Bial Foundation Final Report: Grant 170/06

What does the seer see?

Dean Radin, PhD [1] & Ana Borges, JD, MS [2]

Objective: A broad range of human activity is involved in anticipatory behavior, from the placebo effect, to predicting the next influenza strain, to catching a baseball. Most models of anticipation take for granted that events unfold in a unidirectional flow of time, from past to future. Two experiments were conducted to test this assumption.

Design: Pupillary dilation, spontaneous blinking, and eye movements were tracked before, during and after participants viewed photographs with varying degrees of emotional affect. Photos were selected uniformly at random with replacement. Experiment I used 592 photos from the International Affective Picture System; Experiment II used a custom-designed pool of 500 photos. Eye measurements prior to exposure to emotional and calm photos were compared using nonparametric differential measures.

Outcome measures: Eye data were predicted to show larger anticipatory responses before emotional photos than before calm photos, under conditions that excluded sensory cues, statistical cues, and other conventional means of inferring the future.

Results: Pupillary dilation and spontaneous blinking increased more before emotional vs. calm photos (combined $p = 0.00009$). Horizontal eye movements indicated a brain hemisphere asymmetry before viewing the photos that was appropriate to both the emotionality ($p = 0.05$) and the valence of the future images ($p = 0.01$). Five participants selected because they independently obtained significant differential effects in pupillary dilation showed positive correlations between their eye movements before vs. during exposure to randomly selected photos ($p = 0.002$). A possible "transtemporal interference" effect was observed when the probability of observing future images was varied ($p = 0.05$, two-tailed). Gender splits on these same tests showed that overall females tended to perform better than males.

Conclusions: In alignment with results of conceptually similar studies, these experiments indicate that in principle some seers can indeed see the future. This implies that comprehensive models of anticipation may require consideration of transtemporal influences.

Keywords: retrocausation, eye gaze, pupillary dilation, presentiment

[1] Institute of Noetic Sciences, Petaluma, CA, USA
[2] Department of Psychology, University of Northampton, UK.

INTRODUCTION

The placebo effect is a health outcome modulated by one's expectations, or anticipation. In sports, anticipation allows us to hit and catch objects moving faster than we can see. It prevents us from passing out when standing up from a sitting position,[1] it determines what we see or fail to see,[2] and it forms the basis for a class of humor.[3] A large percentage of the world's workforce is engaged in better understanding and using anticipation, from finance, politics, weather forecasting, and marketing, to counterterrorism and predicting the next health epidemic or earthquake. It is one of the principal characteristics of living systems, perhaps *the* key feature that distinguishes the living from the nonliving. As biologist Robert Rosen wrote,

> Strictly speaking, an anticipatory system is one in which present change of state depends upon future circumstances, rather than merely on the present or past. As such, anticipation has routinely been excluded from any kind of systematic study, on the grounds that it violates the causal foundation on which all of theoretical science must rest, and on the grounds that it introduces a telic element which is scientifically unacceptable.[4]

To avoid the telic veneer, most efforts to model anticipation assume that it can be understood in the form of cybernetic-style interactions between historical precedence and memory, new information, and projected scenarios, all operating within the constraints of conventional cause and effect sequences. But is this assumption correct? Could some forms of anticipation include not just an appearance of teleology, but actual influences from future conditions? In more general terms, can the legendary prophet or seer actually "see" the future?

Superstitions about the organ of sight – the eye – can be found throughout history and across all cultures. From the power of "fascination" attributed to the eye by the Greeks and Romans, to the Hindu and Buddhist symbols for enlightenment, to the omniscient Eye of Providence on the US dollar bill, forces thought to emanate from the eye are both widely feared and revered.[5] Sigmund Freud called fear of the evil eye "the most uncanny and universal" superstition,[5,p.61] and innumerable legends recount tales of prophets or seers, whose extraordinary gaze is said to divine the future.

Could these ancient superstitions – which are still vibrantly alive as evidenced by thousands of websites selling amulets to protect against the evil eye – contain a kernel of truth? Possibly, because a class of scientific experiments suggests that some of the folklore might be worth reconsidering. Meta-analyses of experiments studying the "feeling of being stared at," under conditions that exclude sensory cues and expectation biases, indicate that on average humans do respond both consciously and unconsciously to another's unseen gaze.[6-7] Meta-analyses of experiments testing mind-matter interactions in random physical systems also support the idea that highly focused intention, such as that associated with an intense gaze, appears to influence aspects of the objective world.[8-9] The measured effects are often small in magnitude and nontrivial to replicate, but based on such experimental support,[10-11] we were emboldened to investigate whether the seer can see the future, specifically whether it was possible to detect such an ability in the behavior of the human eye.

To do so, we considered another common belief about the eye, one no longer regarded as superstition. The poetic description of the eye as the "window to the soul" reflects the idea that thoughts and feelings are reflected in the behavior of the eyes.[12] In psychophysiological terms, subjective states can be inferred from pupillary dilation, spontaneous blink rate, and eye movements. Pupillary dilation has been used to study attention, cognitive processing load, emotional responses, anticipation, and the degree of balance between sympathetic and parasympathetic activation.[13-14] Eye gaze direction reflects real-time allocation of attention,[15] mental imagery while imagining a scene[16-17], and preferential processing in the left vs. right brain hemisphere.[18] Spontaneous eye blink rate increases with a rise in dopamine, the brain neurotransmitter associated with factors as diverse as fine motor coordination, insulin regulation, physical energy, and emotional response.[19]

The experimental design was based on experiences often described as a foreboding that something meaningful was about to unfold. We call this experience *presentiment*. To detect this effect, one or more measurements of nervous system activity are collected before, during and after a participant is exposed to stimuli of varying emotional affect. Presentiment predicts that the nervous system will respond differently before emotional vs. calm events under conditions that exclude sensory cues and anticipatory biases. This design resembles psychophysiological experiments using "non-aging foreperiods," which refers to studies involving unpredictable latencies before successive stimuli.[20]

Previous experiments studying presentiment effects have monitored skin conductance level[21-29], non-specific skin conductance response[30-31], heart rate[26-27], brain electrical activity[32-35], and blood oxygenation levels in the brain measured with functional MRI.[36] Stimuli have included emotional vs. calm photographs, stylized happy vs. sad faces, auditory startle tones vs. silence, and electrical shock vs. no-shock. In some studies, participants initiated trials of fixed lengths at will, in others stimuli appeared spontaneously at random times. As of late 2007, at least 14 investigators have reported 20 experiments of this type, of which 17 were in the predicted direction and 10 were significantly positive.[37] Many of these reports included discussions exploring whether the results might be explained by various artifacts, including anticipatory strategies developed through implicit learning. Simulations of idealized strategies suggest that artifacts resembling presentiment effects can be produced when the experiment involves asymmetric distributions of dichotomous stimuli, combined with assumptions about progressively rising levels of autonomic nervous system arousal between successive emotional stimuli.[38] But analyses of actual data collected in these experiments do not support the assumptions of these simulations. To date, no artifacts have been found that can adequately explain these effects via conventional means.

This paper reports two new experiments examining this phenomenon to study what the seer sees, i.e. physiological responses of the eye to future events. Experiment 1 assumed (a) that presentiment effects are largely mediated by the sympathetic nervous system, which would cause the eye to dilate more before emotional events than before calm events, (b) that based on previous speculations about brain lateralization effects, presentiment information would be processed preferentially in the right brain hemisphere in right-handed people,[39-40] and (c) people who showed positive presentiment effects would also show positive correlations between their eye movements recorded before vs. while viewing the stimuli, reflecting the speculation that eye

movements associated with future inspection of a picture might retroactively influence eye movements before that image appeared.

Experiment II investigated what presentiment responds to – the probable present or the actual future.[41-43] If presentiment reacts more to present-time potential events with high *a priori* probabilities of being actualized, even when those events do not manifest as the actual future, then it implies that presentiment perceives the probable present rather than the actual future. But if presentiment reacts to actual future events even when they are *a priori* not likely to occur, then it suggests that presentiment perceives the actual future.

