# INTUITION THROUGH TIME: WHAT DOES THE SEER SEE?

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**Objective:** A great deal of human activity is involved in anticipating the future, from predicting the next influenza strain to the expectations that underlie the placebo effect. 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 one used 592 photos from the International Affective Picture System; experiment two used a custom-designed pool of 500 photos. Eye data before exposure to the photos were compared by using nonparametric techniques.

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

**Results:** Data contributed by 74 unselected volunteers in two experiments showed that: (a) pupillary dilation and spontaneous blinking were found to increase more before emotional versus calm photos (combined $P = .00009$), (b) horizontal eye movements indicated a brain hemisphere asymmetry before viewing photos, appropriate to both the emotionality ($P = .05$) and the valence of the future images ($P = .01$), (c) participants selected for independently obtaining significant differential effects in pupillary dilation showed positive correlations between their eye movements before versus during exposure to randomly selected photos ($P = .002$), and (d) a possible "transtemporal interference" effect was observed when the probability of observing future images was varied ($P = .05$ [two-tailed]). Gender splits on these tests showed that overall females tended to perform better than males.

**Conclusions:** These studies, which replicate conceptual similar experiments, suggest that sometimes seers do see the future. This implies that developing comprehensive models of anticipatory behavior, from understanding the nature of intuition to the placebo effect, may require consideration of transtemporal and teleological factors.

**Key words:** Intuition, anticipation, eye gaze, pupillary dilation, presentiment

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## INTRODUCTION

Evidence-based medicine promotes the idea that medical decisions should be based upon a rational assessment of the outcomes of clinical trials, scientific experiments, and reviews of the available literature. The idea has evoked substantial interest, as demonstrated by over 50,000 journal articles containing the phrase "evidence-based medicine," nearly half of which were published since 2005 (based on a search of PubMed in February 2009). Unfortunately, the literature relevant to any given medical decision is so extensive, interpretation of evidence so uncertain, and time to assess the evidence so limited, that realistically practitioners must also rely on their intuition.[1,2] Intuitive hunches (knowing without knowing how you know) are conventionally attributed to such sources as forgotten expertise, implicit learning, and unconscious somatic influences.[3,4] But there is also evidence that those explanations may not account for all forms of intuition. Sometimes people report accurate hunches about future events that could not have been inferred.[5] These "prefeeling" intuitions are called *presentiment*.[6]

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Understanding the full scope of intuitive abilities, especially intuitions involving future events, is important because a large percentage of the world's workforce is engaged in anticipating the future. Physicians aim to predict their patients' course of healing, epidemiologists anticipate health epidemics, geologists predict earthquakes, and intelligence agencies anticipate terrorist acts. The placebo effect can be thought of as the consequences of anticipating good health. In sports, anticipation allows us to hit and catch objects moving faster than we can see. It prevents us from passing out when we stand up from a sitting position,[7] it determines what we see or fail to see,[8] and it forms the basis for an entire class of humor.[9] Anticipation is also one of the principal characteristics of living systems, perhaps *the* key feature that distinguishes living from 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.[10]

Indeed, most conventional efforts to model anticipation assume that it can be fully understood within the constraints of a

 
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unidirectional arrow of time and conventional cause and effect. But is that assumption correct? Do some forms of anticipation, such as presentiment experiences, present only a telic veneer, or do they involve genuine influences from the future? One approach to exploring such "scientifically unacceptable" questions is to pay close attention to human experiences that have been reported for millennia. A rich source of experiences is folklore, and the relevant folklore is about seers—people said to be able to see the future—and in particular about the seer's "window to the soul," the eye.

Superstitions about special powers attributed to the eye can be found in all cultures. From the power of "fascination" attributed to the evil eye, to the Hindu and Buddhist symbols for enlightenment, to the omniscient Eye of Providence on the US dollar bill, strange forces thought to emanate from the eye are both widely revered and feared.[11] Sigmund Freud called fear of the evil eye "the most uncanny and universal" superstition,[11(p61)] and innumerable legends recount tales of prophets whose extraordinary gaze was said to divine the future.

Could such ancient beliefs—most of which are still vibrantly alive in the modern world as evidenced by thousands of Web sites selling amulets to protect against the evil eye—contain a grain of truth? A class of scientific experiments suggests that some of this folklore might be worth a closer look. Meta-analyses of studies testing 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.[12,13] Meta-analyses of other experiments support the idea that highly focused intention, such as that associated with an intense gaze, may directly influence aspects of the physical world.[14,15] Based on the evidence from such experiments, which support folkloric beliefs about extraordinary capacities of focused attention and intention,[16,17] we were emboldened to take the idea of evidence-based medicine seriously and to test whether a seer could indeed "see" the future. We were specifically interested in whether it was possible to detect presentiment effects in the behavior of the human eye.

