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RESEARCH

Anomalous Switching of the Bi-Stable Percept of a Necker Cube: A Preliminary Study

Dick J. Bierman
University of Amsterdam

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Abstract—Psychophysiological research has shown anomalous correlations between unconscious states reflected by physiological fluctuations and random future conditions. Where the future conditions concerned emotional and neutral events, this anomalous effect has been called presentiment. In the present research, the domain of interest regarding apparent retrocausal effects is further extended to the visual experience of a so-called "transparent" Necker cube. When a picture of this cube is presented to subjects, their experience switches spontaneously between two viewpoints. In one perspective the cube is experienced as observed from "above," in the other it is experienced as observed from "below." We measured switching times from "the above" to "the below" experience. Once the subject had indicated by pressing a button that this shift had taken place, the picture of the transparent cube changed into an opaque presentation of one of the two possible viewpoints. The choice of which perspective was presented, "from above" or "from below", was random. When the opaque view was "from above" this corresponded to the view for which the duration was measured (congruent), the opaque view "from below" was the incongruent condition. Arguing that in the incongruent condition the opaque view would "retrocausally" interfere with the "top view" for which the duration was measured, we predicted that in that condition the duration would be shorter. The switching-time effects found in the pilot and two confirmatory studies were in the same predicted direction. The pooled results showed a mean difference in switching time of 126 msec. These results seem to fit into a growing database of anomalous correlations between conscious and unconscious behavior and random future conditions. It extends the domain of these anomalous correlations to other non-emotional events. Alternative possibilities, such as procedural errors, are discussed.

Keywords: time symmetry—retroactive interference—anomaly—retroactive priming—Necker cube

Introduction

Theory

Psi phenomena can be formally defined as correlations that seem to transcend space or time or both. For instance, there may be correlations between what subjects choose from a set of four potential targets and the actual target about which the subject has no information. This information may be distant in space so that access by normal sensory channels is prohibited, or the information may be distant in time. When the target is known only in the future, the anomaly is quite obvious because any correlation in that case seems to contradict causality.

One of the general issues in this field of anomalous correlations is the role of emotions. Do these anomalous correlations arise especially when the events are very emotional (Broughton, 2006)? That idea originates from case studies such as crisis telepathy. The vast majority of reported cases from the field deal with highly emotional events such as the passing away of relatives. However, one could argue that this is not an intrinsic aspect of the anomalous correlations but rather an intrinsic aspect of the reporting bias (or that emotion tends to focus attention, or provide a motivational factor that non-emotional targets cannot). One cannot exclude that trivial cases just aren't reported but happen nonetheless. In presentiment studies the role of emotions is quite explicit (Radin, 2004). But are correlations between physiological behavior and a random future stimulus restricted to paradigms where we compare neutral and *emotional* events?

In a recent theoretical approach, it has been argued that these correlations should occur in non-emotional events as well. According to this approach, these anomalous correlations arise from time-symmetry restoration (Bierman, 2010). Time symmetry is quite basic in most physical formalisms. For instance, electromagnetic systems theory predicts that there are two consequences of a specific initial state. These two solutions are called the retarded solution (with time running forward) and the time-symmetric advanced solution (where time can be interpreted as running backward). The advanced solution is generally considered a meaningless oddity due to the mathematics used, because in physical systems this symmetry hasn't been observed empirically. However, an alternative view is that the boundary conditions in most simple physical systems are such that the advanced solutions are prohibited. Introducing the brain, while it is sustaining consciousness, into the otherwise material system is assumed to restore time symmetry to some degree. The restoration is assumed to be more complete when the brain system is in a more coherent state. This theoretical approach does not rely on emotions and would predict "retroactive" effects for all events that interact with consciousness, not only emotional ones.

Another issue relates to the idea that it is easier to find anomalous correlations when measuring non-conscious dependent variables such as physiological variables rather than when measuring consciously produced variables (such as explicit oral predictions). In several studies, anomalous correlations were established between non-conscious physiological states and random external (actual or future) conditions while the subjects appeared to be unable to "use" this information in order to improve conscious guessing of the external random condition (i.e. Lobach, 2010). The dependent variable in the current study (switching) can be interpreted as somewhere between conscious and non-conscious behavior.