METHOD

Participants

Participants were recruited by convenience among staff members and visitors to the Institute of Noetic Sciences (IONS), and among attendees at an IONS conference. All volunteers in Experiments I were adults; one participant in Experiment II was a minor female. All volunteers (or adult guardians) read and signed informed consents prior to participating.

Equipment

Eye data were collected using a video eyetracking system that provided eye movement direction and pupil diameter measures at 60 samples per second (Eye-Trac 6000, Applied Science Laboratories, Bedford, MA, USA). Programs written by the first author in Microsoft Visual Basic 6 controlled the random selection and display of picture stimuli, and coordinated the two Microsoft Windows XP computers used to control the experiment. One program running on the "stimulus PC" responded to the participant's interactions, selected and displayed the pictures, communicated with the eyetracking system to inform it about the on-going experimental condition (between trials, prestimulus period, etc.), and retrieved random numbers as needed by a random number generator. Another program running on an "eyetrack PC" continuously collected eye data from the eyetracking systems. The conceptual design of this layout is illustrated in Figure 1.

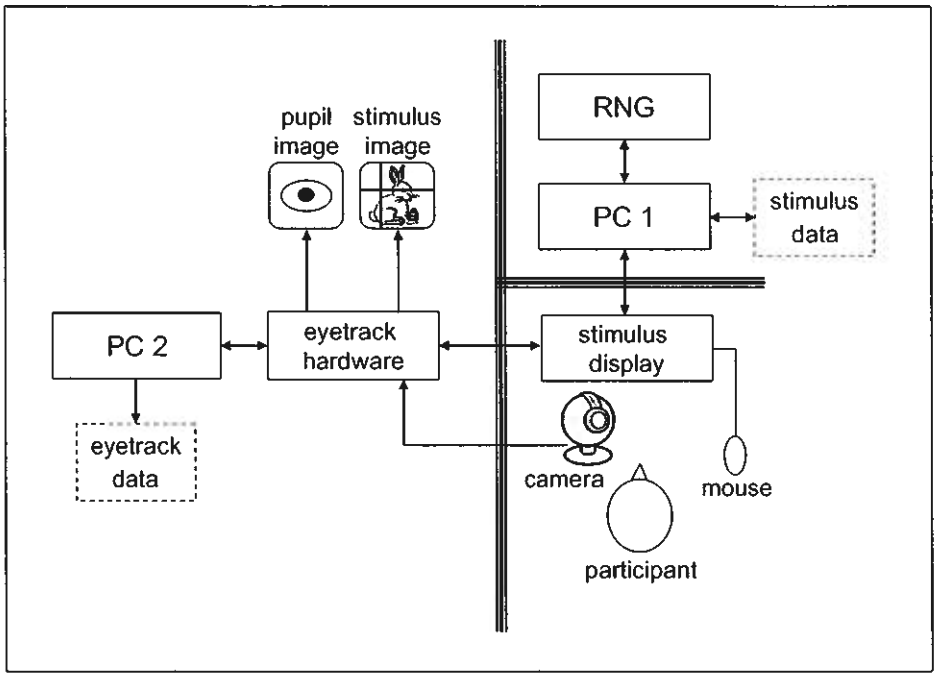

Figure 1. Participants conducted the study in a cubicle containing the stimulus display, a mouse and keyboard, and a small CCD camera used to image the participant's eye. The other equipment included a computer (PC1) used to select, display and record the picture stimuli, a truly random number generator circuit used to select the stimuli (for Experiment II), eyetracking hardware (Eye-Trac 6000 control unit), one video monitor displaying the pupil and a second displaying the stimulus overlaid with crosshairs indicating where the eye was looking, and a second computer (PC 2) used to collect the eyetracking data.

Stimuli

Experiment I used stimuli consisting of 592 images from the International Affective Picture System.[44] These color photographs provide a wide range of emotional affect and valence, and each image is associated with an international standardized score for these two factors. Arousal scores for the set we used ranged from 1.72 (low affect) to 7.35 (high affect), and valence scores ranged from 1.31 (negative affect) to 8.34 (positive affect). In Experiment II we generated a new picture pool of 500 images consisting of 250 emotional images selected from a website that hosts competitions for humorous and bizarre photo-realistic composite images, including human-animal and human-vegetable hybrids.[45] From another website, 250 calm photographs were selected,[46] including images of clouds, lakes, and other low affect scenes. The calm images were then edited into grayscale to further reduce color-associated affect.

Procedure

The procedure used in the two experiments was as follows: When a participant (P) arrived at the lab, P read and signed an informed consent, then the experimenter (E) asked P to rest his or her chin on the Eye-Trac 6000's head and chin rest apparatus. After adjusting this apparatus and focusing the camera on P's left pupil, E dimmed the lights and ran an eye calibration procedure on P. Then E advanced the computer display to a screen showing a gray

rectangle on a black background. The target area subtended visual angles of 21.5° wide × 17.8° high from the perspective of an eye positioned in the eyetracker.

E instructed P that when the target screen was shown to click the mouse button at will to begin each trial. As shown in Figure 2, after the button press the screen remained dark for 3 seconds, then an image was randomly selected from the stimulus set and displayed for 3 seconds (Experiment I) or 5 seconds (Experiment II), and then the screen returned to dark for 3 seconds. At this point a message appeared on the screen alerting P to advance to the next trial at will. Before beginning the session, E asked P to feel the emotions evoked by each successive image, if any, and to allow his or her eyes to freely wander over the display screen both before and during stimulus exposure.

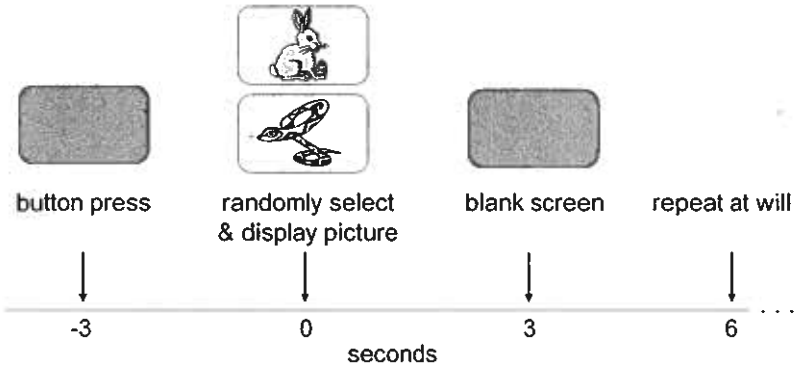

Figure 2. Each trial began with a button press at will (at -3 seconds), a photograph was randomly selected and shown at stimulus onset (0 seconds), and then the screen went black at stimulus offset (+3 seconds in Experiment I, +5 in Experiment II). Three seconds later the next trial could begin.

Experiment-specific procedures

In Experiment I eye data of interest per *trial* consisted of 1 second of baseline, 3 seconds pre-stimulus, 3 seconds of during stimulus display, and 3 seconds of post-display, for a total of 10 seconds × 60 samples per second or 600 samples. In Experiment II the target was displayed for 5 seconds, so each trial consisted of 12 seconds or 720 samples of eye data.

In Experiment I the stimulus pictures were selected uniformly at random, with replacement, from the 592 picture IAPS set. Eye data were collected on the left eye. The random stimulus selections were performed by the Microsoft Visual Basic 6 pseudorandom number generator (PRNG), reseeded with the value of computer's CPU clock immediately after the prestimulus period ended. The prestimulus timer was programmed to fire 3 seconds after the trial-initiating button press, but in practice unpredictable timing delays due to background processes running in the Windows XP operating system caused this 3 second period to unpredictably vary by a few milliseconds.[47] The stimulus computer's CPU clock (1 GHz) ran hundreds to thousands of times faster than this stimulus timing uncertainty, so the seed number

used to reseed the PRNG, and thus the target picture selected on each successive trial, were not determined in advance.[48]

Experiment II used a truly random number generator (RNG) based on electronic noise to make all random selections.[49] When P pressed the button to begin a trial, a program directed the RNG to select one calm and one emotional target, uniformly at random and with replacement, out of the calm and emotional pools of 250 targets each, as created for this experiment. To one of these two targets, selected at random, the RNG assigned a probability of 70% of being selected as the future target; the other target was assigned a 30% probability. In this way, during the prestimulus period two probable futures existed, one more likely than the other. When the prestimulus interval timer fired to begin the stimulus display period, the RNG selected one of the two targets in accordance with its assigned low or high probability.[50] Data of principal interest were the approximately 30% of trials in which the probable future did not manifest into the actual future. Those trials were called the "mismatch condition;" the remaining 70% of trials were called the "match condition."