The eye was selected because subjective states can be inferred by monitoring pupillary dilation (PD), spontaneous blink rate, and eye movements. Pupillary dilation reflects attention, cognitive processing load, emotional responses, anticipation, and the degree of balance between sympathetic and parasympathetic activation.[18,19] Eye gaze direction indicates real-time allocation of attention,[20] mental imagery while imagining a scene,[21,22] and preferential processing in the left versus right brain hemisphere.[23] And spontaneous eye blinking increases with a rise in dopamine, a brain neurotransmitter associated with factors as diverse as fine motor coordination, insulin regulation, physical energy, and emotional response.[24]

The experimental design was based on experiences described as a sense of foreboding that something, probably emotional, was about to unfold. To detect such effects in the lab, 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 randomly presented emotional events than before calm events.

Previous presentiment experiments have used measurements including skin conductance level,[6,25-32] nonspecific skin conductance response,[33,34] heart rate,[29,30] brain electrical activity,[35-38] and blood oxygenation levels in the brain as measured with functional magnetic resonance imaging.[39] Stimuli have included emotional versus calm photographs, stylized happy versus sad faces, auditory startle tones versus silence, and electrical shock versus no shock. In some studies, participants initiated trials of fixed time periods at will, and in others stimuli appeared spontaneously at random times. As of early 2009, at least 14 investigators have reported 19 experiments of this type, of which 17 were in the predicted direction and 10 were significantly positive (five of these experiments were student projects at the University of Edinburgh.).[40] 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 proposed strategies suggest that outcomes similar to presentiment effects can be produced when the experiment involves asymmetric distributions of dichotomous stimuli combined with assumptions about progressively rising levels of nervous system arousal between successive emotional stimuli.[41] However, analyses of physiologic data collected in these experiments have shown that the idealized assumptions are not confirmed in the actual data. To date, no artifacts or realistic strategies have been identified that can adequately explain these effects via conventional means.

This paper reports two new experiments examining the presentiment phenomenon. Experiment one assumed the following: (a) presentiment effects are largely mediated by the sympathetic nervous system, which would cause the pupil to dilate more before randomly selected emotional versus calm images, (b) presentiment information would be processed preferentially in the right hemisphere in right-handed people, and this would be reflected by the direction of gaze,[42,43] and (c) people who showed significant presentiment effects would also show positive correlations between their eye movements recorded before versus while viewing a stimulus picture, reflecting the speculation that eye movements associated with future inspection of an image might mimic eye movements before that image appeared.

Experiment two was exploratory and studied what presentiment might be responding to—the probable present versus the actual future.[44-46] If presentiment reacts to present-time potential events that have high a priori probabilities of being selected, even when those events do not actually manifest, then it implies that presentiment perceives the probable present. But if presentiment reacts to actual future events, even when they are a priori unlikely 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, and among attendees at an Institute of Noetic Sciences conference. All volunteers in experiment 1 were adults; one participant in experiment two was a minor female. All volunteers (and an adult guardian) read and signed informed consents prior to participating.

**Equipment**

Eye data were collected using a video eye tracking system that provided eye movement direction and pupil diameter measures at 60 samples per second (Eye-Trac 600, Applied Science Laboratories, Bedford, Mass). Programs written by the first author in Microsoft Visual Basic 6 controlled the random selection and display of picture stimuli; it also coordinated the two Microsoft Windows XP computers used to control the experiment. One program running on a "stimulus PC" responded to the participant's interactions, selected and displayed the pictures, communicated with the Eye-Trac 600 to inform it about the ongoing experimental condition (between trials, prestimulus period, etc), and retrieved random numbers as needed by a random number generator. Another program running on an "eye-track PC" continuously collected eye data from the Eye-Trac 600. The conceptual design of this layout is illustrated in Figure 1.

**Stimuli**

Experiment one used stimuli consisting of 592 images from the International Affective Picture System (IAPS).[47] These color photographs provide a wide range of emotional affect and valence, and each image is associated with an international standardized score for affect and valence. Arousal scores for the set 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 two, we generated a new picture pool of 500 images consisting of 250 emotional images copied from a Web site that hosts competitions for humorous and bizarre photorealistic composite images, including such things as human-animal and human-vegetable hybrids,[48] and 250 calm stimuli were copied from another photographic Web site,[49] including images of clouds, placid lakes, and other low-affect scenes. The calm images were then edited into grayscale to reduce color-associated affect.

**Procedure**

The basic procedure used in both 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 600's head and chin rest apparatus. After adjusting the apparatus and focusing the camera on P's left pupil, E dimmed the lights and ran an eye calibration procedure. Then E advanced the computer display to a screen showing a gray rectangle on a black background. This target area subtended visual angles of 21.5° wide × 17.8° high from the perspective of an eye positioned in the eye tracker.

