Psychophysical interactions with photon polarization: Two exploratory studies

Dean Radin & Loren Carpenter

Institute of Noetic Sciences

Correspondence concerning this article should be addressed to

Dean Radin, Institute of Noetic Sciences, 101 San Antonio Road, Petaluma, CA 94952 USA

dradin@noetic.org

THIS PAPER IS UNDER REVIEW FOR PUBLICATION. Please do not use any portion without authors' permission.

PSYCHOPHYSICAL INTERACTIONS WITH PHOTON POLARIZATION

Psychophysical interactions with photon polarization: Two exploratory studies

Dean Radin & Loren Carpenter

Institute of Noetic Science

Abstract

The present study explored possible psychophysical interactions between focused mental intention and the electromagnetic field vector, i.e., polarization. To detect the hypothesized effect, a laser beam was passed through horizontal and vertical polarizers. Participants were asked to focus their attention on the beam between the two polarizers while holding the intention for the beam's polarization to rotate. If the photons' electric field vector was affected, then the illumination intensity of the beam exiting the second polarizer should increase. Two exploratory experiments both showed results contrary to the hypothesis, with illumination decreasing during periods when intention was focused toward the beam as compared to periods where attention was withdrawn. Reanalysis of data from previously published experiments, also involving mental influence of beams of light, but designed for different purposes and originally analyzed in other ways, also showed a reduction in light intensity during periods of focused attention. These studies suggest that psychophysical interactions with light appears to result in scattering or absorbing photons. Further research is warranted to confirm these results.

Keywords: psychophysical, mind-matter, consciousness, photon, polarization

Introduction

Experiments investigating the role of consciousness in the physical world have explored the effects of focused mental intention on a broad array of physical systems. A systematic review of that literature is beyond the scope of this article, but such a review would include target systems such as the growth of cell cultures and plants, the electrochemical structure of water, statistical behavior of tossed dice, outputs of electronic random number generators, and radioactive decay latencies, fluctuations in the human nervous system, and animal and human health (Heath, 2011; Jahn & Dunne, 1987; Radin, 2006; Schwartz, 2018).

PSYCHOPHYSICAL INTERACTIONS WITH PHOTON POLARIZATION

In many of these experiments, the absolute magnitude of the reported effects was small, requiring many repeated samples to detect the hypothesized psychophysical phenomena. In an attempt to improve experimental yields, the use of increasingly sensitive targets has been explored, including the direction of an electron's magnetic moment (i.e., its spin), ion transport in water, or the behavior of photons in optical interferometers (Bryan, R. A., 2006; Guerrer, 2019; Kernbach, Zamsha, & Kravchenko, 2016; Radin et al., 2016).

Continuing along this vein, we investigated the effects of focused mental intention on the orientation of a photon's electric field vector, i.e. its polarization. The idea underlying this experiment was based on an analog of the Faraday effect (Atkinson, 2001), in which photon polarization can be affected by applying a magnetic field to the light as it passes through an insulating medium, like glass. The question we explored was whether a Faraday-like polarization rotation could be induced by distant intention alone.

Method

Hypothesis

The hypothesis was that the vector angle of a photon's electric field, i.e. its polarization, would be influenced by mental attention focused on the beam while holding the intention to "twist" the beam.

Apparatus

To test this hypothesis, we used an apparatus that passed a laser beam through crossed linear polarizers, as illustrated in Figure 1. The illumination intensity of the beam passing through the second polarizer is substantially attenuated (how much attenuation depends on the precision of the polarizers), blocking almost all light from reaching the camera. However, if the beam between the two polarizers is influenced by introducing another polarizer or other means, then more light would pass through the second polarizer as a straightforward consequence of the vector nature of the electromagnetic field.

PSYCHOPHYSICAL INTERACTIONS WITH PHOTON POLARIZATION

Figure 1. Apparatus used in experiment 1. The **S** (“standard”) location on the line camera measured the laser power after passing through a neutral density filter, the **B** (“bounce”) location measured the intensity of the beam between the vertical (V) and horizontal (H) polarizers, and the **P** (“polarized”) location measured the intensity of the beam after it passed through both polarizers. The intentional target was the portion of the laser beam between the two polarizers.