Finally there is a theoretical issue related to the stability of the system under consideration. It has been proposed that it is easier to find anomalous correlations in unstable or labile systems (Stanford, 1990).

These three issues together suggest the use of the experience of a bi-stable percept as a dependent variable. There is an ongoing discussion in the field of bi-stable conscious states about where in the brain bi-stability is handled. Globally there are two points of view. Either there is a top-down (attentional) process originating in higher parts of the brain that is the origin of the switching between the two experiences, or the bi-stability is processed and resolved in the very early stages of information processing by the brain (Tong, Meng, & Blake, 2006, Blake & Logothetis, 2002).

Earlier Experiments

The roots of the current research can probably be traced back to the middle of the last century, when instruments to measure physiological processes became more commonly available. A. J. Good reportedly suggested measuring brain potentials on the surface of someone's skull (EEG) while he sits in a dark room and a light is flashed at random moments, to discover whether "the EEG shows any tendency to forecast the flashes of light" (Good, 1961, cited in Radin, 2006:163). In the 1970s, there was in fact a study conducted to explore whether the EEG showed any tendency to forecast, not flashes of light, but the gender of faces in pictures (Hartwell, 1978). The results showed no significant differences in EEG for different genders, however, despite laborious (especially at the time) and extensive analyses. At about the same time, Vassy (1978) did report highly significant results in an experiment that was set up to measure telepathy. That study is worth mentioning because its design was rather similar to that of later presentiment studies. Vassy measured the electrical activity of the skin (EDA) preceding an electrical shock for which the participant either was or wasn't warned telepathically by someone in another room. As with Hartwell's EEG study (Hartwell, 1978), judging and analyzing physiological measures was cumbersome and prone to error in those days. This is perhaps why it took a rather long time before more studies were undertaken in this direction. By the end of the last century, Radin picked up the trail and used modern, automated equipment in the first of a series of presentiment studies (Radin, 1997). Radin got interesting, statistically significant, results corroborating his hypothesis. These results were soon replicated by Bierman, and together they published a summary of five different presentiment studies in a "mainstream" psychological journal (Bierman & Radin, 1997). As in Vassy's study, these early experiments used mainly EDA as the dependent physiological measure of presentiment; this measure seemed to produce the most reliable results.

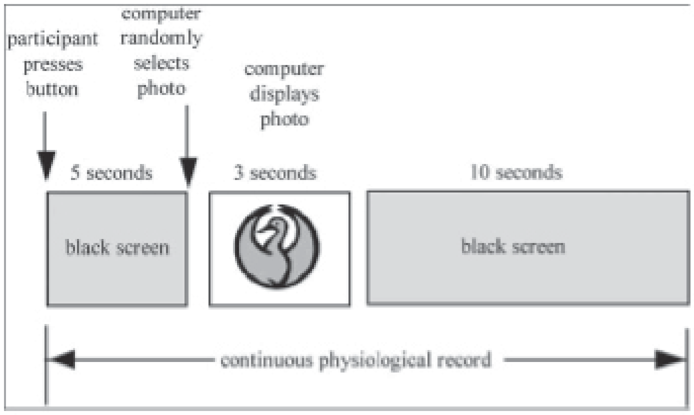

Figure 1. Illustration of a trial in a presentiment experiment (from Radin, 2004).

In a typical presentiment study as reported by Bierman and Radin (1997), a participant is hooked up to an instrument to measure EDA. Changes in the electrical activity of the skin are measured continuously during the whole session. The participant is seated in a comfortable chair in front of a computer screen and remains passive, except when a signal indicates that he or she can start the next trial by pressing a button. The number of trials may vary, but is typically about 30. After the button press, there is a delay of a few seconds until a stimulus is presented, after which there is a cool-down period until the next signal (Figure 1). Stimuli are drawn randomly from two picture pools. One pool contains calm pictures, such as photos of landscapes. The other pool contains arousing pictures with violent (e.g., a bloody car crash) or erotic content. Experiments in mainstream psychology have shown clear EDA responses after arousing stimuli. In presentiment studies the focus is on the time interval directly preceding the stimulus, from the button press until the picture is presented on the screen.