E instructed P that when a target screen appeared, to click the mouse button at will to automatically begin each trial. As shown in Figure 2, after the button press the screen remained dark for three seconds, then an image was randomly selected from the stimulus set and displayed for three seconds (experiment one) or five seconds (experiment two), and then the screen went dark for three seconds. At this point, a message appeared on the screen alerting P to continue to the next trial at will. Before beginning

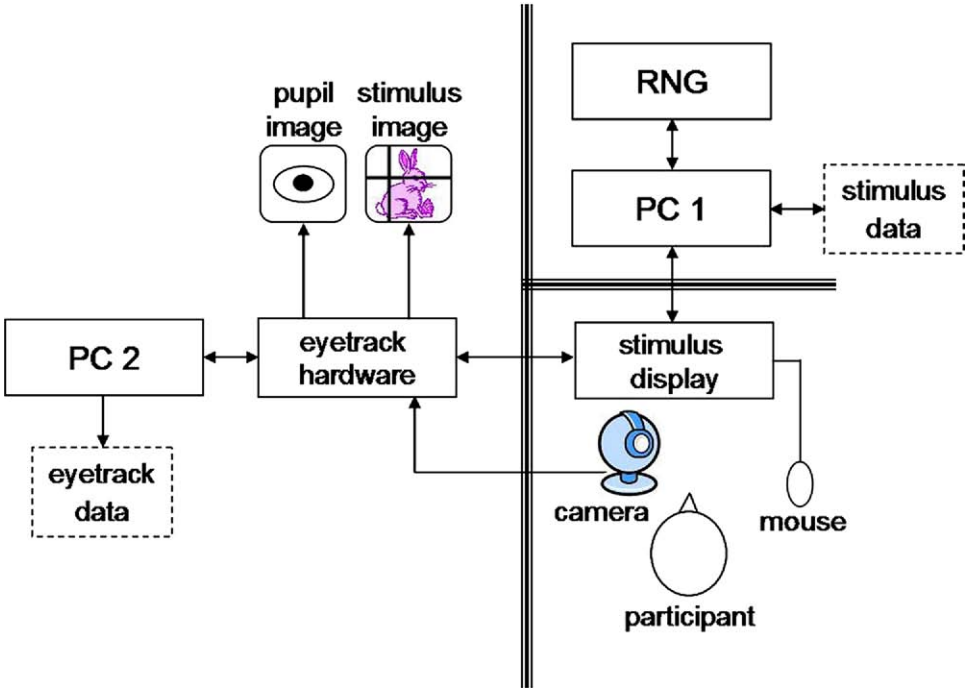


**Figure 1.** Participants conducted the study in a cubicle containing the stimulus display, a mouse and keyboard, and a small charge-coupled device camera used to image the participant's eye. The other equipment included a computer (PC1) used to select, display, and record the picture stimuli, a truly random number generator (RNG) used to select the stimuli (used in experiment two), eye-tracking hardware (Eye-Trac 600 control unit), a video monitor to display the pupil and a second to display the stimulus overlaid with crosshairs indicating where the eye was looking, and a second computer (PC 2) used to collect the eye-tracking data.

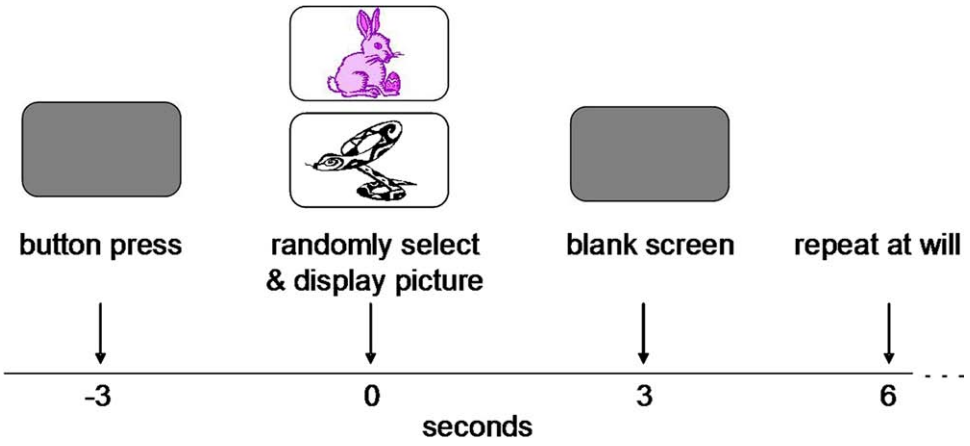


**Figure 2.** Each trial began with a button press at will (at −3 seconds); a photograph was randomly selected and immediately shown at stimulus onset (0 seconds), and then the screen went dark at stimulus offset (+3 seconds in experiment one, +5 seconds in experiment two). Three seconds later the next trial could begin.

the session, E asked P to feel the appropriate emotions evoked by each successive image, and to allow his or her eyes to wander freely over the display screen both before and during stimulus exposure.

**Experiment-specific Procedures**

In experiment one, eye data per trial consisted of one second of baseline, three seconds prestimulus, three seconds during stimulus display, and three seconds of postdisplay, for a total of 10 seconds × 60 samples per second or 600 samples. In experiment two, the stimulus was displayed for five seconds, so each trial consisted of 12 seconds or 720 samples of eye data.

