Unorthodox Forms of Anticipation

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Abstract Prediction involves the act of mentally projecting into possible futures based on knowledge of the past and influenced by present wants and needs. Most scientists assume that prediction is sufficient to account for forms of behavior in which the future is represented by wants and needs. Experiences that are labeled intuitive hunches, gut feelings, premonitions, or presentiments are suggestive of time-reversed forms of anticipation. Despite the seeming impossibility of genuine time-reversed effects, a growing body of empirical data in psychology, psychophysiology, and physics suggests that despite the disquiet associated with the concept of retrocausality, such influences may nevertheless exist.

Keywords Anticipation · Prediction · Presentiment · Retrocausation · Teleology

1 Introduction

Preparing for the future is a central preoccupation of human beings. Adults plan for retirement; children plan for Halloween. Physicians plan a patient's course of healing; patients would like to know if treatments will be effective. Epidemiologists expect epidemics; geologists would like to be able to predict earthquakes, meteorologists forecast weather, and so on.

To anticipate entails capabilities different from those involved in planning, expectation, forecasting, prediction, intuition [1]. A human being's ability to anticipate allows him/her to successfully hit a baseball with a bat without actually watching the ball. Through anticipation, a catcher runs to where the ball will be. A tennis pro returns the serve in anticipation of where the tennis ball is heading [2]. The reactive mode—waiting to see where the ball lands and then acting on that information—spells failure in sports. It prevents us from passing out when we stand up from a sitting position [3]. It determines what we see or fail to see [4], and it

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forms the basis for an entire class of humor [5]. In sum, anticipation is a key feature that distinguishes living from non-living systems, as well as much of human activity from that of other living organisms (e.g., animals, insects). As such, it is important to understand the full range of anticipatory behavior.

Conventional models of anticipation assume that this ubiquitous behavior can be fully understood by common sense notions of causality. But some forms of anticipatory experience, variously called intuitive hunches, flashes of insight, gut feelings, precognition, premonitions, or presentiments, appear to violate ordinary causality and suggest teleological pulls from the future. Are such appearances of retrocausation merely telic veneers, or is it possible that some experiences do involve genuine influence from the future?

The orthodox answer is that experiences of retrocausation are necessarily illusory because reversed causation is impossible. Indeed, scientific explanations are predicated on the assumption of unidirectional and inviolate causality, so claims of precognition must be mistaken because they would presumably violate one or more natural laws [6]. However, despite such common sense assumptions, both empirical and theoretical reasons can be brought to bear to challenge this orthodox stance.

2 Methods

One of the hallmarks of science is that it has repeatedly revealed that many of our intuitions about the nature of reality—including such foundational concepts as space, time, matter and energy—are wrong. For example, everyday experience tells us that Nature is based on three core principles: locality, causality, and reality [7, 8]. *Locality* refers to the idea that all interactions between physical systems occur through physical contact. This disallows any form of "spooky action at a distance," to use a phrase made famous by Einstein. *Causality* tells us that the cause-effect order is sacrosanct, i.e., that time moves strictly forward. *Reality* means that the moon (or any object) is still there even when you are not looking at it, i.e., that the world consists of objects with real properties that are completely independent of observers.

From an everyday perspective, all of these principles are self-evident. The problem is that developments in physics over the course of the 20th century (primarily relativity and quantum theory) have established to very high degrees of confidence that one or more of these three principles are simply wrong [7–10]. To date there is no widespread consensus about whether we need to relinquish locality, causality, or reality, or all three; but it is abundantly clear that *something* about our understanding of the deep nature of reality is radically at odds with common sense. This opens the door to thinking about new, previously unthinkable, possibilities, including retrocausal experience. We will refer to such experiences as forms of "unorthodox anticipation."

Fortunately we are not limited to discussion of anecdotes. These experiences are perfectly amenable to scientific study in a variety of rigorous ways, including

(a) consciously predicting future events that cannot be inferred via ordinary means, and where the probability of a chance outcome is known; (b) similar studies conducted while the participant is dreaming, in which unconscious responses are measured by implicit behavior and physiological manifestations.

2.1 Forced-Choice Tasks

The protocol in these experiments involves asking participants to guess the outcome of a future random decision, like the tossing of a pair of dice or its modern equivalent, generation of a random number by a truly random process instantiated within a hardware-based electronic circuit. The source of randomness in these modern random number generators (RNGs) includes radioactive decay times, electron tunneling, and other quantum-randomness events.