Participants in this experiment were asked to focus their attention at the portion of the beam between the two polarizers, and then mentally “twist” the beam at that point. One strategy used to accomplish this task was to imagine that the laser beam was a taut string held by the thumb and first finger of both hands. During the concentrate epochs, the string could be twisted by having the thumb and finger of the left and right hands rotate the string in opposite directions.

The measurement of interest was the illumination intensity of the beam as it passed through the second polarizer (**P** in Figure 1). This value was determined as the mean intensity recorded by the pixels at a predefined portion of the linear camera for the duration of each camera snapshot. We also monitored the power output of the laser (the “standard” or **S** beam in Figure 1) as well as the illumination level of the beam that passed between the polarizers (the “bounce” or **B** beam in Figure 1). The **S** measure was a baseline metric used to monitor drifts in laser power output due to changes in temperature, vibration, and other environmental factors. The **B** measure was used to gauge the beam intensity before it entered the second polarizer.

Figure 2 shows the average illumination levels recorded in the line camera across one session of 12,000 camera snapshots. The **S** (“standard”) metric for each frame was calculated as the mean illumination from pixel 100 through 275, the **P** (“polarize”) metric was the mean from pixel 950 to 1200, and the **B** (“bounce”) metric was the mean of pixel 1850 to 2048.

PSYCHOPHYSICAL INTERACTIONS WITH PHOTON POLARIZATION

Figure 2. Mean illumination levels over 12,000 frames in a line camera with 2048 pixels. The left-most spike measured **S**, the “standard” laser intensity after passing through a neutral density filter to reduce the beam intensity. The middle spike measured **P**, the laser beam intensity after passing through both polarizers. The right spike measured **B**, the illumination of the beam between the two polarizers.

For Experiment 1, the optical apparatus was assembled on an Edmund Optics (Barrington, NJ) optical breadboard, which was in turn mounted inside a Zarges (Charlotte, NC) K-470 aluminum case, which was closed and light-tight when the experiment was running. The illumination source was a CrystaLaser (Reno, NV) 633 nm single longitudinal mode, frequency and temperature-stabilized diode laser. The line camera was a Thorlabs (Newton, New Jersey) LC100 2048-pixel Si CCD array. Other optical assembly components, including the linear polarizing filters, neutral density filters, and optical posts and related hardware were also purchased from Edmund Optics. The assembled apparatus weighed about 30 pounds, and it rested upon a Herzan (Laguna Hills, CA) Onyx-7M vibration isolation table with pneumatic dampeners. A Panasonic Toughbook PC running Windows 7 was used to control the experiment and record the data. The experiment was programmed using Matlab (Mathworks, Natick, MA) version R2014b.

Experiment 2 was designed to replicate the first experiment with a newly designed, more stable optical apparatus. In addition, rather than use a single line camera to record the **P**, **B** and **S** beams, a Thorlabs DCC1545M monochrome camera was used to record the **P** and **B** beams, and

PSYCHOPHYSICAL INTERACTIONS WITH PHOTON POLARIZATION

a Thorlabs PM200 and S121C sensor was used to measure the laser power output **S**, as illustrated in Figure 3. In the first case, the illumination level was the mean pixel intensities recorded by the camera during each camera snapshot. In the latter case, the laser power output was returned by the Thorlabs device.

The optical apparatus employed a custom-built Arduino-based temperature control system, designed to maintain constant temperature inside the Zarges housing. The experiment was controlled by a program written in LabView (National Instruments, Austin, TX) and run on an Alienware 17 (Dell Inc., Round Rock, TX) computer running Microsoft Windows 10.

Figure 3. Experiment 2 apparatus. The **S** or “standard” meter measured the laser power, the **B** or “bounce” camera measured the intensity of the beam between the vertical and horizontal polarizers, and the **P** or “polarized” camera measured the intensity of the beam after it passed through both polarizers.

Protocol

In Experiment 1, the participant sat about a meter in front of the optically sealed apparatus. The controlling computer was located a half-meter away from the apparatus, on a separate table. During the experiment, a recorded voice announced, “Now please relax,” which directed the participant to withdraw attention from the optical system, or it announced, “Now please concentrate,” which directed the participant’s intention toward the target area with intention to twist the laser beam.

