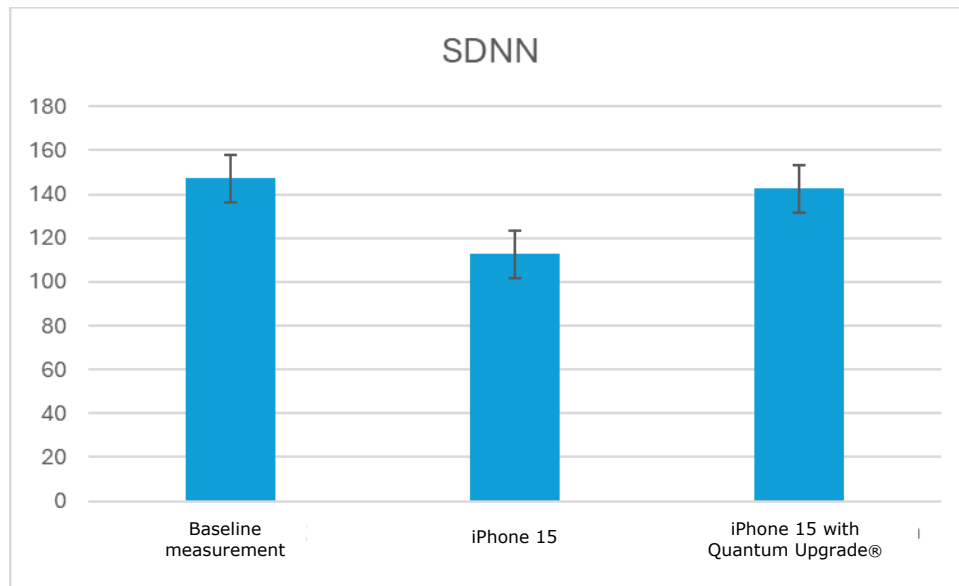
**Table 5:** HRV parameters (mean values, minimum and maximum values) for the test conditions iPhone 15 Pro without Quantum Upgrade® and iPhone 15 Pro with Quantum Upgrade® as well as for the control condition (baseline measurement without EMF exposure).

The results show highly significant effects of 5G mobile phone exposure through the iPhone 15 Pro for the parameters SDNN, SDANN, RMSSD, pNN50, HF and LF/HF ratio.

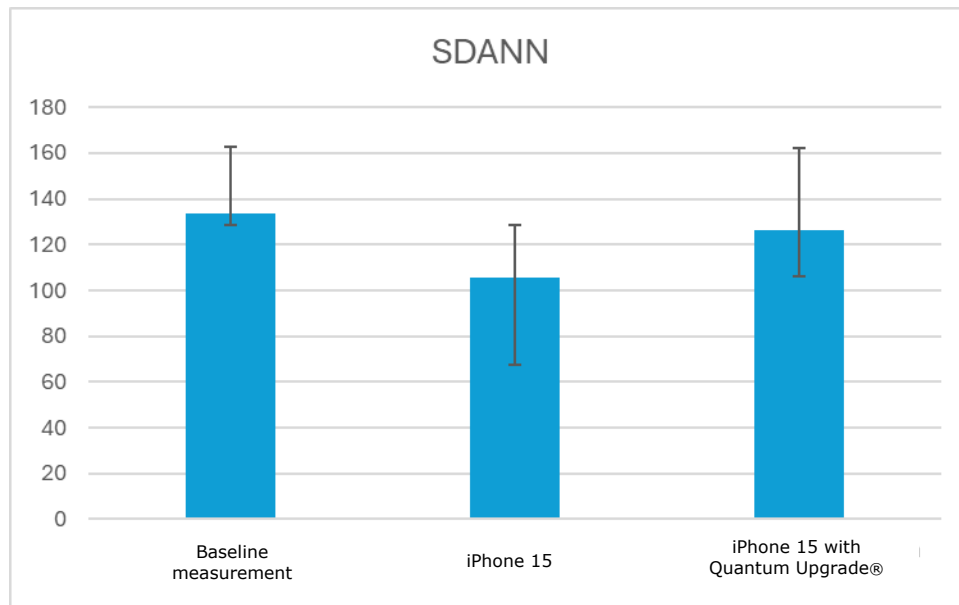
When the Quantum Upgrade® is applied with the iPhone 15 Pro, the parameters SDNN, SDANN, RMSSD, pNN50, HF and LF/HF ratio are highly significantly increased compared to the iPhone 15 Pro test condition without Quantum Upgrade® and are at a comparable level with the baseline measurement without EMF exposure.