In experiment one, the stimulus pictures were selected uniformly at random, with replacement, from a 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 the computer's computer processing unit (cpu) clock immediately after the prestimulus period ended. The prestimulus timer was programmed to fire three 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 three second period to vary unpredictably by a few milliseconds (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).[50] The stimulus computer's cpu clock (1 GHz) ran hundreds to thousands of times faster than the stimulus timing uncertainty, so the seed number used to reseed the PRNG, and thus the target picture selected on each successive trial, was not determined in advance (note that even adjacent seed numbers will cause a PRNG to generate a completely different sequence of random numbers).[51]

Experiment two used a truly random number generator (RNG) based on electronic noise to make all random selections.[52] 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, 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 possible futures existed, one more likely than the other. When the prestimulus interval timer fired to begin the stimulus display period, the RNG first selected one of the two targets according to its preassigned probability, and then displayed it. 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.[53] Data of primary 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 one. Hypothesis one.*** Change in PD from baseline will be larger before randomly selected emotional pictures as compared to before-calm pictures. For purposes of this test, "emotional" was predefined 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.[47]

***Experiment one. Hypothesis two.*** Spontaneous blink rate will be higher before randomly selected emotional versus calm pictures.

***Experiment one. Hypothesis three.*** For persons exhibiting presentiment effects in hypothesis one, eye movements recorded before viewing the stimulus will be positively correlated with eye movements recorded while viewing the stimulus.

***Experiment one. Hypothesis four.*** Horizontal eye movements before randomly selected emotional pictures will move more towards the left than before calm pictures.

***Experiment two. Hypothesis five.*** The presentiment effect as defined in hypothesis one will differ depending on whether the probable and actual future targets matched or mismatched.

The first four hypotheses were directional and thus one-tailed tests were employed. The last hypothesis was nondirectional, so a two-tailed test was used.

**Analyses**

All analyses were performed in MATLAB 7 programs written by D.R. (The Mathworks, Inc, Natick, Mass). Hypotheses one and five proposed that PD would be larger prior to emotional versus calm stimuli. This was evaluated using a nonparametric randomized permutation procedure, as follows:

1. Determine PD data and the target affect score for each trial contributed by each participant.
2. Transform all per-trial PD data into baseline adjusted percentage change values, based on the average PD measured during the 10 samples collected just before the button was pressed to begin each trial; thus $P_\Delta = (P_i - \bar{P}_{51\text{-}60})/\bar{P}_{51\text{-}60}$, where i ranged from samples 1 to 600 (experiment one) or 1 to 720 (experiment two), and where samples 51 to 60 represented PD data measured 167 ms before the trial-initiating button press. During this period the eye was gazing at a dark screen.
3. Form the ensemble mean of $P_\Delta$ 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, $P_\delta = (P_{\Delta Ei} - P_{\Delta Ci})$, where $i$ ranged over samples 61 to 240.
5. Randomly permute the assignment of target affect scores used on each trial and recalculate $P_\delta$ by using those new assignments; call the recalculated value $P_{\delta r}$, where $r$ indicates random.
6. Repeat the previous step 5,000 times to build up a distribution of possible $P_{\delta r}$ values.
7. Form a normalized score for the observed $P_\delta$ value as $z_P = (P_\delta - \mu(P_{\delta r}))/\sigma(P_{\delta r})$, where $\mu$ refers to the mean and $\sigma$ to the standard deviation of the $P_{\delta r}$ values. The $P$ value associated with $z_P$ is then used to assess the likelihood that *PD* prior to emotional targets differed from *PD* prior to calm targets.

Hypothesis two predicted more spontaneous blinking prior to emotional versus calm stimuli. When blinking occurred, the eye-tracker camera could no longer see the eye, and PD values were recorded as missing, 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 if ambient light reflections off the cornea confused the eye-tracking algorithms. The latter two reasons for tracking failure were substantially reduced through the initial calibration procedure by running the experiment in an ambient 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 analytical 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; 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 the previous step 5,000 times to build up a distribution of possible $PD_{\Delta nr}$ 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 three predicted that participants who exhibited presentiment abilities, based on individual analysis of their PD measurements as in hypothesis one, would show a positive correlation between their eye movements tracked before versus while observing the stimuli. Participants who did not show a presentiment effect based on their 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 one, but based on a per person 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 "chance sessions."
2. For the sessions identified in step one, 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 10 samples before the button press, ie, samples 51 to 60; thus, $H_\Delta = (H_i - \bar{H}_{51\text{-}60})/\bar{H}_{51\text{-}60}$ and similarly for $V_\Delta$, 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 (ie, if one person always tended to look to

the upper right and another always to the lower left, then after pooling those data we may see a positive correlation created solely by habitual differences in eye movement).

4. For each trial in step three, 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 × 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 timing position, are also removed (eg, if samples 150 to 155 were missing from array P, then samples 150 to 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. Determine the 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 four and five. This step mismatches the prestimulus and during-stimulus eye movements, to provide an analytical control.
8. Recalculate $r_s$ and $r_c$ by using the random assignments; call them $r_{sr}$ and $r_{cr}$.
9. Repeat the previous two steps 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 $\mu$ indicates the mean and $\sigma$ 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 four 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 versus 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, $H_\Delta = (H_i - \bar{H}_{51\text{-}60})/\bar{H}_{51\text{-}60}$, where $i$ ranged from 1 to 600.
3. Form the ensemble mean of $H_\Delta$ 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: $H_\delta = \Sigma(H_{\Delta Ei} - H_{\Delta Ci})$, where $i$ ranged from 61 to 240.
5. Randomly scramble the assignment of IAPS arousal values, then recalculate $H_\delta$; call it $H_{\delta r}$, where $r$ refers to random.
6. Repeat the previous step 5,000 times to build up a distribution of $H\delta r$ values.
7. Form a normalized score for the observed $H_d$ value as $z_{HD} = (H_\delta - \mu(H_{\delta r}))/\sigma(H_{\delta r})$, where $\mu$ refers to the mean and $\sigma$ to the standard deviation of the $H_{dr}$ 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 One