Hypotheses

- Experiment I. *Hypothesis 1*: Change in pupillary dilation will be larger before randomly selected emotional vs. calm pictures. For purposes of this test "emotional" was pre-defined as the 5% of contributed trials having targets with the highest IAPS arousal scores, and "calm" as the 5% of trials with the lowest IAPS arousal scores. The ±5% emotional contrast threshold was selected based on previous presentiment experiments using IAPS targets.[29]
- Experiment I. *Hypothesis 2*: Spontaneous blink rate will be higher before randomly selected emotional vs. calm pictures.
- Experiment I. *Hypothesis 3*: Eye movements during the prestimulus period will be positively correlated with eye movements recording while viewing the stimulus.
- Experiment I. *Hypothesis 4*: Horizontal eye movements before randomly selected emotional pictures will move more towards the left than before calm pictures. These are directional hypotheses and thus one-tailed tests were used.
- Experiment II. *Hypothesis 5*: The presentiment effect as defined in Hypothesis 1 will differ depending on whether the probable and actual future targets matched or mismatched. This is a non-directional hypothesis, so a two-tailed test was used.

Analyses

All analyses were performed in custom Matlab 7 programs (The Mathworks, Inc., Natick, MA, USA). Hypotheses 1 and 5 proposed that pupillary dilation would be larger prior to emotional vs. calm stimuli. This was evaluated using a nonparametric randomized permutation procedure, as follows:

1. Determine pupillary dilation (PD) data and the target affect score (IAPS for Experiment I or emotional/calm category for Experiment II) for each trial contributed by each participant.

2. For each trial transform all PD data into baseline adjusted percentage change values, based on the average value of PD measured the 10 samples just before the button was pressed to begin each trial. Thus, $P_{\Delta} = (P_i - \overline{P}_{51-60}) / \overline{P}_{51-60}$, where i ranged from samples 1 to 600 (Experiment I) or 1 to 720 (Experiment II), and where samples 51 – 60 represented PD data measured 167 msec before the trial-initiating button press.
3. Form the ensemble mean of P_{Δ} across the top 5% most emotional trials; call this $P_{\Delta E}$. Do the same for the 5% most calm trials; call this ensemble mean $P_{\Delta C}$.
4. Determine the summed difference in these two curves during the prestimulus period. Thus, $P_{\delta} = \sum(P_{\Delta Ei} - P_{\Delta Ci})$, where i ranges over samples 61-240, i.e. the prestimulus period.
5. Randomly permute the assignment of target affect scores for each trial and recalculate P_{δ} using those new assignments. Call the recalculated P_{δ} value $P_{\delta r}$, where r indicates random.
6. Repeat step 5 5,000 times to build up a distribution of $P_{\delta r}$ values.
7. Form a normalized score for the observed Pδ value as $z_P = (P_{\delta} - \mu(P_{\delta r}))/\sigma(P_{\delta r})$, where μ refers to the mean and σ to the standard deviation of the $P_{\delta r}$ values. The p-value associated with z_P can be used to assess the likelihood that PD prior to emotional targets differed from PD prior to calm targets.

Hypothesis 2 predicted more spontaneous blinking prior to emotional vs. calm stimuli. When blinking occurred the eyetracker stopped recording PD, thus blinking was inferred based on missing PD data. The pupil could also fail to be detected if the participant's eye moved beyond the ability of the camera to track, or ambient light reflections off the cornea confused the eyetracking algorithms. The latter two reasons for tracking failure were reduced through the initial calibration procedure, by running the experiment in a light-controlled cubicle, and by the experimenter monitoring the data collection process on a separate video screen during each session to ensure proper eye tracking. The following steps were used to evaluate this hypothesis:

1. Determine PD data and target affect score for each trial contributed by each participant.
2. Determine the number of PD samples per trial recorded during the prestimulus period; call these numbers PD_{ni}, where n means "number" and i refers to the trial number. PD_n could range from 0 (pupil could not be detected at all during the prestimulus period) to 180 (pupil successfully detected throughout the prestimulus period).
3. Find the sum of PD_n for the top 5% most emotional trials, then do the same for the 5% most calm trials. Call the former PD_{nE} and the latter PD_{nC}.
4. Determine the difference $PD_{\Delta n} = PD_{nC} - PD_{nE}$. In this way if there is more blinking in the emotional condition than the calm condition, then $PD_{nE} < PD_{nC}$, and $PD_{\Delta n}$ will be positive.
5. Randomly scramble the assignment of target affect scores and recalculate $PD_{\Delta n}$. Call this $PD_{\Delta nr}$, where r refers to random.
6. Repeat step 5 5,000 times to build up a distribution of $PD_{\Delta nr}$ values.
7. Form a normalized score for the observed $PD_{\Delta n}$ value as $z_{\Delta n} = (PD_{\Delta n} - \mu(PD_{\Delta nr}))/\sigma(PD_{\Delta nr})$. The p-value associated with $z_{\Delta n}$ can be used to assess the likelihood that missing data prior to emotional targets, which is mostly due to blinking, differs from missing data prior to calm targets.

Hypothesis 3 predicted that participants who showed apparent presentiment abilities, based on individual analysis of their PD measurements as in Hypothesis 1, would show a positive correlation between their eye movements tracked before vs. while observing the stimuli. Participants who did not show a presentiment effect based on the PD data would not be expected to show such correlations. The following steps were used to evaluate this hypothesis:

1. Following the steps for evaluating Hypothesis 1, but based on a per session analysis instead of combining results across all participants, select those sessions with independently significant evidence for presentiment (call these the "significant sessions"). Then select an equal number of sessions with results as close to chance as possible (call these the "chance sessions").
2. For the significant and chance sessions identified in step 1, determine the horizontal and vertical eye movement data for each trial.
3. For each trial transform the eye movement values into baseline-adjusted percentage change values based on the average of the first ten samples before the button press, i.e., samples 51-60. Thus, $H_\Delta = (H_i - \bar{H}_{51-60}) / \bar{H}_{51-60}$ and similarly for V_Δ, where H and V refer to horizontal and vertical, respectively, and i ranged from 1 to 600.. These adjustments are necessary when pooling data because otherwise idiosyncratic differences in eye movement across participants might create spurious correlations. I.e., if one person tended to always look to the upper right and another always to the lower left, then upon pooling these raw data we may see a positive correlation created solely by habitual differences in eye movement.
4. For each trial in step 3, form an array consisting of all baseline-adjusted prestimulus horizontal samples followed by all vertical samples; call this array P. Then form a second, similar array, except consisting of all baseline-adjusted samples collected *during* stimulus display; call this array D. For one trial arrays P and D will consist of 180 samples x 2 (horizontal and vertical) = 360 samples, unless some samples are missing due to blinking. If this occurred, then the same number of missing samples in the other array, and in the same position, are also removed. E.g., if samples 150 – 155 were missing from array P, then samples 150 – 155 would also be removed from array D.
5. Concatenate arrays P and D with similar data from all trials in the significant sessions, and then do the same for all trials in the chance sessions.
6. Find the Pearson correlation between arrays P and D for the significant sessions and then separately find the same correlation for the chance sessions. Call the former r_s and the latter r_c.
7. Randomly permute the trial assignments for array D, then rebuild the two sets of arrays as in steps 4 and 5. This step mismatches the prestimulus and during-stimulus eye movements, to provide an analytical control.
8. Recalculate r_s and r_c using the random assignments, call them r_{sr} and r_{cr}.
9. Repeat steps 7 and 8 5,000 times to build up a distribution of randomized r_{sr} and r_{cr} values.
10. Form a normalized score for the observed r_s value as $z_{sr} = (r_s - \mu(r_{sr}))/\sigma(r_{sr})$, where μ indicates the mean and σ the standard deviation. Then do the same to calculate a normalized score for r_c. The p-values associated with these z scores can be used to assess the probability that the eye movement correlations in people with apparent

presentiment abilities differed from similar correlations in people who did not display those abilities.