PSYCHOPHYSICAL INTERACTIONS WITH PHOTON POLARIZATION

Each attentional epoch was 30 seconds in duration, during which 20 camera snapshots per second were recorded by the computer. One experimental session consisted of 20 epochs, alternating between relax and concentrate conditions, thus a total of 12,000 camera frames were recorded per session. For feedback, during concentrate epochs the computer drew a graph indicating the real-time illumination of the polarized beam. During relax epochs, the graph remained blank.

The experiment was planned to consist of 15 such sessions. A matched set of 15 control sessions, used to test the apparatus, protocol, and analytical procedures for possible systematic biases, was conducted using the same apparatus and controlling program, and in the same location as the experiment, but without anyone present.

Experiment 2 followed a similar protocol, with a few variations. Each test session consisted of 10 concentrate and 10 relax epochs alternated, each epoch was 25 seconds in length, and 10 camera frames and laser power samples were collected per second, for a total of 5,000 samples per session. This experiment also added random inter-epoch periods of 1 to 3 seconds to decouple the attention epochs from potential cyclic behavior in the laser or environment; on average this added about 250 additional camera frames per session. The experimental phase of this study was planned for a total of 30 sessions, and the control phase consisted of 100 sessions. A larger number of control sessions were run to provide additional statistical power for detecting possible systematic biases.

Analytical Procedure

Figure 4 (top) shows that the raw illumination data tended to drift in a nonlinear fashion. The largest component driving the drift was likely due to variations in ambient temperature. To adjust for these drifts, a Savitzky-Golay third-order linear polynomial, with a window size of 10% of the sample length, was applied to each session's **S**, **B** and **P** signals (Savitzky & Golay, 1964). The resulting polynomial was subtracted from the original data, and the residuals were used in the remainder of the analysis (Figure 4, second from top).

Figure 4. (Top) Illumination samples (black dots) and nonlinear fit (white line) in data from one session in second experiment. (Second from top) Residuals produced by the difference between the samples and nonlinear curve. (Third from top) Histogram of residuals. (Bottom). Autocorrelation of residuals.

PSYCHOPHYSICAL INTERACTIONS WITH PHOTON POLARIZATION

To then adjust the **B** and **P** residuals for possible variations in laser power output (**S**), the **B**, **P**, and **S** arrays were each z-score normalized (call these **B_z**, **P_z**, and **S_z**), and then **B'** = **B_z** – **S_z**, and **P'** = **P_z** – **S_z**. Analysis of the adjusted residuals indicated small autocorrelations between samples up to lag 3, so all data were down-sampled by a factor of 5. Figure 4 (bottom two graphs) shows a histogram and autocorrelation of the residuals after down-sampling. By inspection the resulting samples appeared to be normal and independent, but to confirm that impression Durbin-Watson (Durbin & Watson, 1971) and Jarque-Bera (Jarque & Bera, 1980) tests were applied to these samples (Matlab functions *dwtest* and *jbtest*). Those tests confirmed that the down-sampled residuals conformed to parametric statistical assumptions, thus a two-sample t-test was used to compare means between the concentrate and relax conditions in each session.

Because the t-tests involved large degrees of freedom, the resulting t scores per session were distributed essentially as standard normal deviates (z scores). Those scores were combined over all experimental (and separately all control) sessions using the Stouffer Z method (Stouffer, Suchman, DeVinney, Star, & Williams, 1949). The same analysis was then performed with the condition assignments lagged from -5 to +20 seconds to test the expectation that the cognitive load associated with switching attention between concentrate and relax conditions would take a few seconds, and thus the maximum results ought to be observed at a lag of +3 to +5 seconds.

Results

Experiment 1

The 15 planned sessions were contributed by the authors. Figure 5 (left) shows the results of Experiment 1 in terms of a Stouffer Z score for experimental sessions combined (black dots) and control sessions combined (white dots). No prediction was made for the **B'** "bounce" measure, but the hypothesis predicted that the **P'** polarized measure should increase if the laser beam's polarization was affected by the intention to "twist" the beam. Instead, both the bounce and polarize results were negative, reaching minimum values at lags of +10 to +11 seconds, and then returning to baseline by lag +20 seconds. The control data fluctuated around chance for both measures.