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

***Hypothesis one.*** At the planned 5% level of emotional contrast, there were 72 calm trials, with an average IAPS arousal of 2.43, and 72 emotional trials with an average IAPS arousal of 7.05. The differential change in PD during the prestimulus period was determined to be significantly positive ($z = 3.17$, $P = .0008$ [one-tailed]; Figure 3). Figure 4 shows the effect of varying the

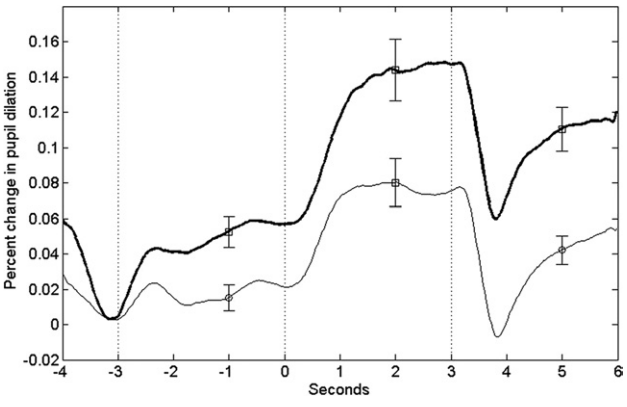


**Figure 3.** The bold (top) line shows average proportional change in pupillary dilation for the 5% most emotional targets across all 1,438 usable trials; the thin (bottom) line shows the same for the 5% calmest targets. Both lines are baseline adjusted to the average pupillary dilation value per trial during the 167 ms 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 ms to clarify the figure.

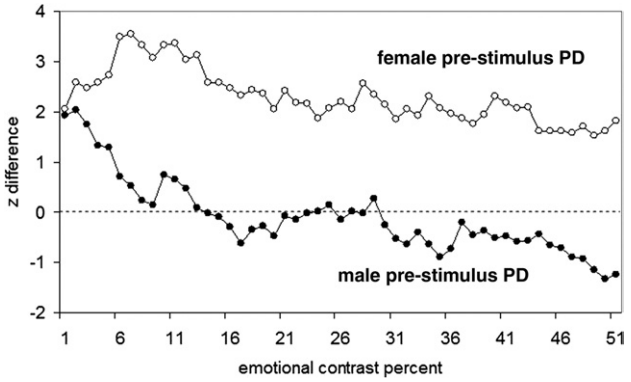


**Figure 4.** Presentiment results, in the form of $z_p$, for varying emotional contrast percentages, by gender. Females (white dots) peaked at a 7% contrast ($z = 3.54$), males (black dots) at a 2% contrast ($z = 2.03$).

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.[6] In addition, the stronger and more consistent results for females are in alignment with a similar gender difference found in a presentiment study based on measurements of slow cortical potentials in the brain.[32]

***Hypothesis 2.*** At a 5% emotional contrast, there was more spontaneous blinking before emotional versus calm pictures ($z = 2.13$, $P = .02$ [one-tailed]; Figure 5). At the same contrast level females showed a larger effect than males (female $z = 2.64$, n = 818 trials; male $z = 1.59$, n = 620 trials). Over all, prestimulus periods in all trials, 94.6% of PD data were recorded, so this spontaneous blinking difference is based upon a small amount of missing (and thus eye-closed) data. In a post hoc test, differential effects for PD and spontaneous blinking, analyzed per participant, were found not to be correlated ($r = -0.06$, $t$ (35 *df*) = $-0.38$, $P = .71$ [two-tailed]), so the overall results for these two measures could be considered independent measures. This leads to a general presentiment effect in eye data, contributed by 33 unselected volunteers, associated with a (Stouffer *Z*) combined $z = 3.75$ ($P = 9 \times 10^{-5}$).

***Hypothesis 3.*** Five participants in this study 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 ($r = 0.049$, $z = 2.91$, $P = .002$ [one-tailed], N = 190 trials). Five additional participants selected based on their obtaining results closest to chance showed no significant correlation ($r = 0.006$, $z = -0.79$, $P = .78$ [one-tailed], N = 190 trials). The difference between outcomes in these two groups is significant ($z = 2.61$, $P = .005$ [one-tailed]), suggesting that when presentiment effects occurred, they were driven not only by future emotional responses but also by spatially relevant information specific to those future targets.

