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Increased photon emission from the head while imagining light in the dark is correlated with changes in electroencephalographic power: Support for Bókkon's biophoton hypothesis☆

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ABSTRACT

Bókkon's hypothesis that photons released from chemical processes within the brain produce biophysical pictures during visual imagery has been supported experimentally. In the present study measurements by a photomultiplier tube also demonstrated significant increases in ultraweak photon emissions (UPEs) or biophotons equivalent to about 5×10^{-11} W/m^2 from the right sides of volunteer's heads when they imagined light in a very dark environment compared to when they did not. Simultaneous variations in regional quantitative electroencephalographic spectral power (μV^2/Hz) and total energy in the range of $\sim 10^{-12}$ J from concurrent biophoton emissions were strongly correlated ($r = 0.95$). The calculated energy was equivalent to that associated with action potentials from about 10^7 cerebral cortical neurons. We suggest these results support Bókkon's hypothesis that specific visual imagery is strongly correlated with ultraweak photon emission coupled to brain activity.

Most neuroscientists are familiar with the threshold of $\sim 5 \times 10^{-17}$ J as the retinal dark-adapted threshold of energy for the experience of "light" ($\lambda \sim 380$–800 nm) from exogenous photons [25]. Endogenous production of ultraweak photon emissions (UPEs), energies more than 10,000 times less intense than the light from the stars on a clear moonless night, within the human brain was the focus of a recent international symposium [21]. The quantification of the photonic interaction and the electrical activity of neurons within the human brain [6,18] might also help harmonize the apparent dichotomy between matter (ions)- and energy (photons)-based models of information processing within biological systems [22]. In the history of Science, for example in physics, alternative considerations for apparent matter-energy dichotomies opened new perspectives. Here we report the replication of previous observations that demonstrated a specific type of cognition was associated with reliable increases in UPE from the cerebrum and in addition show that the magnitude of these photon emissions were strongly correlated with a specific band of power within the spectrum of quantitative electroencephalographic (QEEG) activity.

According to Popp living systems emit in the order of 10^6 UPEs per m^2 s [7,19,23]. Assuming an average wavelength of 500 nm (0.6 petaHz), the energy (the product of the frequency of the electromagnetic wave and Planck's constant) would be $\sim 4 \times 10^{-19}$ J for a sum of about 4×10^{-13} W/m^2. This value is just above the background energy densities ($\sim 10^{-13}$ W/m^2) for cosmic rays near the earth's surface and that produced from natural radioactive isotopes from the atmosphere and ground [15]. Recent direct measurements of melanoma cells when removed from incubation temperatures have shown photon emissions of $\sim 10^{-20}$ J per cell per s. These values are measured reliably and can be temporally altered by treatments that affect the cell's plasma membrane [8,9].

The value of 10^{-20} J is congruent with the energy between the individual ions (potassium) that are most correlated with the resting membrane potential of cells [18]. In addition, the effect of a single action potential (net change of 1.2×10^{-1} V) upon a unit charge (1.6×10^{-19} A s) is about 2×10^{-20} J. This "quantum" of energy is also the amount required to stack a nucleotide on a synthesizing RNA sequence as well as other essential biophysical parameters [18]. Interestingly, a photon with a wavelength of 500 nm whose frequency was phase- or frequency-modulated through intrinsic processes that were equivalent to a net change of

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$\sim 10^{-20}$ J, would require a shift in λ of only 10 nm. This is the width of the neuronal membrane.

UPEs, coupled to intrinsic theta activity, from rodent hippocampal slices have been measured to be in the order of 10^{-13} to 10^{-12} W/m^2 [13,14]. In human beings there is evidence that intracerebral changes in biophoton activity are related to consciousness and phosphene phenomena. In extraordinarily original and innovative articles Bókkon [1–4] hypothesized that biophotons may actually *be* the information from which dreams and visual images during the waking state are constructed. Recently Wang et al. [24] tested Bókkon's hypothesis and was the first to demonstrate spontaneous and visible light-induced photon emission from rat eyes.