A meta-analysis of these forced-choice experiments conducted from 1935 to 1987 [11], based on 309 publications, found a small overall average effect size (Rosenthal effect size $r = 0.02$ [12]), but due to the large statistical power, the deviation from chance was highly significant (associated with a standard normal deviate of $z = 6.02$, or $p < 1.1 \times 10^{-9}$). The possibility that this outcome was inflated due to selective reporting practices was addressed by calculating how many unreported or unretrieved studies averaging a null effect would be necessary to reduce the effect to a non-significant level. That number turned out to be 14,268 studies, which was deemed implausible given the number of researchers known to have conducted these studies. It was further found that while experimental methods had significantly improved from 1935 and 1987, the effect size remained constant, which argues against the potential that the results were biased by differences in study quality. Also, studies with participants selected for better performance produced significantly larger effects as compared to unselected participants, which is consistent with the observation that human performance displays wide variations in natural talent.

While this literature provides evidence for a form of unorthodox anticipation, forced-choice experiments eventually declined in popularity for two main reasons. First, repeated-guessing tasks are boring, and as such they encourage participants to guess the next target based on the gambler's fallacy rather than on intuitive impressions. Second, this type of test constrains the impressionist and spontaneous way that these abilities manifest in everyday life [13, 14]. These limitations led to the development of new experimental designs.

2.2 Free-Response Tasks

In a free-response task, participants are asked to describe a photo, video clip, or a geographic location that will be randomly selected and displayed or visited in the

future. Independent judges then compare the participant's impressions against a pool of five targets, one of which was the actual (randomly selected) target and four were decoys. The five-item target pool is devised in advance so the possible targets are as different from one another as possible. The judge's task is to rank-order the participant's impressions to the best match of the five, the next best, and so on. In the simplest form of analysis, if the actual target is ranked first, then that trial would be classified a "hit;" otherwise it would be a "miss." Many other, more sophisticated methods of analysis have also been applied to this type of data. Most of the free-response trials based on this general protocol were performed by two groups. The first was (at the time) a classified project housed first at the Stanford Research Institute (SRI) from 1973 to 1988, and then later continued at Science Applications International Corporation (SAIC) from 1988 to 1995 [15]. The second was conducted by the Princeton (University) Engineering Anomalies Research Laboratory (PEAR Lab) from 1978 through the late 1990s [16].

Analysis of the trials conducted at SRI, consisting of 770 individual sessions, resulted in a mean effect size of (Rosenthal's) $r = 0.21$, associated with $z = 5.8$, $p < 3.3 \times 10^{-9}$. Some 445 tests conducted later at SAIC resulted in a mean effect size of $e = 0.23$, $z = 4.85$, $p < 6.1 \times 10^{-7}$ [15]. A total of 653 sessions conducted at about the same time at the PEAR Lab resulted in a mean effect size of $r = 0.21$, $z = 5.42$, $p < 3.0 \times 10^{-8}$) [16]. The similar effect sizes observed in these three sets of data suggest the presence of similar underlying phenomena, and the magnitude of these effects as compared to that observed in the forced-choice tasks confirms the suspicion that experimental designs based more closely on how this information spontaneously arises in everyday life might produce stronger effects.

2.3 *Dream Experiments*

Precognitive dreams, to which Burk made reference during the conference Anticipation and Medicine[1] (see Burk[2]) are one of the more frequent spontaneous forms of unorthodox anticipation [17, 18]. To explore these experiences under controlled conditions, experiments have been conducted while participants were in the dream state. A participant would go to bed in a sleep lab and periodically be awakened to report his/her dream when exhibiting REM (rapid eye movements). If the dreamer was at home, he/she would simply be asked to write down the dreams upon spontaneously awaking. In the morning, a target would be randomly selected from a pool of prepared targets, and the selected target would be shown to the dreamer. As with the free-response technique, independent judges would blindly

[1]*Anticipation and Medicine*. Third International Conference: Anticipation Across Disciplines. Hanse Institute for Advanced Study/Hanse Wissenschaftskolleg, September 28–30, 2015. http://www.h-w-k.de/index.php?id=2181.

[2]Burk, L.: Anticipating the Diagnosis of Breast Cancer: Screening Controversies and Warning Dreams. In: Nadin, M.: (ed.) Anticipation and Medicine, pp. 285–297. Springer, Cham (2016).

compare the dream content against the actual target and the decoy targets; and if the actual target was assigned a rank of 1, then that would be considered a "hit."

Three of four published experiments using this technique reported significant results based on simple counting statistics ($p < 0.05$, two-tailed tests [19–21]). The fourth study did not achieve a statistically significant outcome, but the result was in the predicted direction.

In two other dream precognition experiments [22, 23], rather than showing the dreamer just the actual target, all of the target images were shown and the dreamer had to rank the similarity of his/her dreams to each of the items in the target pool. This design may have introduced some confusion because the dreamer's future experience included both the actual target and the decoys. This may be why both of these studies produced non-significant results. With each of three of four well-designed studies producing significant outcomes, this limited empirical database suggests that information from the future may be present below the level of awareness.