One might ask whether the positive correlation in eye movements between the prestimulus and during-stimulus periods might have been due to artifacts associated with habitual eye movements. For example, a spurious positive correlation can occur if people tended to examine certain areas of the screen before and during target presentation, regardless 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 6 shows *z* scores associated with correlations in eye movement between prestimulus versus during stimulus periods (labeled "pre-dur" in the figure), for the five individuals who obtained independently significant presentiment results (hi group), and for the five individuals who obtained results closest to chance (lo group). For the hi group, prestimulus eye movements significantly correlated with eye movements while viewing the target, but not across successive targets (labeled "dur-dur" in the figure; $r = 0.02$, $z = 0.14$, $P = .45$), suggesting that their eye movements were *not* habitual, but rather driven by visually attractive elements in the targets. Nor did their eyes follow strong habitual movements during the prestimulus period (labeled "pre-pre"; $r = 0.10$, $z = 1.23$, $P = .11$). 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 ($r = -0.05$, $z = -2.95$, $P = .01$ [two-tailed]) and also during successive prestimulus periods ($r = 0.17$, $z = 4.47$, $P < .001$ [two-tailed]). This suggests that the lo group *did* exhibit habitual eye movements, and that they were not strongly influenced by the target images. This habitual behavior may also be the reason why this group failed to show a presentiment effect.

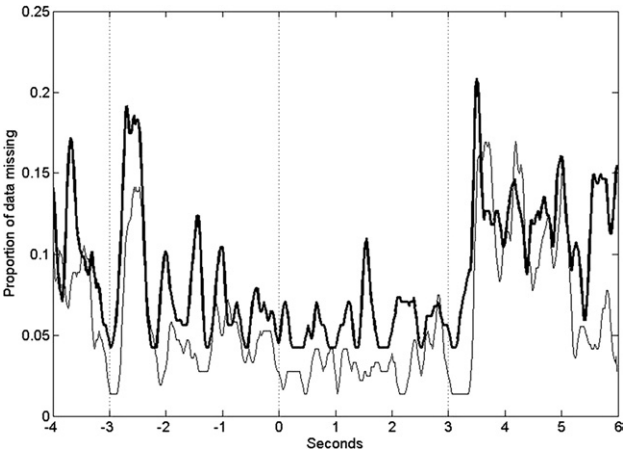


**Figure 5.** The bold line (top) shows average proportion of pupillary dilation data missing in the 5% most emotional targets; the thin line (bottom) represents the same for 5% of most calm targets. This indicates more spontaneous blinking both before and during display of emotional targets as compared to calm targets.

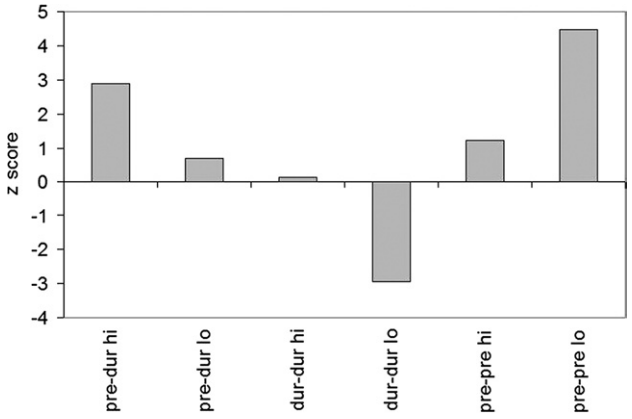


**Figure 6.** *Z* scores associated with statistical significance of correlations (determined by randomized permutation analysis) for significant (hi) and nonsignificant (lo) presentiment responders. The correlations were between eye movement in prestimulus versus during stimulus periods (pre-dur), during successive stimulus periods (dur-dur), and during successive prestimulus 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 toward the left than before calm pictures ($z = -1.65$, $P = .05$ [one-tailed]; Figure 7). This suggests greater involvement of the right brain hemisphere prior to emotional targets.

In a post hoc test, the same analysis was performed on image valence (ie, contrasting the 5% of images with the most positive affect versus 5% most negative affect). This found that for negative valence, the eyes moved more to the left (right brain) and for positive images the eyes moved more to the right (left brain), with $z = 2.21$, $P = .01$ (one-tailed). This finding is consistent with experiments examining brain hemispheric asymmetries in the study of emotion,[51] offering further evidence that presentiment effects are responses linked to unique image content and not just to emotional reaction.

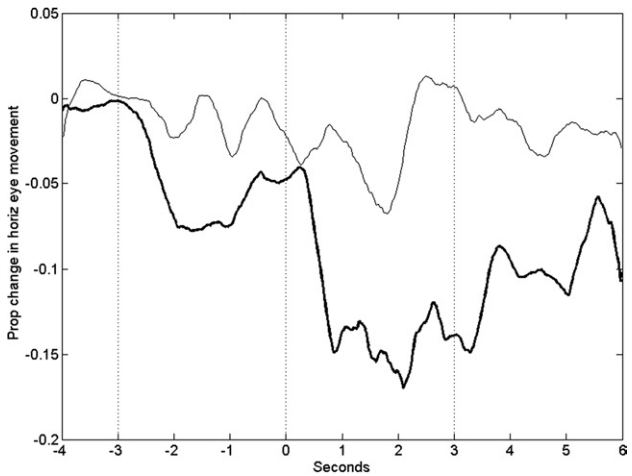


**Figure 7.** Bold line (bottom) shows the ensemble average of proportional changes (prop) in horizontal (horiz) eye movements for the 5% most emotional trials, thin line (top) shows the same for the 5% most calm trials. Negative values on the y-axis correspond to the eye looking to the left.