EDA measures can be analyzed in a number of different ways. The studies conducted by Radin and Bierman looked at the average skin conductance level response (SCL). The statistical analysis compares the SCL averaged across all emotional trials with the SCL averaged across all neutral trials. Although in most studies the future condition was either emotional or non-emotional using pictures from the International Affective Picture system (Lang, Bradley, & Cuthbert, 1999), there have been a few studies that used a pleasant or an unpleasant tone (Spottiswoode & May, 2003, May, Paulinyi, & Vassy, 2005). These studies yielded comparable results.

Since then, several other physiological measures have been used as dependent variables with a similar design as in Figure 1 or with a design where the stimuli are unexpected loud sounds or light flashes to induce strong responses like in the study by May and Spottiswoode. Variables that have been used include Evoked Potentials (Radin & Lobach, 2007), CNV (Bierman, 2006), Bold (Bierman & Scholte, 2002, Bierman, 2007), Eye Movement (Radin & Borges, 2009), Pupil Dilation (Radin & Borges, 2009), Blinking (Radin & Borges, 2009), and HR (heart rate) (Tressoldi, Martinelli, Massaccesi, & Sartori, 2005, McCraty, Atkinson, & Bradley, 2004a, 2004b). The results of all these studies suggest anomalous correlations, though the interpretation is far from clear and the results are not very robust. Also a number of experiments have used behavioral measures such as preference scores in a mere-exposure experiment where the preference score was given before the mere exposure (Bem, 2011). Preferences that increase as in mere exposure or decrease as in habituation can still be seen in the framework of emotion research. Apparent retrocausal effects were also observed in a priming task where the prime was presented after the response was given (de Boer & Bierman, 2006). This retroactive priming study showed a clear effect of a faster response in a gender-discrimination task when the target was followed by a congruent "prime" (which actually should be called "post"). In this case, "emotions" apparently were not involved explicitly or implicitly.

Research Question

In the present research, the domain of interest regarding apparent retrocausal effects is further extended to the visual experience of a so-called "transparent" Necker cube. When a picture of this cube is presented to subjects, their experience switches spontaneously between two viewpoints. In one perspective the cube is experienced as observed from above, in the other it is experienced as observed from below. We measured switching times from the "above" to the "below" experience. Once the subject had indicated by pressing a button that this shift had taken place, the picture of the transparent cube changed into an opaque presentation of one of the two possible viewpoints. The choice of which perspective was presented, "from above" or "from below", was random. This created two conditions. When the opaque view was "from above", this corresponded to the view for which the duration was measured (congruent), the opaque view "from below" was the incongruent condition. Arguing that in the incongruent condition the opaque view would "retrocausally" *interfere* with the "top view" for which the duration was measured, we predicted that in that incongruent condition the duration would be shorter. Alternatively one could argue that presenting a future congruent opaque view would stabilize retroactively the experienced "top view", thereby enhancing the switching time. The direction of the differential effect between congruent and incongruent condition would be the same for both arguments. Deciding between the two “models” is possible only when a baseline condition with no future opaque view of the cube is presented. We have considered using a balanced design where the duration of the bottom view would also be measured in a congruent and incongruent condition. However, most subjects find it easier to experience the “top view” and also have difficulty performing the task. For this preliminary study, we therefore opted to keep the task as simple as possible (see also in the Discussion section the recommendations for future research).

Method

Subjects

Subjects for the pilot and confirmatory studies were recruited from the Dutch University of Groningen student population. The second confirmatory study used voluntary subjects from the Amsterdam area. About half of those subjects in the Amsterdam study practiced yoga while the other half consisted of matched control subjects. See Table 1 for gender counts and age information.