A strong temporal association between cerebral photon emissions and quantitative changes in global brain activity is also predicted by Bókkon's hypothesis. In previous studies we showed that during brief intervals when an exceptional person [12] or normal volunteers [10] sitting in the dark imagined white light there were reliable and very statistically significant increases in photon emissions at 15 cm from the *right* but not the left hemisphere. This marked right hemispheric increase was obvious both within subjects over repeated trials and when group averages were calculated.

The net increase, which was not evident when the subjects relaxed and engaged in mundane thinking and accommodated more than 25% of the variance, was about 3×10^{-11} W/m^2 or the equivalent of about 10^7 action potentials per second when the cross-sectional area of the brain was accommodated. In the present study we replicated this right hemispheric increase in photon emissions and in addition demonstrated their strong correlation with specific frequencies of cerebral electroencephalographic activity.

In the first experiment, 8 volunteers (ages 23 through 26; 4 men, 4 women) were dark adapted while they sat blind folded in a dark room that was sealed from extraneous light as demonstrated by no change in PMT measures when external lightning was reversibly activated. To replicate the procedures for the previous study [10] we measured the photon emission with a Model 15 Photometer from SRI Instruments (Pacific Photometric Instruments) with a photomultiplier tube (PMT) housing (BCA IP21) for a RCA electron tube (no filters). The PMT was placed 15 cm away from the *right* side of the head in the same plane as the temporoparietal lobes. Calibration by several methods [8,9,11] indicated that a change of 1 unit within the medium range of the 0 to 100 unit meter was equivalent to 5×10^{-11} W/m^2. The output was transformed to mV (millivolt meter) and sent to the photometer and IBM ThinkPad laptop (Windows 95) in another room where samples were taken three times per second (the limits of the software).

Instructions to think about white light (60 s) and project the light into the PMT along the right side of the head followed rest or "baseline" intervals (also 60 s, most of which involved either no recollection or thoughts about friends or studies) were given vocally from another room and repeated three times. The means for the PMT values for each of the 6 intervals (3 thinking about light, 3 not) were obtained for each subject. The mean and the standard deviations for these 6 values were obtained and *z*-scores were calculated. The mean *z*-scores for the three intervals of "thinking about light" and for the three comparison intervals (casual thinking) were analyzed. Paired *t*-tests were completed to discern any statistically significant ($p < 05$) changes between the relaxation and "imagining light" periods.

The results are shown in Fig. 1. There was a statistically significant increase [$t(7) = 12.50$, $p < 001$] in UPE while the subjects were thinking about white light compared to not thinking about light. This increase was noted for all 8 subjects. The condition of thinking about light compared to the reference condition accommodated 94% of the variance. The net difference in energy emission between the two conditions ranged between 0.5 and 2 units or between 25 and 100 pW/m^2. In general from the time of the instruction to

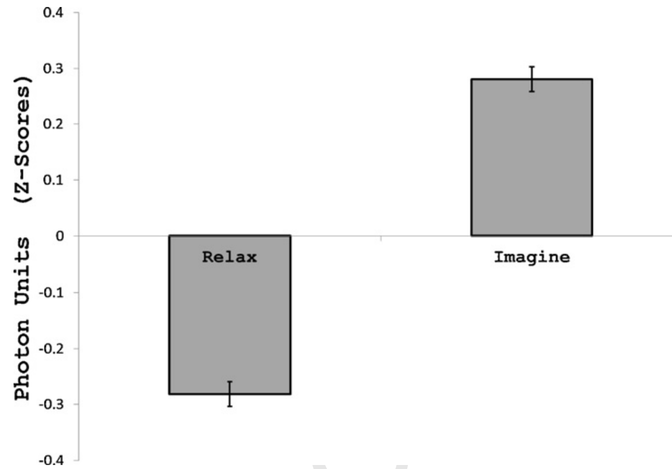

Fig. 1. Means and standard errors of the mean for the *z*-scores (standardized for within-subject measures) of the changes in photon energy measured during intervals of "imagining white light" while sitting blind folded in the dark or not imaging light (casual thinking). The absolute increase is $\sim 10^{-10}$ J/s m^2.

imagine white light to the first increases in photon emission above background fluctuations was about 4 s. During the 60 s intervals of imaging white light the durations of the elevations in UPE occurred in cycles of approximately 7–9 s peaks followed by 3–4 s troughs. This was not observed during the intervals of the reference condition. These fluctuations suggest that the averaged values for the UPE per 60 s interval may be underestimates of the peak output.