**Table 1.** Results of Experiment Two

| Condition | Trials (Total) | Calm | Emotional | $z_p$* |
|---|---|---|---|---|
| Mismatch | 640 (2099) | 330 | 310 | 1.71 |
| Match | 1459 (2099) | 701 | 758 | −1.10 |
| Difference | | | | 1.99 |
| Female mismatch | 382 (1349) | 197 | 185 | 2.43 |
| Female match | 967 (1349) | 481 | 486 | −1.12 |
| Difference | | | | 2.51 |
| Male mismatch | 258 (750) | 133 | 125 | −1.10 |
| Male match | 492 (750) | 220 | 272 | −0.28 |
| Difference | | | | −0.58 |

*$Z$ score associated with statistical significance of the presentiment effect, following the first procedure described in the Analysis section.

## Experiment 2

Forty-one 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 to 82 (mean 50.9 years), 15 males ranged from 20 to 67 years (mean 46.3 years), and 27 females ranged from 8 to 82 years (mean 52.3 years).

***Hypothesis 5.*** By design, 30% of the data were expected to be "mismatch trials" in which 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 PD presentiment effects between the mismatch and match conditions was significant ($z = 1.99$, $P = .05$ [two-tailed]). The same analysis split by gender showed that females were largely responsible for this result ($z = 2.51$, $P = .02$ [two-tailed]). 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.[52,53]

Closer examination of the female data suggests that when there was a mismatch between the probable present and the actual future, presentiment appeared to respond to the actual future (Figure 8). 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 PD *during* exposure to the targets did not show a clear differential effect. This suggests that the custom target pool created for this test may not have been optimal for producing a strong emotional contrast. Because PD continually increased in this test while examining the calm targets, we speculate that the use of humorous and bizarre images for the emotional targets may have caused participants to imag-

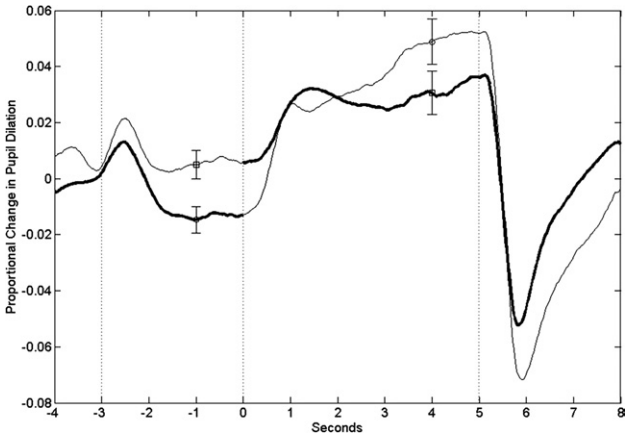


**Figure 8.** These curves show mean baseline-adjusted proportional change in pupillary dilation for female-contributed trials. The bold line (bottom) during the prestimulus period, seconds −3 to 0, indicates high probability emotional targets; the thin line (top) indicates the high probability calm targets. During the stimulus period, seconds 0 to 5, the bold line indicates actual emotional targets, the thin line actual calm targets. The jump in target types 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 targets did not manifest into actual future targets.

ine that the calm images were also hiding something interesting, so they persisted in examining the calm images as long as they were displayed. Progressive pupil dilation is consistent with the cognitive processing load associated with continual searching.

## DISCUSSION

These experiments resulted in five outcomes: (1) Under conditions controlling for anticipatory strategies and conventional cues, PD and spontaneous blinking increased more before viewing randomly selected emotional versus calm photographs. (2) At high levels of emotional contrast in the target photos, males and females showed similar PD effects, but overall females showed more consistent effects. (3) PD in females responded differently when the probable and actual futures matched than when they mismatched, suggesting a possible transtemporal interference effect associated with the probability of a future target. (4) Horizontal eye movements indicated a brain hemispheric asymmetry appropriate to both the emotionality and the valence of the future targets. (5) 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.

Replication of the basic presentiment effect confirms results observed in previous experiments, and the new findings extend earlier outcomes by indicating that presentiment appears to respond to specific information in the future targets. These results also support folklore suggesting that, at least in principle, some seers can indeed "see" the future. Of course, folklore carries little capital in science, so it is prudent to discuss whether the apparent outcomes 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 in experiments one and two, only two trials proved to be unusable, so the analyses in hypotheses one, two, four, and five presented here are based on over 99.9% of all data collected, and for hypothesis three, all data were used in the two subsets of participants selected.

With regard to optional stopping, no previous data based on this specific 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 one was planned in advance to include at least 30 sessions based on D.R.'s experience in conducting previous experiments. Seven additional sessions were ultimately conducted as pilot sessions and demonstrations, but data from those sessions were included here to avoid arbitrary selection of sessions.