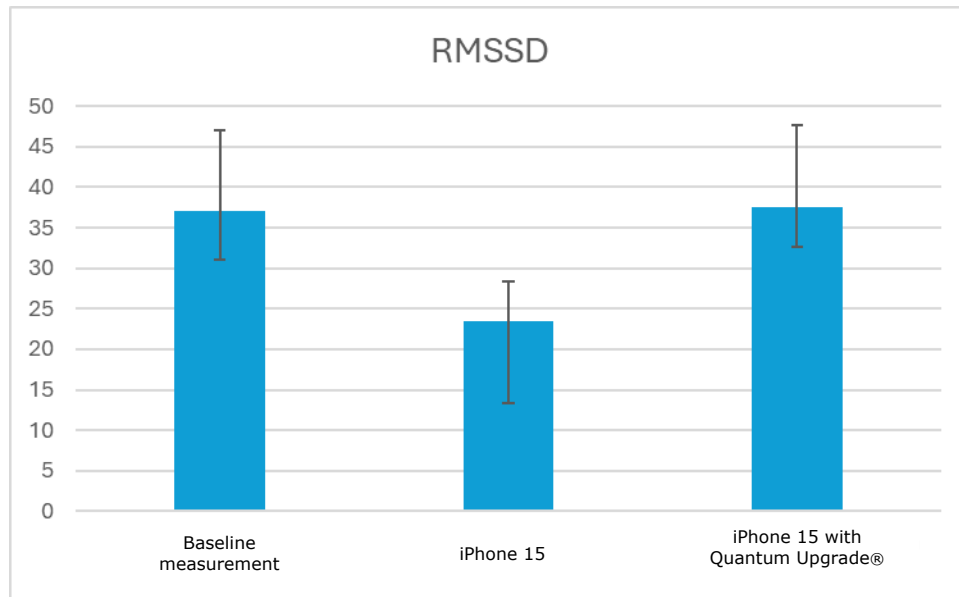


*Fig. 7:* HRV parameter standard deviation of the mean value of the NN intervals (SDNN, in ms) during the baseline measurement without mobile phone exposure, during a 30-minute 5G phone call with the iPhone 15 Pro and during the application of the Quantum Upgrade® during the 5G phone call with the iPhone 15 Pro. The results show a significant decrease in SDNN during the 5G call without using Quantum Upgrade®. When using the iPhone 15 Pro with the Quantum Upgrade®, the SDNN is highly significantly increased compared to the test condition iPhone 15 Pro without Quantum Upgrade® and remains at a comparable level with the baseline measurement without mobile phone exposure.