During the PMT measurements for the same instruction procedure in the second experiment quantitative EEG (QEEG) was recorded at 250 Hz with a Mitsar-201 amplifier equipped with 19-channel sensors [12] for 3 subjects. We employed this "in triplicate" approach from biochemistry because we assumed that if Bókkon's hypothesis were valid, the coupling between power measures in photon emission and EEG power during the same cognitive states would be extremely strong. We also reasoned that any opacity from the EEG cap would not be an issue because we were interested in the strength of the temporal correlates with quantitative fluctuations in UPE.

According to our usual protocol [12] spectral analyses and power in μV^2/Hz were integrated over traditional frequency bands by using Matlab software for the delta (1–3.9 Hz), theta (4–7.9 Hz), low alpha (8.0–10.5 Hz), high alpha (10.6–13 Hz), low beta (13.1–20 Hz, high beta (21–35 Hz), and gamma (35.1–50 Hz) frequency bands. The averaged UPEs from the right hemisphere as measured by the PMT for each interval were correlated with EEG power (in μV^2/Hz) values from artifact-corrected records for each interval for each of the 9 intervals (3 for each of 3 persons) of "thinking about light". A separate correlation was completed for the 9 intervals when the subjects were not thinking about light. Correlations (Spearman rho and Pearson *r*) were employed to discern the strength of associations between fluctuations in photon emission energy and power within specific EEG bands.

As can be seen in Fig. 2, the correlation between the average fluctuations in quantitative EEG power (sum of all bands) over the left prefrontal region for the intervals of "imaging light" and the fluctuations in UPE from the right hemisphere was 0.95 ($p < 01$). On the other hand the energy for photon emissions was *negatively* correlated with the power within the beta band (13–20 Hz) over the *right* frontal (rho and $r = -0.65$, $p < 05$) lobe with marginal effects over the right temporal lobe (T4, $r = -0.40$, $p < 10$). There was no significant correlation ($r = 0.13$, $p > 05$) between the energy of biophoton emission from the right hemisphere and the EEG power over the left prefrontal region during the intervals associated with not thinking about white light, i.e., thoughts about mundane events.

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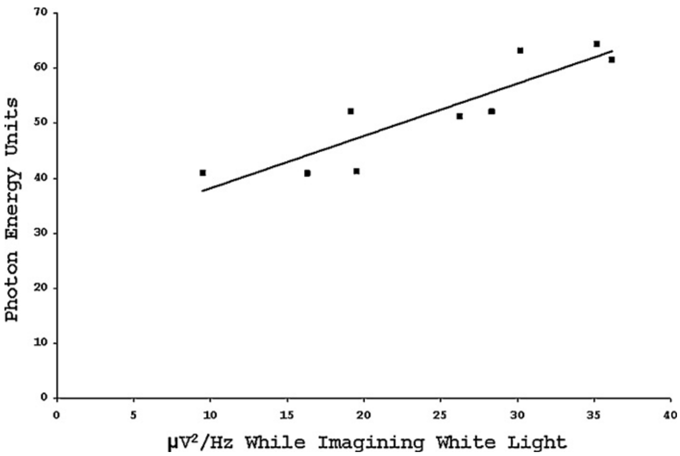

Fig. 2. Regression line and plot for the correlation between photon energy units (1 unit = 5×10^{-11} W/m^2) measured by the PMT over the right hemispheres and EEG power (averaged μV^2/Hz for all bands) over the left prefrontal regions during intervals of "imagining white light". These values were not correlated significantly during reference intervals (casual thinking).