Hypothesis 4 tested whether presentiment might exhibit a brain lateralization effect, specifically preferential processing in the right hemisphere, by examining whether the eyes moved more towards the left prior to emotional vs. calm targets. The following steps were used to evaluate this hypothesis:

1. Determine horizontal eye movement data and IAPS arousal scores for each trial across all participants.
2. For each trial transform the horizontal eye movement values into baseline-adjusted percentage change values starting at sample 61. Thus, $H_{\Delta} = (H_i - \bar{H}_{51-60}) / \bar{H}_{51-60}$, where i ranged from 1 to 600.
3. Form the ensemble mean of H_{Δ} for the top 5% most emotional trials; call this $H_{\Delta E}$. Do the same for the 5% calmest trials; call this $H_{\Delta C}$.
4. Determine the difference in these two curves during the prestimulus period: $H_{\delta} = \sum(H_{\Delta Ei} - H_{\Delta Ci})$, where i ranged from 61-240.
5. Randomly scramble the assignment of IAPS arousal values, then recalculate H_{δ}. Call it $H_{\delta r}$, where r refers to random.
6. Repeat step 5 5,000 times to build up a distribution of $H_{\delta r}$ values.
7. Form a normalized score for the observed Hd value as $z_{HD} = (H_{\delta} - \mu(H_{\delta r}))/\sigma(H_{\delta r})$, where μ refers to the mean and σ to the standard deviation of the Hdr values. The p-value associated with z_{HD} can be used to assess the likelihood that horizontal eye movements prior to emotional targets differed from the same movements prior to calm targets.

RESULTS

Experiment I

A total of 33 volunteers contributed 37 sessions, of which 32 sessions consisted of 40 trials, one of 39 trials (one trial was inadvertently skipped), and 4 early sessions were 30 trials each, for a total of 1,439 trials. In one of those trials the participant's eye was closed most of the time, so just one eye tracking sample was recorded; this trial was dropped from further consideration. This left 1,438 usable trials, which constitute all data collected in this experiment. Of the 33 participants, 31 were right handed and two were ambidextrous. Ages ranged from 20 – 83 (mean 47.5), 14 were male (20 – 30, 25.4) and 19 were female (20 – 30, 25.4).

Hypothesis 1. At the planned 5% level of emotional contrast (72 calmest trials, average IAPS arousal of 2.43 vs. 72 most emotional trials, average IAPS arousal of 7.05), the differential change in pupillary dilation during the prestimulus period was significantly positive, $z = 3.17$, $p = 0.0008$ (one-tailed, see Figure 3).

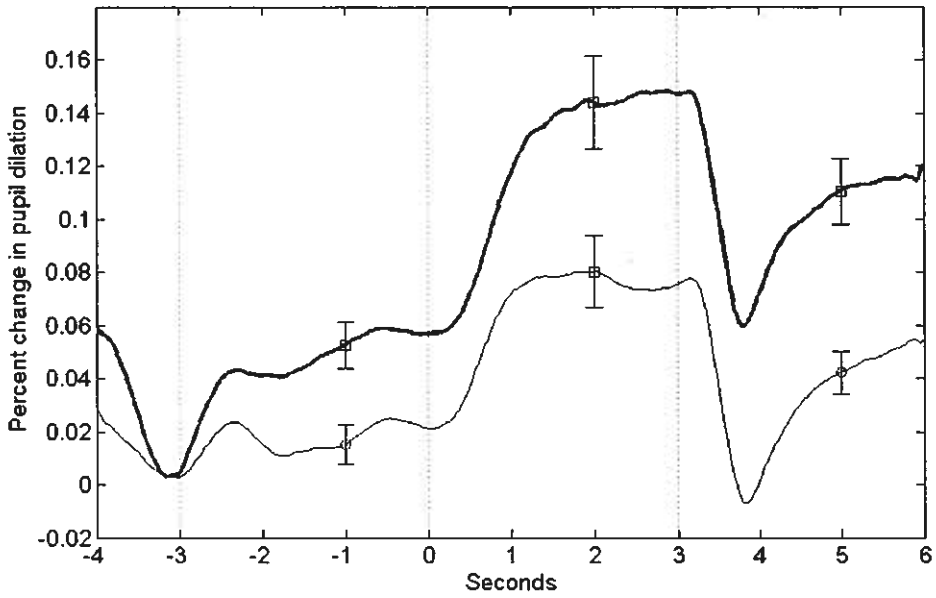

Figure 3. The bold line shows average proportional change in pupillary dilation for the 5% most emotional targets across all 1,438 usable trials; the thin line shows the same for the 5% most calm targets. Both lines are baseline adjusted to the average pupillary dilation value per trial during the 167 msec prior to the trial-initiating button press (at second -3). Stimulus onset is at second 0 and stimulus offset at second +3. Confidence intervals are plus and minus one standard error, and curves are smoothed 500 msec to clarify the figure.

Figure 4 shows the effect of varying the level of emotional contrast used in the analysis, from ±1% (subset of trials with highest emotional contrast) to ±50% (all trials), split by gender. Consistent with observations from previous presentiment studies using the IAPS picture set, this analysis shows stronger presentiment results for higher levels of emotional contrast.[29] In addition, the stronger and more consistent results for females are consistent with a similar gender difference found in a presentiment study based on measurements of slow cortical potentials in the brain.[34]

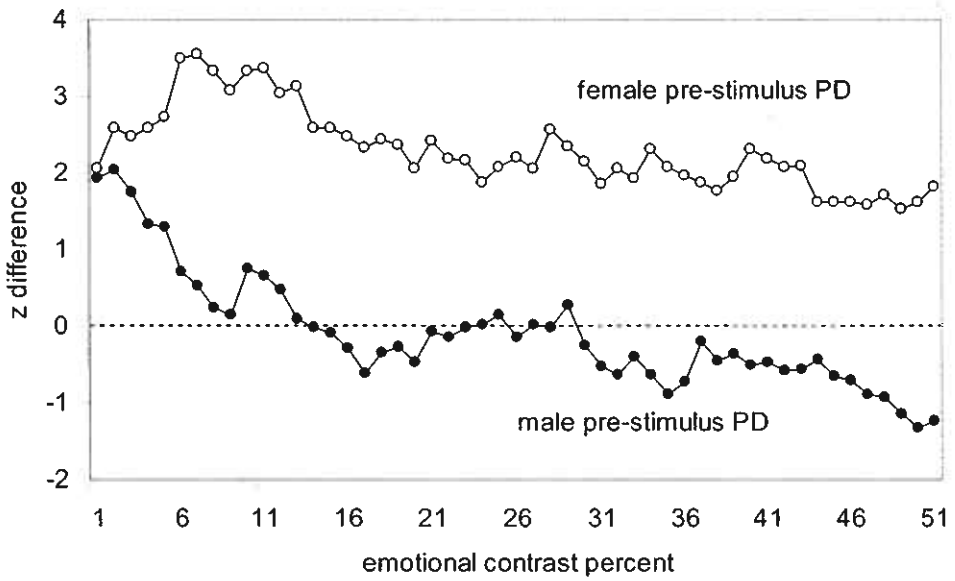

Figure 4. Presentiment results, in the form of z_p, for varying emotional contrast percentages, by gender. Females peaked at a 7% contrast (z = 3.54), males at a 2% contrast (z = 2.03).

Hypothesis 2. At a 5% emotional contrast there was more spontaneous blinking before emotional vs. calm pictures (z = 2.13, p = 0.02, one-tailed). At the same contrast level females showed a larger effect than males (female blink z = 2.64, N = 818 trials; males blink z = 1.59, N = 620 trials). Over all prestimulus periods in all trials, 94.6% of pupillary dilation data were recorded, so this spontaneous blinking difference is based upon a small amount of data (i.e., blinking was identified by missing data). In a post-hoc test, differential effects for pupillary dilation and spontaneous blinking, analyzed per participant, were found not to be correlated (r = -0.06, t (35 *df*) = -0.38, p = 0.71, two-tailed), so the results for these two measures may be regarded as independent and combined. This results in a general presentiment effect in eye data associated with z = 3.75 ($p = 9 \times 10^{-5}$).