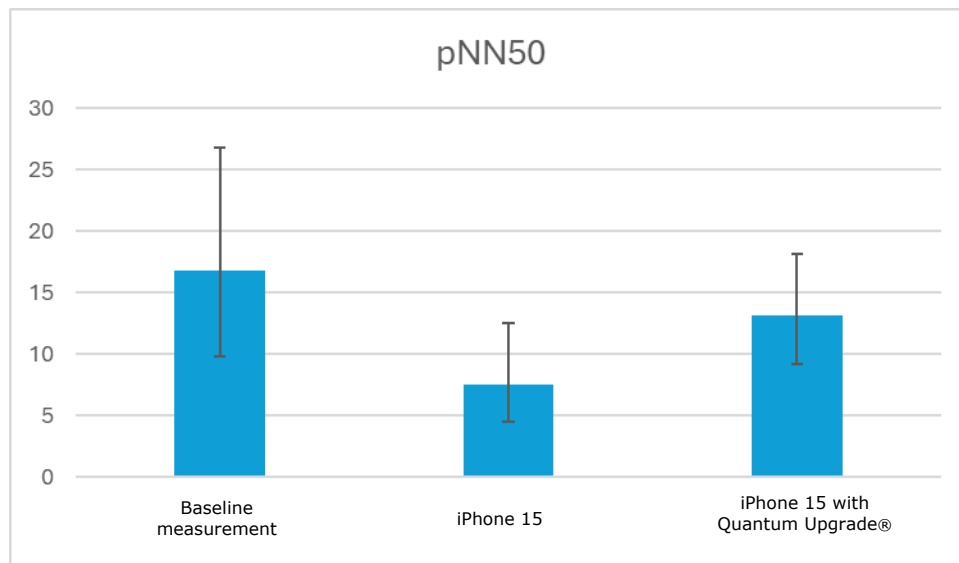
*Fig. 8:* HRV parameter standard deviation of the mean value of the NN intervals in all 5-minute intervals (SDANN, in ms) during the baseline measurement without mobile phone exposure, during a 30-minute 5G phone call with the iPhone 15 Pro and during the application of the Quantum Upgrade® during the 5G phone call with the iPhone 15 Pro. The results show a significant decrease in SDANN during the 5G call without using Quantum Upgrade®.

When using the iPhone 15 Pro with the Quantum Upgrade®, the SDANN is highly significantly increased compared to the test condition iPhone 15 Pro without Quantum Upgrade® and remains at a comparable level with the baseline measurement without mobile phone exposure.



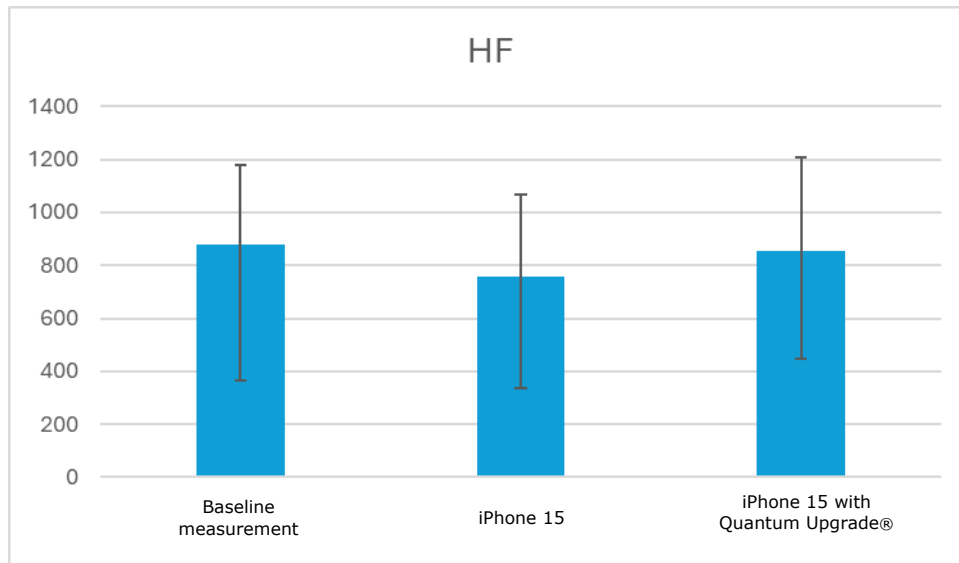
*Fig. 9:* HRV parameter RMSSD (in ms) during the baseline measurement without mobile phone exposure, during a 30-minute 5G phone call with the iPhone 15 Pro and during the application of the Quantum Upgrade® during the 5G phone call with the iPhone 15 Pro. The results show a significant decrease in the RMSSD parameter during the 5G call without using Quantum Upgrade®.