TABLE 1
Mean Age and Standard Deviations Split for Study and Gender

	FEMALE			MALE		
Study	**N**	**Mean**	**sd**	**N**	**Mean**	**sd**
Pilot	3*			3*		
Amsterdam	13	41	17.13	16	36.25	13.4
Groningen	41	22.88	3.84	93	21.62	1.42
TOTALS	***57***	***26.91***	***11.41***	***112***	***23.75***	***7.30***

* Data from the pilot study were unavailable.

Procedure

The experimental software was developed at the University of Amsterdam, and then the same program was mailed to the University of Groningen where the experiment was conducted by a Ph.D. student unaware of the hypotheses.

Parallel to that study, a Master's student in Amsterdam ran the same experiment in Amsterdam, also blind to the hypotheses.

Subjects were exposed to a picture of a Necker cube with a fixation point embedded “inside” the cube (see Figure 2).

They were asked to gaze at the fixation point and wait until they experienced the cube with a “bottom view” perspective and then press the spacebar (response 1) at the moment that this subjective experience spontaneously changed to a “top view.” As soon as the “top view” returned to the bottom view they pressed the spacebar again (response 2). The trial then ended by the software changing the picture into an opaque view of the cube randomly in either “top view” or “bottom view” (see Figure 3).

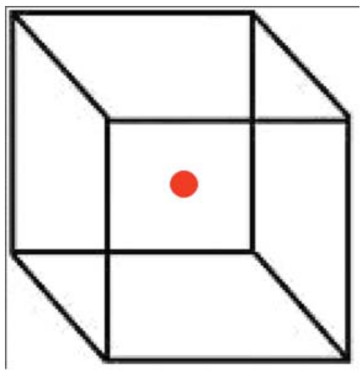

Figure 2. Transparent view of Necker cube.

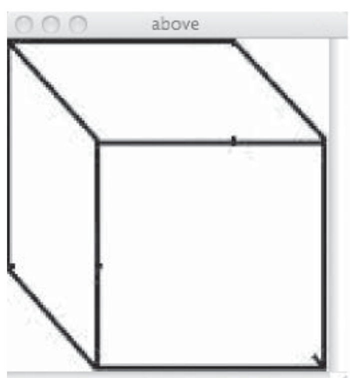

Figure 3. Example of opaque "top view" of Necker cube used for feedback.

This opaque-cube feedback remained for one second on the screen. The time between the two responses was the duration that the “top view” was experienced. The subjects were unaware of the psi hypothesis. In the Groningen study also the experimenter was unaware of the psi hypothesis. The experiment was framed as a study in the category of consciousness research.

From the pilot experiment we learned that this task is not an easy one and that subjects sometimes missed a switch or did not follow the gaze instruction. We therefore adjusted the subject’s instructions and also added instructions for naïve experimenters. Further, in the confirmatory studies, the subjects were asked to indicate if they succeeded in giving the response according to instructions, otherwise the trial was not included in the analyses. For each subject, a session consisted of 32 valid trials and lasted about six minutes.

Analysis

Data from the Groningen confirmatory experiment were mailed to the University of Amsterdam to be analyzed. The Amsterdam experiment was analyzed separately and later all data were pooled. Outlier trials with a perspective switch time value larger than three standard deviations or with a switch time smaller than 800 msec were removed. This procedure, based upon trying out several outlier removal algorithms on the pilot data, was repeated until no further outliers were present. Then the mean durations of the “top view” percept were calculated for each subject and for each of the two (future) conditions. The means were compared using SPSS 16 (Mac-version) with a two-sample t-test.

Results

Pilot

Six subjects were tested. Outliers were removed as described above. The mean difference of 58 msec between the two (future) conditions was in the theoretically expected direction but not significant. Inspection of the preprocessed data showed that one subject had more than nine outliers. When this subject was removed from the analysis, the two conditions differed by 384 msec and the t-test was marginally significant (t = 2.5, df = 4, p = 0.065 two-tailed). Two-tailed tests were used here because we decided that in spite of the theoretical argument that gave us an expectation for the direction of the effect, we would use the pilot data to specify a direction to be used in the confirmatory phase of the study. Although the p-values of the pilot study are marginal, the fact that the effect was in the predicted direction gave us confidence to also predict the same direction for the confirmatory studies and thereby justified the use of one-tailed testing in those studies. It can be argued that two-tailed testing is always required when effects on both directions are of interest, and we certainly feel that this might be the case for the study of anomalous phenomena. On the other hand, we feel that this field is in need of theory-driven research generally predicting a direction of an effect, rather than that any anomaly be published.