PSYCHOPHYSICAL INTERACTIONS WITH PHOTON POLARIZATION

Figure 5. (Left) Results of first experiment (black dots) and control (white dots) for bounce and polarized illumination levels between concentrate and relax epochs, expressed in terms of a Stouffer Z score. (Right) Same analyses applied to second experiment.

Experiment 2

Experiment 2 consisted of the planned 30 experimental sessions contributed by the authors and two other participants, along with 100 control sessions. Figure 5 (right) shows that at a +4 second lag both the bounce and polarize results were again *negative*, and in this study reaching statistically significant levels beyond 2 sigma (standard errors). Control data were at chance for both measures.

Discussion

Two exploratory experiments designed to explore a possible psychophysical interaction with photon polarization resulted in evidence opposite to the original hypothesis. Figure 6 shows the results of the two studies combined. Rather than intention causing laser intensity passing through crossed linear polarizers to increase, light intensity was attenuated. The combined control results suggest no systematic biases in the apparatus, protocol, or analytical methods that might have caused these results. An important limitation of these studies is that the participants

PSYCHOPHYSICAL INTERACTIONS WITH PHOTON POLARIZATION

were the authors and two other individuals, thus it is not known whether the observed outcomes would generalize to the population at large. In addition, as exploratory studies, no predictions were made for what lag would show optimal deviations, so no adjustments were made for multiple analyses.

Figure 6. Results of both experiments (black dots) and controls (white dots) combined.

One way to interpret this outcome is that focusing attention toward a laser beam scatters or absorbs photons. In either case, such effects would result in an attenuation of light intensity. Such a possibility is intriguing because it is reminiscent of anecdotal reports of “cold spots” associated with ostensible poltergeist and haunting episodes (Andrews, 1977; Batcheldor, 1966).

To further examine this possibility, data collected in experiments designed to investigate other hypotheses, but also involving attention focused toward laser beams, were examined from four previously published optical experiments (Radin et al., 2013; Radin et al., 2016; Radin et al., 2019). The data consisted of 4,800 experimental sessions and 7,400 control sessions, comprising a total of 992 hours of experimental efforts by several hundred individuals, where the individuals were engaged in focusing their attention toward or away from the optical system, and 1,508 hours of control runs where no one was interacting with the system.

Each sample of data within a session consisted of the mean illumination value of a camera frame. To analyze the array samples collected during each test session, the first step was

PSYCHOPHYSICAL INTERACTIONS WITH PHOTON POLARIZATION

removing outliers from the array using the Matlab 2019b *rmoutliers* function (this removes samples beyond three scaled median absolute deviations). Then, based on the remaining samples, a Solvay-Galitsky second order polynomial, with a sliding window the equivalent of one minute in length, was used to form a nonlinear curve from the outlier-removed array.

That array was then subtracted by the nonlinear curve to form nonlinear residuals, and then to further ensure that the overall mean was zero and the array contained no linear drift, the resulting samples were detrended (Matlab *detrend* function). The resulting data were then segmented into samples collected during the two attention conditions, and subsequently compared using a two-sample t-test. Because the degrees of freedom in the t-test were over 500 in each subsample, the resulting t score was equivalent to a z score. The z scores were cumulated to assess differences in the mean illumination levels in the experimental and control sessions, and then the attention conditions were lagged from -2 to 10 seconds to explore an expected increase in the differential effects due to the cognitive cost of switching attention.

Figure 7. (Left) Data array as circles and nonlinear curve as white line. (Right) Residuals.

The results shown in Figure 8 indicate that in experimental studies the level of illumination significantly declined during attention vs. relax conditions, reaching maximum deviations beyond 4 sigma at lags of 7 to 8 seconds. By contrast, the same measures at the same lags were at chance. This effect, which was not originally hypothesized or tested, is consistent with the results observed in the polarization experiments.