When using the iPhone 15 Pro with the Quantum Upgrade®, RMSSD is highly significantly increased compared to the test condition iPhone 15 Pro without Quantum Upgrade® and remains at a comparable level to the baseline measurement without mobile phone exposure.



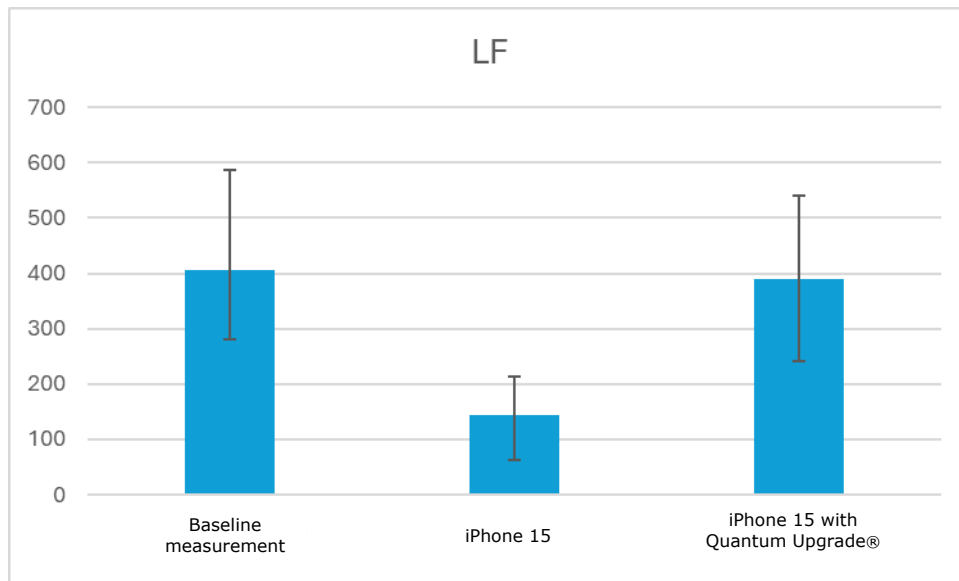
*Fig. 10:* HRV parameter pNN50 (in %) during the baseline measurement without mobile phone exposure, during a 30-minute 5G phone call with the iPhone 15 Pro and during the application of the Quantum Upgrade® during the 5G phone call with the iPhone 15 Pro. The results show a significant decrease in the pNN50 parameter during the 5G call without using Quantum Upgrade®.

When using the iPhone 15 Pro with the Quantum Upgrade®, the pNN50 is highly significantly increased compared to the test condition iPhone 15 Pro without Quantum Upgrade® and remains at a comparable level to the baseline measurement without mobile phone exposure.



*Fig. 11:* HRV parameter HR (in ms2) during the baseline measurement without mobile phone exposure, during a 30-minute 5G phone call with the iPhone 15 Pro and during the application of the Quantum Upgrade® during the 5G phone call with the iPhone 15 Pro. The results show a significant decrease in the RF parameter during the 5G call without using Quantum Upgrade®.