2.4 Implicit Behavioral Responses

Implicit anticipation experiments investigate whether present-time behavior is unconsciously influenced by events in the future. For example, the phenomenon of "mere exposure" indicates that people who are exposed to one of two equally preferably items (e.g., photographs of similar-looking people) will tend to prefer the one they have already seen, even when that exposure is subliminal [24]. An unorthodox anticipation version of the mere exposure experiment first asks a participant to select one of two images, and then a computer randomly selects one of the images and presents it subliminally. If mere exposure in the future influences present-time behavior, then the participant's freely selected present choice should be biased to match the randomly selected future image.

This paradigm was popularized by Bem, who in 2011 reported a series of nine such experiments with overall highly significant results [25]. Two years later a meta-analysis collected 90 studies using similar implicit designs, as well as replications of Bem's method, conducted between 2000 and 2013 by laboratories around the world. The results showed that the effect was independently repeatable and highly significant overall (*Hedges' g* = 0.09; $p < 1.2 \times 10^{-10}$) [26].

After categorizing the 90 studies according to the cognitive style required by the task (known as "fast-thinking" versus "slow-thinking" [27]), 61 of the experiments were determined to be fast-thinking and 29 were slow-thinking. The former refers to snap judgments performed without conscious effort, whereas the latter refers to conscious deliberation. Over all, the fast-thinking implicit anticipation tasks were highly significant ($z = 7.11$, $p < 6 \times 10^{-13}$), but the slow-thinking tasks were not ($z = 1.38$, $p > 0.15$). This difference was consistent with the observation that unorthodox anticipatory phenomena appear to arise first in the unconscious mind and only rarely bubble up to the level of conscious awareness [28–30].

2.5 Physiological Responses

If unorthodox anticipation does indeed reside in the unconscious, then the phenomenon should also be detectable by monitoring unconscious bodily changes in the nervous and circulatory systems. Psychophysiological tasks examining these purported effects have been dubbed "presentiment effects," i.e., pre-feeling as opposed to pre-cognitive responses [28].

Unlike the implicit anticipation tasks, these studies do not require behavioral responses or decisions. Instead, the participant is simply exposed to random dichotomous stimuli, e.g., a series of unpredictable weak vs. strong electrical shocks, or calm vs. emotional photographs, while an aspect of their physiology is monitored. The hypothesis is that the physiological measure will begin to react in a manner consistent with the future stimulus. Thus, seconds before an emotional photo is randomly selected and displayed, the participant's sympathetic nervous system (SNS) activity is expected to increase, reflected by say, a rise in skin conductance level, whereas before a calm picture the SNS will remain calm and skin conductance level will show no unexpected deviations from the baseline.

One of the first presentiment experiments used a reaction time task to test if contingent negative variation (CNV), an unconscious brainwave indicator of anticipation, would detect a randomly timed stimulus in the immediate future [31]. The experiment showed a small but statistically significant difference. Shortly thereafter, two independent replication attempts obtained outcomes in the expected direction, but not to statistically significant degrees [32, 33]. At about the same time, an experiment was reported that included presentiment as a possible factor with electric shock as the stimulus [34]. Based on skin conductance measures, 6 of 10 experimental sessions individually showed significant results, each at $p < 0.01$.

Two decades later a presentiment experiment was conducted using skin conductance as the main measure and calm versus emotional photographs as stimuli [28]. That study resulted in a statistically significant outcome, which was soon independently and successfully replicated [35]. That sparked many new replications using physiological measures, including skin conductance, heart rate, peripheral blood flow, pupil dilation, brain electrical activity, and brain blood oxygenation [36–57]. The basic protocol in these studies was conceptually similar, but the stimuli ranged from photographs to cartoons, audio tones, light flashes, and electrical shock. As in the other experiments mentioned herein, the future stimuli in most of the presentiment studies were selected by hardware-based random number generators (RNG).

By 2011, over three dozen presentiment replications had been reported. The first meta-analysis retrieved 37 experiments involving a total of 1064 participants [58]. The overall average effect size was a Cohen's d of 0.26 ($CI^{95\ \%} = 0.19$ to 0.37), and the combined statistical result was $p < 1.6 \times 10^{-18}$. A Bayes factor was also calculated, providing a Bayesian interpretation of the strength of evidence for or against the hypothesis. According to Jeffreys [59], for a Bayes factor less than 3 to 1 the hypothesis under test may be interpreted as "barely worth mentioning." If it

reaches 10 to 1, the evidence may be considered "substantial;" above 30 to 1, it may be considered "strong;" above 100 to 1, it is "very strong;" and above 100 to 1, the evidence can be regarded as "decisive." For the presentiment studies, the Bayes factor was an unambiguous 28 trillion to 1. The worst case file-drawer was estimated to be 954, a ratio of 26 hidden, unpublished, or non-retrievable studies for each of the known 37 experiments. Such a degree of selective reporting was judged implausible.