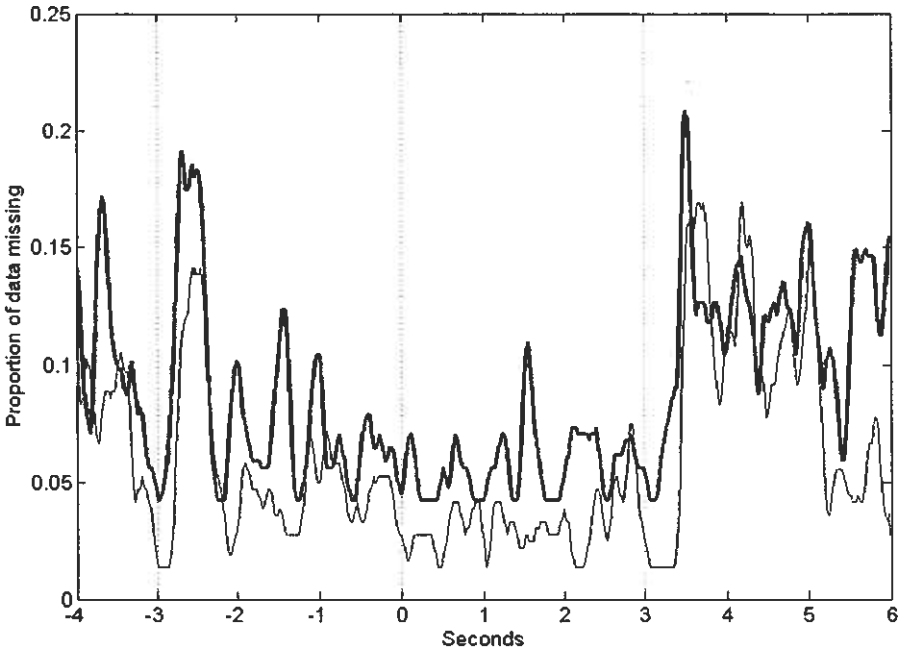

Figure 4. Bold line shows average proportion of pupillary dilation data missing in the 5% most emotional targets; thin line represents the same for 5% of most calm targets. This indicates more spontaneous blinking both before and during emotional targets as compared to calm targets.

Hypothesis 3. Five participants achieved individually significant presentiment results ($z_p > 1.65$). Their horizontal and vertical eye movements recorded during the prestimulus period, and pooled across all of their contributed trials, were weakly but significantly correlated with their eye movements recorded while viewing the stimuli ($r = 0.049$, $z = 2.91$, $p = 0.002$, one-tailed, $N = 190$ trials).[51] Five additional participants selected based on their obtaining results closest to chance showed no significant correlation ($r = 0.006$, $z = -0.79$, $p = 0.78$, one-tailed, $N = 190$ trials). The difference between outcomes in these two groups is significant ($z = 2.61$, $p = 0.005$, one-tailed), suggesting that when presentiment effects occurred they were driven not only by future emotional responses, but also by spatial information specific to the future targets.

One might ask whether the positive correlation in eye movements between the prestimulus and during-stimulus periods were due to artifacts associated with habitual eye movements. A spurious positive correlation might occur if people always tended to examine certain areas of the screen before and during target presentation, independently of what was actually being displayed. To test this possibility, we examined eye movement autocorrelations between successive during-stimulus periods, and between successive prestimulus periods. An artifact would manifest as a dependency, and thus as a large autocorrelation (positive or negative).

Figure 5 shows z scores associated with correlations in eye movement between pre-stimulus and during stimulus periods (labeled "pre-dur" in the figure), for five individuals who obtained independently significant presentiment results ("hi" group), and for five individuals who obtained results closest to chance ("lo" group). For the "hi" group prestimulus eye

movements significantly correlated with eye movements during the target, but not across successive targets (labeled "dur-dur" in the figure, r = 0.02 z = 0.14, p = 0.45), suggesting that their eye movements were not habitual but rather were driven by visually attractive elements in the targets. Nor did their eyes follow strong habitual movements during the prestimulus period (labeled "pre-pre", r = 0.10 z = 1.23, p = 0.11). In contrast, for the "lo" group prestimulus eye movements did not correlate with eye movements while examining the target, but their eye movements *did* correlate while examining successive targets (r = -0.05 z = -2.95, p = 0.01, two-tailed) and also during successive prestimulus periods (r = 0.17, z = 4.47, p < 0.001, two-tailed). This indicates that people who failed to show a presentiment effect had habitual eye movements, suggesting that they were not strongly influenced by the target images.

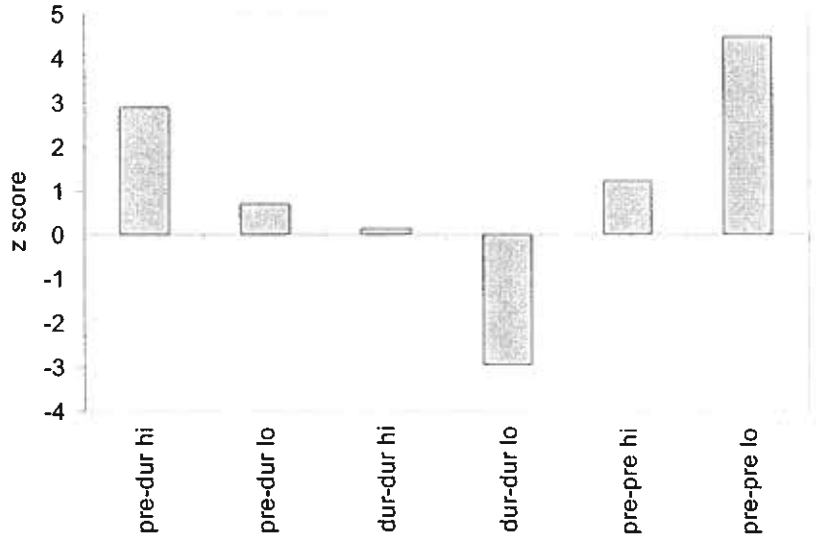

Figure 5. Z scores of correlations, determined by randomized permutation analysis, for significant ("hi") and nonsignificant ("lo") presentiment responders, for eye movement correlations between the pre-stimulus and during stimulus periods ("pre-dur"), during successive stimulus periods ("dur-dur"), and during successive pre-stimulus periods ("pre-pre").

Hypothesis 4. At the 5% emotional contrast level across all trials and all participants, horizontal eye movements before emotional pictures moved more towards the left than before calm pictures (z = -1.65, p = 0.05, one-tailed, Figure 6). This suggests greater involvement of the right brain hemisphere prior to emotional targets.

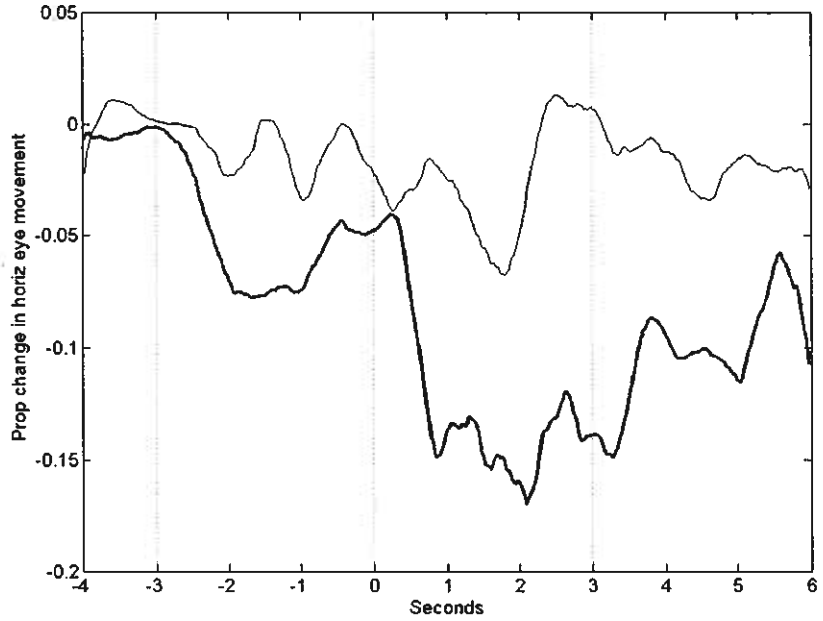

Figure 5. Bold line shows the ensemble average of proportional changes in horizontal eye movements for the 5% most emotional trials; the thin line shows the same for the 5% most calm trials. Negative values on the y-axis correspond to the eye looking to the left.