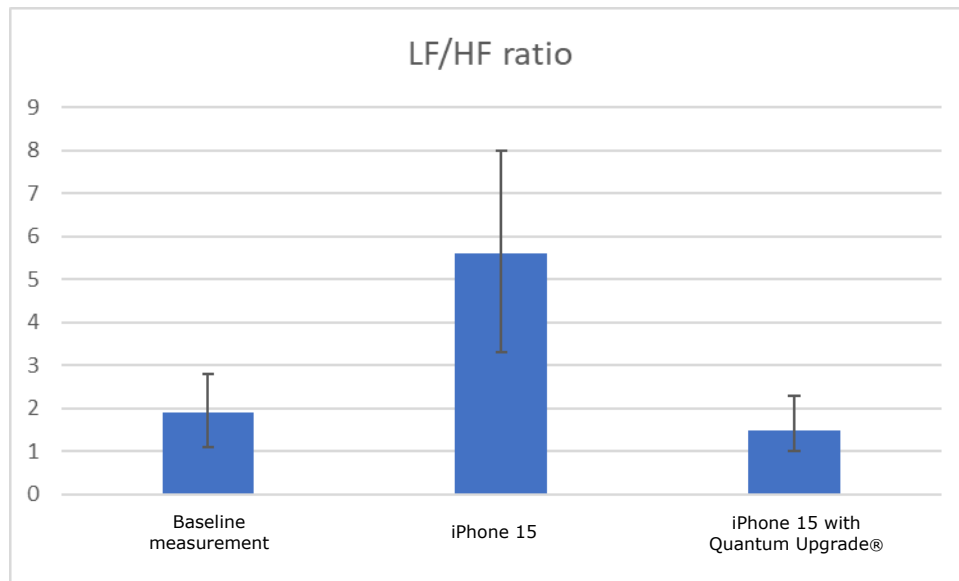
When using the iPhone 15 Pro with the Quantum Upgrade®, the RF is highly significantly increased compared to the test condition iPhone 15 Pro without Quantum Upgrade® and remains at a comparable level to the baseline measurement without mobile phone exposure.



*Fig. 12:* HRV parameter LF (in ms<sup>2</sup>) during the baseline measurement without mobile phone exposure, during a 30-minute 5G phone call with the iPhone 15 Pro and during the application of the Quantum Upgrade® during the 5G phone call with the iPhone 15 Pro. The results show a significant decrease in the LF parameter during the 5G call without using Quantum Upgrade®.

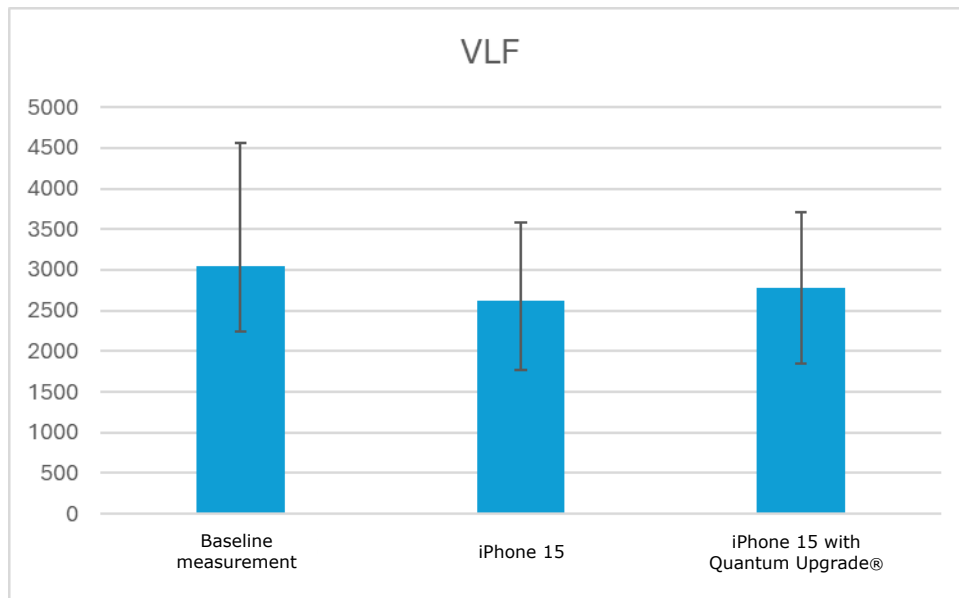
When using the iPhone 15 Pro with the Quantum Upgrade®, the LF is highly significantly increased compared to the test condition iPhone 15 Pro without Quantum Upgrade® and at a comparable level to the baseline measurement without mobile phone exposure.