A second meta-analysis found 49 published and unpublished presentiment experiments through 2010 [60]. To help narrow the scope of that analysis, each study included was required to have specified a preplanned analysis, use human physiological measures, and contain clear expectations (or *desiderata*) for the physiological outcomes both before and after the stimuli. Of the 49 studies, 26 reported by seven laboratories fit these criteria. The result was an effect size similar to that observed in the first meta-analysis (Cohen's $d = 0.21$), and the overall probability was again highly significant with $p < 2.7 \times 10^{-12}$. Higher quality studies were associated with larger effect sizes, and the file-drawer estimates ranged from a conservative 87 studies to a more liberal 256 studies, with both estimates judged as implausible. Finally, among those studies that had explicitly investigated the possibility that mundane anticipatory strategies may have been responsible for the significant outcomes, no evidence was found.

3 Discussion

The orthodox response to the experiments reviewed here is that retrocausality—a reversal of the ordinary cause-and-effect relationship—violates common sense, and thus apparently positive evidence can be understood only as flaws or flukes. This reaction is not unreasonable because retrocausation strongly challenges the everyday sense of the unidirectional flow of time. But the history of science has amply demonstrated that "naïve reality" is often revealed as a special case of a more comprehensive reality the moment we glimpse beyond the ordinary senses. For example, Einstein showed that matter, energy, space, and time are not the absolutes suggested by common sense, but rather they are intimate relationships [61]. Likewise, quantum theory informs us that quanta (i.e., elementary particles) do not have definite properties when no one is looking—at least not in the way we understand either "properties" or "looking" in common sense terms [7].

But perhaps the oddest challenge to what we take as self-evident is the nature of causality. This topic has generated more restlessness among scientists and philosophers than is commonly appreciated. As Bertrand Russell put it,

> All philosophers imagine that causation is one of the fundamental axioms of science, yet oddly enough, in advanced sciences, the word 'cause' never occurs …. The law of causality, I believe, is a relic of bygone age, surviving, like the monarchy, only because it is erroneously supposed to do no harm [62, p. 337].

Or as mathematician John von Neumann wrote in 1955,

> We may say that there is at present no occasion and no reason to speak of causality in nature—because no [macroscopic] experiment indicates its presence … and [because] quantum mechanics contradicts it [63, p. 88].

It is also worth noting that within physics, it is well known that at the quantum scale the present can be influenced by the future. As described by Greene, referring to the delayed choice experiment in quantum mechanics:

> By any classical-common sense-reckoning, that's, well, crazy. Of course, that's the point: classical reckoning is the wrong kind of reckoning to use in a quantum universe [64, p. 875].

This retrocausal effect, first proposed as a thought experiment by physicist John Wheeler, has been experimentally demonstrated to high degrees of confidence in physics labs around the world [65–67]. A critic might respond by saying that time reversal might exist at microscopic scales, but that is irrelevant for understanding unorthodox forms of anticipation at the human scale because the special state of quantum coherence—required to sustain these strange effects—is fragile and rapidly washed out within the hot, wet environment of the brain. This was the prevailing view for many years [68]. But today, with rapid theoretical and experimental advancements in quantum biology [69], there is good reason to suspect that living systems, by their nature, take advantage of quantum effects in nontrivial ways, including "harnessing quantum coherence on physiologically important timescales" [70, p. 10].

In addition, with new evidence indicating that individual neurons are associated with cognitive tasks such as memory, learning, and reaction to stimulus novelty, it appears increasingly likely that quantum effects in the brain at the level of individual neurons may cause cascades that can influence unconscious processes, occasionally rising even to the level of conscious awareness [71]. This line of reasoning presents a new explanatory approach toward understanding unorthodox anticipatory phenomena. It also indicates that previous assertions that such effects are impossible are no longer tenable.

Beyond theoretical challenges in modeling these phenomena, the philosophical, and especially the epistemological, consequences of unorthodox forms of anticipation are far from settled. One disconcerting implication is that it may not be possible to prevent time-reversed influences in experiments, at least not through any currently known methods. Indeed, if the gold-standard, double-blind, randomized protocols used to demonstrate these effects continue to repeatedly support the existence of time-reversed effects in human experience, then we must be prepared to reconsider the possibility of retrocausation and—an even greater heresy—teleological pressure from the future [72, 73]. Indeed, at our current level of understanding, the idea that the present depends on both the past and the future is so remote from engrained ways of thinking that the first reaction to the evidence presented here is that it must be wrong. The second reaction, after a closer consideration of trends in quantum biology [65, 69, 74], may be surprise that a rational

explanation for unorthodox forms of anticipation may be on the horizon. In his overview of some theories of anticipation expression, Nadin [75, 76] offers a number of such rational explanations.

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