Independent quantitative validations of the PMT's specific sensitivity were determined by chemical reactions. The easily discernable exothermic reaction when lithium chloride is dissolved in water did not produce any changes in photon emission. This was tested in our standardized procedure [11] by injecting different small volumes of water through intramedic tubing into lithium chloride within cell culture dishes over the PMT aperture that was housed in black box covered with several layers of cloth kept in a dark room in the basement (windowless) laboratory. On the other hand the injection of 0.1 cm^3 of 3% (w/v) of hydrogen peroxide into culture dishes containing 6 cm^3 of sodium hypochlorite solution (available chlorine >4%) produced sharp, transient (about 1 s) increases in photon emission of over 50 units. When the quantum efficiency was accommodated the calculated photon energy was within the same order of magnitude as that expected from the numbers of singlet oxygen molecules involved with this reaction [11].

The results of this study replicate our previous results that when normal volunteers are dark adapted and think about white light, reliable, discernable and physiologically realistic densities of photons are emitted from the (right side) of the cerebrum. We selected the simple instruction to "visualize white light" to assess Bókkon's [1–4] innovative concepts that when a person "generates" an image during thinking or dreaming there are actual photons emitted with the cerebral matrices. Given the recent calculations by Bókkon et al. [4] that photon intensity is higher inside of cells than outside during "visual perception", we had reasoned that some extracerebral emission (even from visual imagery) should occur at levels sufficient to be measured in the dark with a PMT. This instrument is required because the actual magnitude of the increase in photon emission while thinking about white light compared to casual ideation was about 100,000 times weaker than star light (mlux) on a clear moonless night.

The effect size of the "right hemisphere effect" for photon emission during imaging was much greater than the small increase in blood flow [20], electroencephalographic voltage [16] for alpha activity, or, proportion of white matter compared to the left hemisphere. At a distance of 0.15 m for our system where a 1 unit increase is 5×10^{-11} W/m^2, the increased photon emission while thinking of white light would be equivalent to between 3 and 6×10^{-12} J/s when the cross-sectional area of the cerebrum is accommodated. When divided by the essential quantum of 2×10^{-20} J/action potential [18] and assuming an average of ~20 Hz per neuron, this would suggest that an additional 10^7 (on average) neurons within the cerebral cortices were activated during the imagining of light by the subjects.

These values are remarkably similar to those predicted by Bókkon et al. [3,4] for the numbers of photons involved with the final stage of non-linear (iterative) biochemical reactions in the V1 and V2 regions of the cerebral cortices during visual imagery. The estimates are even more convergent when Bókkon et al's calculations [4] are considered. For comparison fMRI measurements during reconstructions of visual experiences can involve voxels with summed volumes of about 100–150 mm^3 [5]. With an average of ~58 neurons per 0.001 mm^3 within the cerebral cortices, the total numbers of neurons for this volume would be about 10^7. In comparison one cerebral hemisphere contains about 2×10^{10} cortical neurons [17].

One argument that the photon emissions were functionally coupled to cognition was the strong correlation between the power spectra of the quantitative EEG during intervals when the light was being visualized and the absolute increase in UPE. The net change in EEG power associated with the range in photon density while imagining white light (vs. not imagining) was ~25 μV^2/Hz. When this value is multiplied by the sum of 1 Hz increments within about 15 Hz (low beta band) the potential is 20 μV. The net change in energy detected by the PMT during this activity was ~2×10^{-9} W/m^2 or 3×10^{-10} J from the cerebrum at the measured distance. The quotient of energy to voltage would be ~10^{-5} A s or the equivalent of 10^{14} charges. With the summed movement of about 10^6 to 10^7 ions across a membrane [18] to produce an action potential, this would involve about 10^7 to 10^8 neurons.

A particularly intriguing observation was the strong positive correlation between EEG power from the left prefrontal region and UPE from the right side of the head but negative correlation between frontal and temporal EEG power (within the beta range) over the right hemisphere and UPE. The left prefrontal positive correlation is consistent with the volitional and intentional nature of the task. However, this inverse relationship between cerebral fluctuation in electroencephalographic voltage and photon levels from the right hemisphere would be consistent with the principle of conservation of energy.

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