In a post-hoc test, the same analysis was performed on image *valence*, i.e. contrasting the 5% of images with the most positive affect vs. 5% most negative affect. This found that for negative valence the eyes moved left (right brain) and for positive images the eyes moved right (left brain), with $z = 2.21$, $p = 0.01$ (one-tailed). This finding is consistent with experiments examining EEG hemispheric asymmetries in the study of emotion,[52] offering further evidence that presentiment effects are responses linked to unique image content and not just to emotional affect.

Experiment II

A total of 41 volunteers contributed one session of 50 trials each. One trial was unusable, leaving a total of 2,099 analyzable trials. Participants ranged in age from 8 – 82 (average 50.9), including 15 males ages 20 – 67 (46.3), and 27 females ages 8 – 82 (52.3).

Hypothesis 5. By design, 30% of the data were expected to be "mismatch trials" where the probable present did not manifest into the actual future, leaving 70% of the data as the remaining "match trials." The observed percentages were 30.5% and 69.5%, respectively, indicating that the random selection process worked as expected. As shown in Table 1, the difference in presentiment effects in pupillary dilation between the mismatch and match conditions was significant ($z = 1.99$, $p = 0.05$, two-tailed). The same analysis split by gender showed that females were largely responsible for this result ($z = 2.51$, $p = 0.02$, two-tail). This suggests, at least for the female data, that presentiment is modulated by whether the probable present and actual future match or mismatch, reminiscent of Stroop-type cognitive-perceptual interference effects, and of time-reversed interference effects using a Stroop task .[53-54]

Table 1. Results of Experiment II.

CONDITION	TRIALS/TOTAL	CALM/EMOTIONAL	Z_P	Z_{BLINK}
Mismatch	640/2099	330/310	1.71	-0.41
Match	1459/2099	701/758	-1.10	-0.04
Difference			1.99	
Female mismatch	382/1349	197/185	2.43	-1.24
Female match	967/1349	481/486	-1.12	-1.03
Difference			2.51	
Male mismatch	258/750	133/125	-1.10	0.81
Male match	492/750	220/272	-0.28	1.53
			-0.58	

Closer examination of the female data, shown in Figure 7, suggests that when there was mismatch between the probable present and actual future, presentiment appeared to respond to the actual future. The graph shows that the pupil constricted when the probable future was emotional but the actual future turned out to be calm, and vice versa. However, this result is not completely unambiguous because pupillary dilation during exposure to the targets did not show a clear differential effect. This indicates that the custom target pool created for this test was not optimal for producing a strong emotional contrast. We speculate that the use of humorous and bizarre images for emotional targets may have caused participants to imagine that the calm images also hid something interesting, so they persisted in examining the calm images as long as they were displayed, looking for a surprise. Progressive pupil dilation is consistent with the cognitive processing load associated with continual searching.

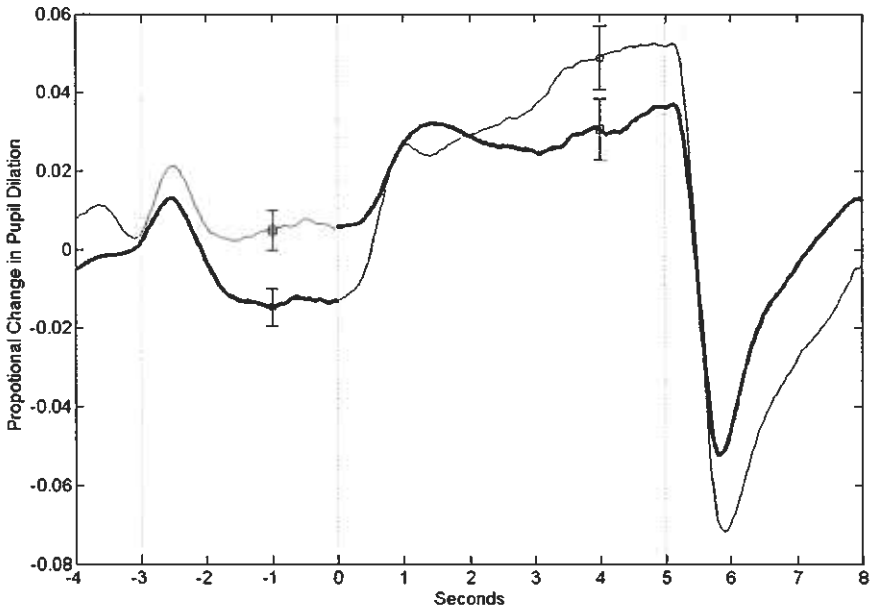

Figure 7. These curves show mean baseline-adjusted proportional change in pupillary dilation for female-contributed trials. The bold line during the prestimulus period indicates high probability emotional targets; the thin line indicates high probability calm targets. During the stimulus period the bold line indicates actual emotional targets; the thin line actual calm targets. The apparent discontinuity in the two curves at stimulus onset (second 0) is due to the fact that this graph shows only the "mismatched" subset of trials in which the probable present did not manifest into the actual future.

DISCUSSION

These experiments found that (a) under conditions controlling for anticipatory strategies and other conventional cues, pupillary dilation and spontaneous blinking increased more before viewing randomly selected emotional vs. calm photographs, (b) at high levels of emotional contrast in the target photos, males and females showed similar pupillary dilation effects, but females showed stronger overall effects, (c) pupillary dilation in females responded differently when the probable and actual futures matched than when they mismatched, suggesting a possible transtemporal interference, (d) horizontal eye movements suggested a brain hemispheric asymmetry appropriate to both the emotionality and the valence of the future targets, and (e) individuals selected for successful presentiment sessions obtained a positive correlation in their horizontal and vertical eye movements before and after exposure to randomly selected targets, whereas people who did not show a presentiment effect did not show this correlation.

These outcomes indicate that presentiment responds to specific information from the future, and they support folklore suggesting that, at least in principle, seers can see the future. Of course, folklore carries no evidential capital within science, so it is prudent to discuss whether these results might have been due to one or more artifacts.

Alternative explanations

Four categories of artifacts can potentially simulate the results observed here: selective data reporting, optional stopping, sensory cues, and anticipatory strategies. Biases due to selective data reporting were prevented by planning in advance to analyze all usable trials contributed by all participants. Of the total of 3,537 trials collected across the Experiments I and II, only 2 trials proved to be unusable, so the analyses in Hypotheses 1, 2, 4 and 5 presented here are based on over 99.9% of all data collected, and for Hypothesis 3 all data were used in the two subsets of participants selected.

With regard to optional stopping, no previous data based on this experimental design were available to inform effect size estimates. Thus in lieu of using a power analysis to establish a preplanned number of trials and sessions, Experiment I was planned in advance to include 30 sessions based on the first author's experience in conducting previous experiments. Seven additional sessions were ultimately conducted as pilot sessions and demonstrations, but data from those sessions were included in the analyses to prevent arbitrary selection of sessions.

Experiment II was exploratory, but rather than specifying a fixed number of sessions to conduct in advance, we planned instead to collect as many sessions as possible by a specific end-date, and to not analyze the majority of the data (25 of 41 sessions) until after that date had been reached.[55] This strategy diminished an optional stopping bias, which depends on data being analyzed after each trial or session so as to monitor and possibly capitalize on random fluctuations.

Sensory cues as a source of potential artifacts were eliminated by generating the future targets after the pre-stimulus period had ended. There were no computer disk sounds or any other cues available to inform anticipatory responses that might have driven a presentiment-like result.