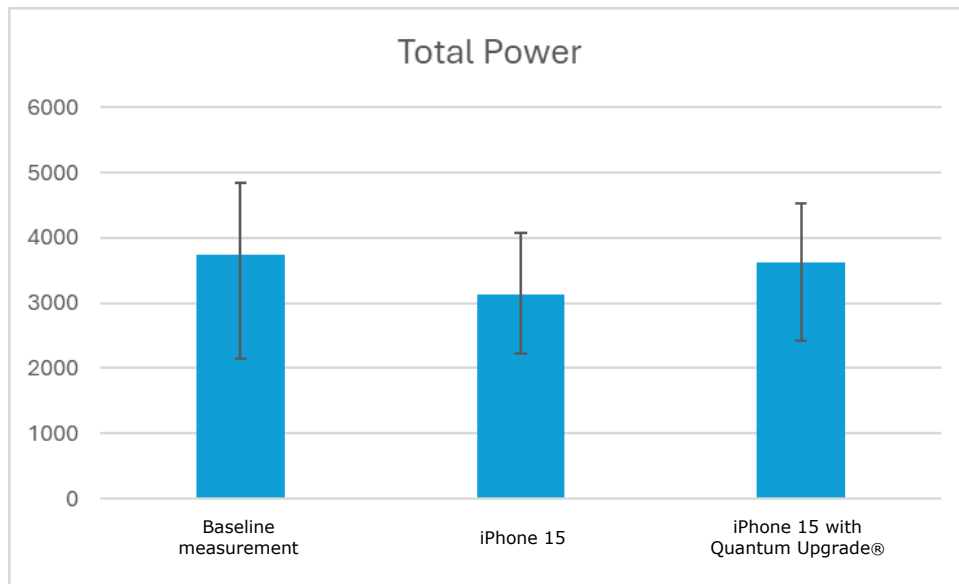


*Fig. 13:* HRV parameters LF/HF ratio during the baseline measurement without mobile phone exposure, during a 30-minute 5G phone call with the iPhone 15 Pro and during the application of the Quantum Upgrade® during the 5G phone call with the iPhone 15 Pro. The results show a highly significant increase in the LF/HF ratio during the 5G call without using Quantum Upgrade®.

When using the iPhone 15 Pro with the Quantum Upgrade®, the LF/HF ratio is highly significantly increased compared to the test condition iPhone 15 Pro without Quantum Upgrade® and remains at a comparable level to the baseline measurement without mobile phone exposure.



*Fig. 14:* HRV parameter VLF (in ms2) during the baseline measurement without mobile phone exposure, during a 30-minute 5G phone call with the iPhone 15 Pro and during the application of the Quantum Upgrade® during the 5G phone call with the iPhone 15 Pro. The results show a decrease in VLF during the 5G call without using Quantum Upgrade®. When using the iPhone 15 Pro with the Quantum Upgrade®, VLF remains at a comparable level to the baseline measurement without mobile phone exposure. However, the differences are not statistically significant.