Figure 8. Effect sizes of experimental (black dots) and control (white dots) differential effects in previously published optical studies involving attention focused toward and away from laser beams, with one standard error bars.

As with any exploratory experiment obtaining surprising results, interpretations must be approached with caution. In the present case, from a statistical perspective the outcome of the polarization experiments, bolstered by a substantial block of data from similar studies conducted for other purposes, is intriguing enough to suggest that focused attention attenuates the illumination intensity of a laser beam. Whether this effect is generally due to focused attention or to unidentified systematic errors, the results justify further study of this phenomenon.

References

- Andrews, A. K. (1977). The use of instrumentation to detect temperature fields in haunting, poltergeist, and experimental PK investigations. *Journal of the American Society for Psychical Research*, 71(3), 333–334.
- Atkinson, R. (2001). Faraday and Kerr Rotation: Phenomenological Theory. In K. H. J. Buschow, R. W. Cahn, M. C. Flemings, B. Ilshner, E. J. Kramer, S. Mahajan, & P. Veyssire (Eds.), *Encyclopedia of Materials: Science and Technology* (pp. 2839–2843). <https://doi.org/10.1016/B0-08-043152-6/00507-6>
- Batcheldor, K. J. (1966). Report on a case of table levitation and associated phenomena. *Journal of the Society for Psychical Research*, 43(729), 339–356.
- Bryan, R. A. (2006). Mental control of a single electron. *Physics Essays*, 19, 169–173.

PSYCHOPHYSICAL INTERACTIONS WITH PHOTON POLARIZATION

- Durbin, J., & Watson, G. S. (1971). Testing for serial correlation in least squares regression.III. *Biometrika*, 58(1), 1–19. <https://doi.org/10.1093/biomet/58.1.1>
- Guerrer, G. (2019). *Consciousness-related interactions in a double-slit optical system*. <https://doi.org/DOI10.17605/OSF.IO/QDKVX>
- Heath, P. R. (2011). *Mind-Matter Interaction: A Review of Historical Reports, Theory and Research*. Jefferson, N.C: McFarland.
- Jahn, R. G., & Dunne, B. J. (1987). *Margins of Reality*. New York: Jovanovich.
- Jarque, C. M., & Bera, A. K. (1980). Efficient tests for normality, homoscedasticity and serial independence of regression residuals. *Economics Letters*, 6(3), 255–259. [https://doi.org/10.1016/0165-1765\(80\)90024-5](https://doi.org/10.1016/0165-1765(80)90024-5)
- Kernbach, S., Zamsha, V., & Kravchenko, Y. (2016). Experimental Approach Towards Long-Range Interactions from 1.6 to 13798 km Distances in Bio-Hybrid Systems. *NeuroQuantology*, 14(3). <https://doi.org/10.14704/nq.2016.14.3.917>
- Radin, D. I. (2006). *Entangled minds*. New York: Simon & Schuster.
- Radin, D. I., Michel, L., Galdamez, K., Wendland, P., Rickenbach, R., & Delorme, A. (2012). Consciousness and the double-slit interference pattern: Six experiments. *Physics Essays*, 25(2).
- Radin, D., Michel, L., Pierce, A., & Delorme, A. (2015). Psychophysical interactions with a single-photon double-slit optical system. *Quantum Biosystems*, 6(1), 82–98.
- Radin, D., Michel, L., & Delorme, A. (2016). Psychophysical modulation of fringe visibility in a distant double-slit optical system. *Physics Essays*, 29(1), 14–22.
- Savitzky, A., & Golay, M. (1964). Smoothing and differentiation of data by simplified least squares procedures. *Analytical Chemistry*, 36, 1627–1639.
- Schwartz, S. A. (2018). Water, Wine and the Sacred, an Anthropological View of Substances Altered by Intentioned Awareness, Including Objective and Aesthetic effects. *EXPLORE*. <https://doi.org/10.1016/j.explore.2018.03.010>
- Stouffer, S. A., Suchman, E. A., DeVinney, L. C., Star, S. A., & Williams, R. M. (1949). *The American soldier: Adjustment during army life (Vol. 1)*. Princeton, NJ.: Princeton University Press.