What about anticipatory strategies arising due to implicit learning of nonrandom patterns in the stimulus presentation sequence? To preclude such strategies, targets were selected uniformly at random and with replacement, and in Experiment I only a small subset (10% total) of the most emotional and most calm trials were actually used for the preplanned presentiment analyses. Nevertheless, to see whether participants might have been able to learn patterns in these sequences, we examined the autocorrelations of the arousal levels in the target sequences used in the experiments.

For Experiment I, autocorrelations lagged from 1 to 40 resulted in two correlations beyond chance at $p < 0.05$, two-tailed. This is in accord with chance expectation (exact binominal $p = 0.60$). The two significant autocorrelations were at lag 13 ($r = -0.06$) and lag 38 ($r = -0.06$). This suggests that if participants were able to systematically keep track of the IAPS arousal level of each successive trial (without any quantitative indication of what those levels might be), then they might have noticed that every 13 trials the emotional affect of the photograph viewed alternated from low to high, or vice versa, as compared to the target viewed 13 trials before.[56] An autocorrelation of $r = -0.06$ accounts for less than 0.4% of the variance, so it seems unlikely based on three exemplars (trials 13, 26, and 39 in a single session of 40 trials) that anyone would have noticed this correlation. A similar analysis for trials in Experiment II

showed that two autocorrelations through lag 40 exceeded chance at $p < 0.05$, two-tailed, one with $r = 0.06$ at lag 11 and another with $r = -0.06$ at lag 33. In single sessions of 50 trials each, it again seems unlikely that participants would have noticed that affect levels on every 11^{th} trial were similar to each other. In sum, it is implausible that the present results are explainable as manifestations of systematic anticipatory strategies.

It might be argued that it is not necessary for the trial sequences pooled across all sessions to be adequately random. All it would take would be a few sessions with nonrandom sequences to sway the overall statistics. To test this idea, for Experiment I we determined the number of significant autocorrelations in the target sequences in each session, and then correlated those figures against the presentiment results (based on pupillary dilation) of each session in terms of z_p. If sessions with significant presentiment were due to inadequate target randomization, then this relationship ought to be positive, because the more non-chance autocorrelations per session, the more likely the participant might have gained statistical cues about the upcoming targets.

We calculated autocorrelations up to lag 20 for each session; out of 20 correlations one would be expected to be significant by chance at $p < 0.05$, two-tailed. Thus, out of 37 sessions run in Experiment I, we would expect by chance 37 significant correlations, and that is exactly what occurred. The number of significant correlations ranged from 0 to 4 per session. A Spearman rank order correlation between these figures vs. z_p per session resulted in $r = 0.08$, $p = 0.64$. Thus there was no evidence that the results of Experiment I could be explained by statistically informed anticipatory cues at either the trial or the session level.

What does presentiment respond to?

If presentiment responds to a future target's affect, valence and unique visual elements, and to transtemporal cognitive-perceptual interference, might it also react to the level of brightness of the future target?[34] This question arises in the present experiments because our primary measure – pupil dilation – is exquisitely sensitive to illumination level, and because the correlation between image illumination level and emotional affect for the 1,438 trials used in Experiment I was significantly positive ($r = 0.09$, $p = 0.001$).[57] This means that there were potentially opposing forces in that the brighter and more emotional the target, the more the pupil would tend to *constrict while viewing* the target for physiological reasons, but at the same time the more it would *dilate before viewing* the target for presentiment reasons. Given these counteracting effects, the significant results obtained in Experiment I suggest that the presentiment effect was not especially sensitive to the illumination level of the future targets.

To further test this suggestion, we examined pupillary dilation before a subset of the 5% brightest and 5% dimmest targets, as measured by the target's grand average illumination level. Figure 8 shows that while observing a target the pupil was strongly influenced by that target's illumination level. As expected, the pupil dilated if the target was dim and constricted if the target was bright. This bright vs. dim analysis led to a strong differential effect ($z_p = -5.64$) while viewing the stimuli, as expected. Now, if presentiment responded to future illumination level, then the differential analysis during the prestimulus period should also have been negative, but in fact it was positive ($z = 1.24$, $p = 0.11$). This suggests that presentiment responds more to the target's future emotion rather than its future illumination level, and that confirmed in this case

because the 5% of the brightest targets had a significantly higher average IAPS arousal level (5.08) than the 5% of dimmest targets (4.40; p = 0.003, two-tail t-test). Further support is provided by analysis of spontaneous blinking, which resulted in a significant increase before the brightest (more emotional) targets than before the dimmest (more calm) targets (z = 3.01, p = 0.001).

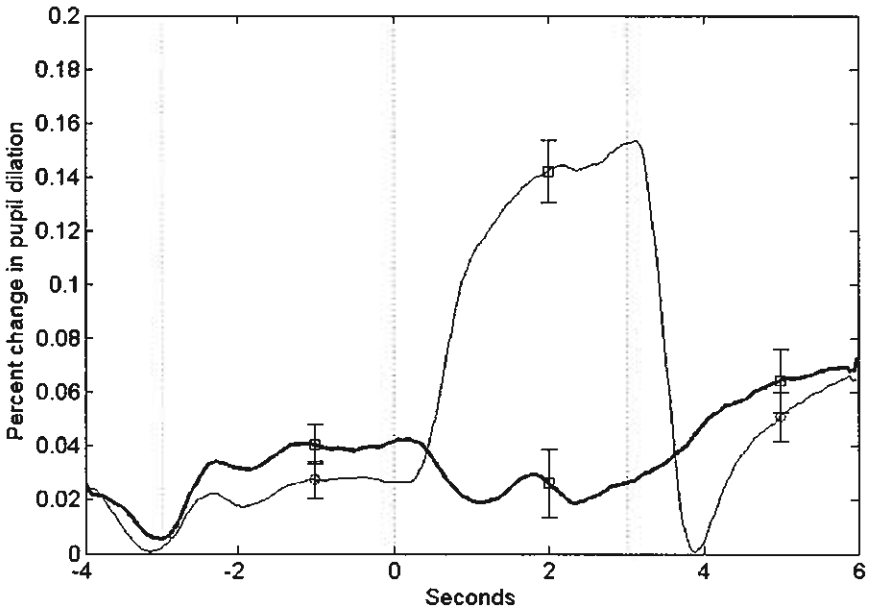

Figure 3. Bold line represents average pupillary dilation response to the 5% brightest targets, thin line is the same measure for the 5% dimmest targets.

In conclusion, the future influencing the present appears to violate our common sense perceptions of the flow of time, so it is tempting to imagine that presentiment effects must actually be anticipatory responses of a subtle but conventional form yet to be discovered. Unfortunately, even ordinary anticipation is not as simple as it appears to be. Experiments looking for an overall preparatory state in the nervous system, using negative slow cortical potentials in the brain, heart rate deceleration, and pupillary dilation measures, have failed to show *any* correlation between anticipatory readiness and subsequent responses.[20] Even triggering stimuli during what presumably ought to be optimal physiological states, such as heart rate deceleration, does not yield better anticipatory performance compared to controls. As Jennings, Van der Molen, and Steinhauer put it, "Preparation is best viewed as the transient organization of a multitude of components, each of which is modestly related to an efficient performance."[20, p. 97] Given the results of the present and previous presentiment experiments, and despite theoretical challenges presented to conventional causal modeling, we would suggest that one of Van der Molen and Steinhauer's preparatory components might be influences from the future.

ACKNOWLEDGMENTS

We thank the Bial Foundation for generously funding this research project, and the many volunteer participants for graciously allowing us to record their eye behavior while they gazed at pictures.