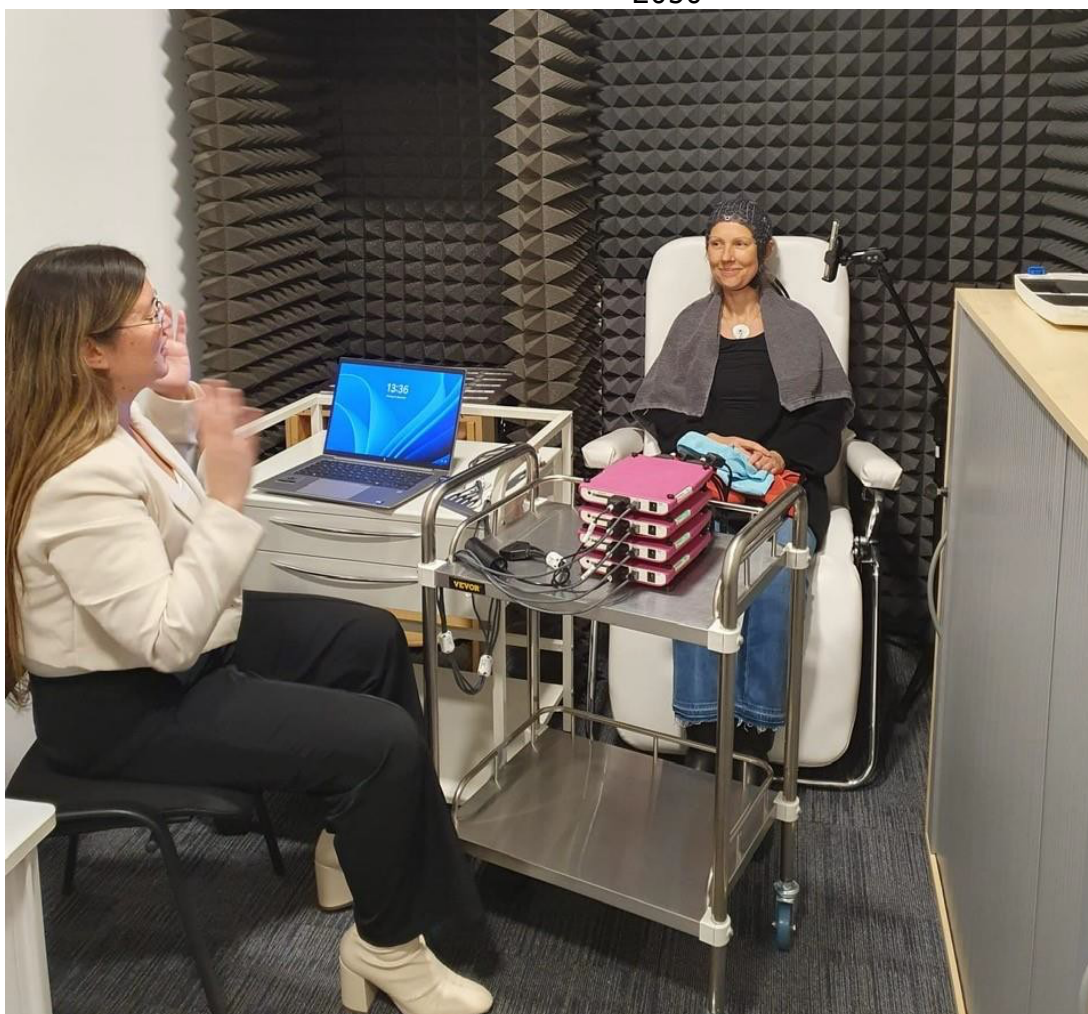
*Fig. 15:* HRV parameter total power (in ms<sup>2</sup>) during the baseline measurement without mobile phone exposure, during a 30-minute 5G phone call with the iPhone 15 Pro and during the application of the Quantum Upgrade® during the 5G phone call with the iPhone 15 Pro.

The results show a decrease in total power during the 5G call without using Quantum Upgrade®.

When using the iPhone 15 Pro with the Quantum Upgrade®, the total power remains at a comparable level to the baseline measurement without mobile phone exposure. However, the differences are not statistically significant.



2050





2051



2052



2053





2054



2055



2056





2057



2058



2061




Study was conducted by: Deutsche Stiftung für Gesundheitsinformation und Prävention  
(German Foundation for Health Information and Prevention)

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**Bundesverband**  
Bundesverband Deutscher  
Sachverständiger und Fachgutachter e.V.

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Der Auftrag beschränkt sich auf die Ermittlung und Interpretation der messbaren Größen im EEG und HRV. Nicht Bestandteil des Auftrags ist die Untersuchung der Herstellung oder des Wirkmechanismus der untersuchten Proben. Ebenso gehört die Weitergabe von Informationen über die untersuchten Produkte an Dritte nicht zum Aufgabenbereich des Auftragnehmers.

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