Experiment two 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 until after that date had been reached (data for experiment two were collected during a six-week summer internship of A.B.). 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 prestimulus 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 one only a small subset (10% total) of the most emotional and most calm trials were actually used for the preplanned presentiment analyses. To check 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 one, autocorrelations lagged from 1 to 40 resulted in two correlations beyond chance at $P < .05$ (two-tailed). This is in accordance with chance expectation (exact binominal $P = .60$). The two significant autocorrelations were at lag 13 ($r = -0.06$) and lag 38 ($r = -0.06$). They suggest that if participants were able to systematically keep track of the IAPS arousal level of each successive trial (without any quantitative feedback of what those levels actually were), then they might have noticed that every 13 trials the emotional affect of the photograph would have alternated from low to high and vice versa (no participant would have noticed the lag at 38 trials because the sessions ended at 30 or 40 trials). Of course, an autocorrelation of $r = -0.06$ accounts for less than 0.4% of the variance, so it is unlikely that based on three exemplars (trials 13,

26, and 39 in a single session of 40 trials) anyone could have learned this correlation. A similar analysis for trials in experiment two showed that again two autocorrelations through lag 40 exceeded chance at $P < .05$ (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 could have noticed that affect levels on say, every 11th trial, were similar to each other. Thus, it seems implausible that the observed results could be adequately accounted for by strategies developed through implicit learning.

It might be argued that it is not necessary for the trial sequences pooled across all sessions to be nonrandom. All it would take would be a few sessions with nonrandom sequences to sway the overall statistics. To test this idea, for experiment one 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 PD) 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 nonchance 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; of 20 correlations, one was expected to be significant by chance at $P < .05$ (two-tailed) of the 37 sessions run in experiment one. This analysis resulted exactly in the chance-expected 37 significant correlations, ranging from zero to four per session. A Spearman rank order correlation between these figures versus $z_p$ per session resulted in $r = 0.08$, $P = .64$. Thus, there was no evidence that the results of experiment one could be explained by statistically informed anticipatory cues at either the trial or the session level.

### What Does Presentiment Respond To?

If presentiment potentially responds to transtemporal cognitive-perceptual interference, and to the future target's affect, valence, and unique visual elements, might it also respond simply to the brightness of the target? This question arises because an earlier study using a light flash as a stimulus showed a significant presentiment effect in females.[37] In addition, the correlation between image illumination level and emotional affect for the 1,438 trials used in experiment one was significantly positive ($r = 0.09$, $P = .001$; the average illumination level for each picture was calculated using routines in the MATLAB 7 Image Analysis Toolbox). This correlation introduced opposing forces in experiment one in that the brighter the target, the more the pupil would tend to constrict, but at the same time the more emotional the target, the more it would tend to dilate. Given these counteracting effects, the significant results obtained in experiment one suggest that the presentiment effect was not especially sensitive to the illumination level of the future targets.

To test this suggestion, we examined PD before a subset of the 5% brightest and 5% dimmest targets, as measured by the target's overall average illumination level. Figure 9 shows that on average—as expected while observing the target—the pupil was strongly influenced by the image's illumination level; the pupil dilated if the target was dimmer and constricted if the target was brighter. This bright versus dim analysis led to a differential $z_p = -5.64$ during stimulus presentation. If presentiment responded to future illumination level, then the same differential analysis during the prestimulus period should also have been negative, but instead it was positive ($z = 1.24$, $P = .11$). This makes sense if presentiment responds more to the future *emotion* than to the future illumination level, and that was confirmed in this case because the 5% of brightest targets had a significantly higher average IAPS arousal level (5.08) than the 5% of dimmest targets (4.40; $P = .003$ [two-tailed], by $t$ 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 ($z = 3.01$, $P = .001$).

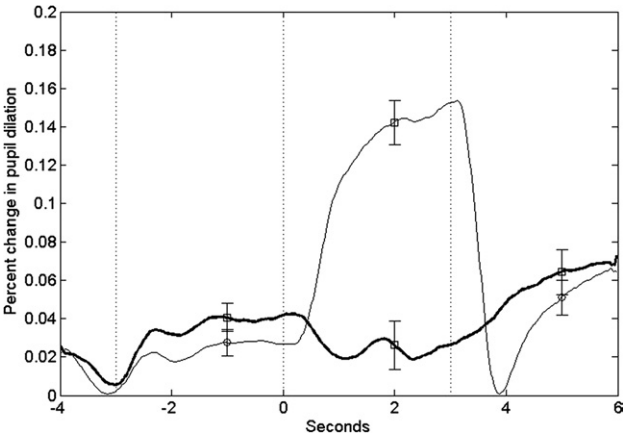


**Figure 9.** Average pupillary dilation response to the 5% brightest targets (bold line), and same measure for the 5% dimmest targets (thin line).

In summary, the concept of the future influencing the present appears to violate 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 ordinary form yet to be discovered. This cannot be ruled out, although care was taken to avoid all known forms of conventional cueing. However, even "ordinary" anticipation is not as simple as it appears to be. Experiments searching for an overall preparatory state in the nervous system, using negative slow cortical potentials in the brain, heart rate deceleration, and PD measures, have failed to show any correlation between anticipatory readiness and subsequent responses.[54] Even triggering stimuli during what are thought to be optimal physiologic states, such as heart rate deceleration, does not yield better anticipatory performance as compared with controls.

As Jennings et al[54(p97)] 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." Given the results of the present and previous presentiment experiments, it seems possible that one of those preparatory components might be influences from the future.


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