REFERENCES

1 Friedman HS, Silver RC. Foundations of Health Psychology. Oxford, UK: Oxford University Press; 2006, p. 78.
2 Mack A, Rock I. Inattentional Blindness. Cambridge, MA: MIT Press; 1998.
3 Morreall J. Taking Laughter Seriously By. New York: SUNY Press; 1983.
4 Rosen R. Anticipatory Systems: Philosophical, Mathematical and Methodological Foundations. New York: Pergamon Press; 1985, from the Foreward.
5 Gross CG. The fire that comes from the eye. Neuroscientist. 1999; 5:58-64.
6 Schmidt S, Schneider R, Utts J, Walach H. Distant intentionality and the feeling of being stared at: Two meta-analyses. Brit J Psychol, 2004; 95: 235–247.
7 Radin DI. The sense of being stared at: A preliminary meta-analysis. J Consciousness Studies, 2005; 12 (6): 95-100.
8 Bösch H, Steinkamp F, Boller E. Examining psychokinesis: The interaction of human intention With random number generators—A meta-analysis. Psychol Bull. 2006; 132: 497–523.
9 Radin DI, Nelson R, Dobyns Y, Houtkooper J. Reexamining psychokinesis: Comment on Bösch, Steinkamp, and Boller (2006). Psychol Bull. 2006; 132: 529–532.
10 Radin DI. The conscious universe. San Francisco: HarperOne, 1997.
11 Radin DI. Entangled minds. New York: Simon & Schuster.
12 Titelman GY. Random House dictionary of popular proverbs and sayings. New York: Random House; 1996.
13 Steinhauer SR, Hakerem G. The pupillary response in cognitive psychophysiology and schizophrenia. In: Friedman D, Bruder G., eds. Psychophysiology and experimental psychopathology: A tribute to Samuel Sutton. Annals of the New York Academy of Sciences. 1992; 658: 182-204.
14 Bitsios P, Szabadi E, Bradshaw CM. The fear-inhibited light reflex: Importance of the anticipation of an aversive event. Intl J Psychophysiol. 2004; 52: 87–95.
15 Loewenfeld IE. The pupil: Anatomy, physiology, and clinical applications. Ames, Iowa: Iowa State University Press; 1993.
16 Laeng B, Teodorescu D-S. Eye scanpaths during visual imagery reenact those of perception of the same visual scene. Cognitive Science. 2002; 26: 207—231.
17 Spivey MJ, Geng JJ Oculomotor mechanisms activated by imagery and memory: Eye movements to absent objects. Psychological Research. 2001; 65: 235–241.
18 Andreassi JL. Chap. 10, Pupillary response and behavior. In: Psychophysiology: Human Behavior & Physiological Response, 4th ed. Lawrence Mahwah, N.J.: Erlbaum Assoc. 2000; pp. 218-233.
19 Bacher LF, Smotherman WP, Spontaneous eye blinking in human infants: A Review. Dev Psychobiol 2004; 44: 95–102.

20 Jennings JR, van der Molen MW, Steinhauer SR. Preparing the heart, eye, and brain: Foreperiod length effects in a non-aging paradigm. Psychophysiology. 1998; 35: 90-98.
21 Bierman DJ, Radin DI. Anomalous anticipatory response on randomized future conditions. Percept Motor Skills, 1997; 84: 689-690.
22 Vassy Z. Method of measuring the probability of 1-bit extransensory information transfer between living organisms. J Parapsychol. 1978: 43(2), 158-160.
23 Bierman DJ, Radin DI. Conscious and anomalous non-conscious emotional processes: A reversal of the arrow of time? Toward a Science of Consciousness, Tucson III. Cambridge, MA: MIT Press. 1999; 367-386.
24 Radin DI. Unconscious perception of future emotions: An experiment in presentiment. J Sci Explor, 1997; 11: 163–180.
25 Wildey C. Impulse response of biological systems. Master's Thesis, Department of Electrical Engineering, University of Texas at Arlington, 2001.
26 McCraty R, Atkinson M, Bradley RT. Electrophysiological evidence of intuition: Part 2. A system-wide process? J Alt Comp Med, 2004; 10: 325–336.
27 McCraty R, Atkinson M, Bradley RT. Electrophysiological evidence of intuition: Part 1. The Surprising role of the heart. J Alt Comp Med, 2004; 10: 133–143.
28 Parkhomtchouk DV, Kotake J, Zhang T, Chen W, Kokubo H, Yamamoto M. An attempt to reproduce the presentiment EDA response. J Int Society Life Inform Sci, 2002; 20 (1): 190-194.
29 Radin DI. Electrodermal presentiments of future emotions. J Sci Explor, 2004; 18: 253-274.
30 Spottiswoode SJP, May EC. Skin conductance prestimulus response: Analyses, artifacts and a pilot study. J Sci Expl, 2003; 17: 617–641.
31 May EC, Paulinyi T, Vassy Z. Anomalous anticipatory skin conductance response to acoustic stimuli: Experimental results and speculation about a mechanism. J Alt Comp Med, 2005; 11: 695-702.
32 Levin J, Kennedy J. The relationship of slow cortical potentials to psi information in man. J Parapsychol, 1975; 39: 25-26.
33 Hartwell JW. Contingent negative variation as an index of precognitive information. European Journal of Parapsychology, 1978; volume: 83-102.
34 Radin DI, Lobach E. Toward understanding the placebo effect: Investigating a possible retrocausal factor. J Alt Comp Med. 2007; 13: 733–739.
35 Hinterberger T, Studer P, Jäger M, Haverty-Stacke C, Walach H. Can a slide-show presentiment effect be discovered in the brain electrical activity. J Soc Psychical Res. 2007; 71: 148-166.
36 Bierman DJ, Scholte HS. Anomalous anticipatory brain activation preceding exposure of emotional and neutral pictures. Paper presented at Toward a Science of Consciousness, Tucson IV, 2002.
37 Five of these experiments were student projects at the U of Edinburgh. Watt C. A peek in the file-drawer: Review of 96 undergraduate student projects at the Koestler Parapsychology Unit. In: Proceedings of Presented Papers, 50th Annual Convention of the Parapsychological Association, Petaluma, CA: Parapsychological Association. 2007; 133-142.
38 Dalkvist J, Westerlund J, Bierman DJ. A computational expectation bias as revealed by simulations of presentiment experiments. In: Proceedings of Presented papers, 45th Annual

Convention of the Parapsychological Association, Cary, NC: Parapsychological Association. 2002; 62–79.
39 Broughton RS. Possible brain hemisphere laterality effects in ESP performance. J Soc Psychical Res, 1978; 48, 384-399.
40 Broughton RS. Psi and the two halves of the brain. J Soc Psychical Res. 1975; 48: 133-147.
41 Steinkamp F. Testing clairvoyance and precognition by manipulating probabilities: A conceptual assessment of the experimental literature. J Parapsychol. 1999; 63: 99-130.
42 Radin DI. Effects of a priori probability on psi perception: Does precognition predict actual or probable futures? J Parapsychol. 1988; 52: 187-212.
43 Targ E, Targ R. Accuracy of paranormal perception as a function of varying target probabilities. J Parapsychol. 1986; 50: 17-27.
44 Lang PJ, Bradley MM, Cuthbert BN. International affective picture system (IAPS): Technical manual and affective ratings. Gainesville, Florida: University of Florida, Center for Research in Psychophysiology. 1999.
45 www.Worth1000.com, accessed October 28, 2007.
46 www.clipart.com, accessed July 11, 2007.
47 This usually occurred because the hard disk or network controller were engaged in some other process when the timer fired. No other user-controlled programs were running during the experiment.
48 Note that even adjacent seed-numbers will cause an PRNG to generate a completely different sequence of random numbers.
49 Orion, www.randomnumbergenerator.nl, accessed October 28, 2007
50 It did this by generating a random number from 1 to 100; if the resulting value was 1 through 70 the high-probability target was selected, otherwise the low-probability target was selected.
51 These were comprised of five sessions with 40 trials and one session with 30 trials. Five people were selected who obtained $zp \geq 1.65$, and five people were selected who obtained $|zp|$ closest to 0.
52 Canli T. Hemispheric asymmetry in the experience of emotion: A perspective from functional imaging. Neuroscientist. 1999; 5; 201-207.
53 Stroop JR. Studies of interference in serial verbal reactions. J Exp Psychol. 1935; 12: 643-662.
54 Radin DI, May EC. Evidence for a retrocausal effect in the human nervous system. In: Proceedings of Presented Papers, 43rd Annual Convention of the Parapsychological Association, Cary, NC: Parapsychological Association. 2001; xxx-xxx.
55 Data for Experiment II were collected during a six-week summer internship of the second author.
56 No participant would have noticed the lag at 38 trials because the sessions ended at 30 or 40 trials.
57 Average illumination level for each picture was calculated using routines in the Matlab 7 Image Analysis Toolbox.