It should be noted that the preprocessing procedures dealing with outliers introduce some extra degrees of freedom. A subject was removed from the study if he or she produced nine or more outliers. This value is rather arbitrary and was chosen on the basis of optimization of the end result of the pilot study outcome. Once these parameters were set, they were not changed again when analyzing the confirmatory experiments.

Removal of the pilot study's one subject who obtained a large number of outliers also considerably improved the correlation between the two conditions. The correlation between conditions for all six subjects was 0.77, while after removal of the suspect subject the correlation became 0.96, adding to the impression that this removed subject really was an outlier.

The results of the pilot experiment were used as a predictor for the confirmatory experiment. This allowed us to predict a direction for the effect. The predicted direction was in line with the idea that the duration of the "top view" perspective was disturbed by showing an opaque bottom view afterward. We called this retroactive interference. We also expected on the basis of the pilot experiment that subjects in the confirmatory experiments with nine or more outliers would not contribute to a switching time effect.

Confirmatory Studies

The overall difference between the two conditions pooled for all 169 subjects from the three studies was in the same direction and of the same magnitude (88 msec) as in the pilot study, but as in the pilot this effect was non-significant ($t = 1.41$, df = 168, $p = 0.08$ one-tailed). After removal of the 16 subjects (9.5%) who had nine or more outliers, the mean differential effect was 129 msec ($t = 1.97$, df = 152, $p = 0.026$ one-tailed). In Table 2 the results are given for each of the three studies separately.

The mean number of outliers per subject over all studies (including the pilot) was 3.00 from the 32 trials (sd = 1.78). The mean time that each participant spent was 12:20 (sd = 11:53).

Discussion and Conclusion

The statistical strength of the differential effect does not allow for a strong conclusion, rather it suggests further experimentation along these lines. The established scientific worldview appears to conflict with the effects reported here because these effects would imply a violation of traditional causality where cause precedes effect. And extraordinary claims need extraordinary evidence, which

TABLE 2

Review of Results for the Two Conditions, Top View Feedback and Bottom View Feedback, of the Opaque Final Picture

Study	N	Top View	Bottom View	Diff. effect	st error	t	P*
PILOT	5	3669	3306	+363	142.7	2.5	0.065 2-t
AMS	26	4959	4765	+184	104.6	1.76	0.045
GRONINGEN	122	5027	4959	+103	78.2	1.36	0.090
TOTAL	***153***	***5004***	***4875***	***+129***	***78.2***	***1.97***	***0.026***

* One-tailed p-values in confirmatory experiment.

in the current experimental results is lacking. The results, therefore, should be considered only as suggestive and should be replicated widely before drawing stronger conclusions.

Recommendations for further studies are:

1. a balanced design with regard to measurement of top-view duration and bottom-view duration, but between subjects because mixing of these two conditions is too confusing for the subject.

2. An extra baseline condition without an opaque view after measurement of the top- or bottom-view duration. This would allow for discrimination between retroactive interference and retroactive facilitation.

It should be emphasized that the study outcome is sensitive for the choice of parameters that determine how to handle outliers and individual subjects who generate many outliers. Other parameters often result in smaller effect sizes although the direction of the effect is unaffected by change of any of these parameters. For example, the effect becomes statistically non-significant if the 16 subjects who had many outliers are included in the overall analysis. One could argue that many outliers might be an indication of subjects not performing according to task instruction, but this was not explicitly assessed in the exit interview.

Furthermore, one can object to using parametric testing on response-time differences because the data are in principle non-normally distributed. We therefore repeated the analysis using a random permutation test. This test yielded a *p*-value of 0.023, slightly smaller than the *p*-value obtained by the analytical approach.

If we assume the effects to be real, it can be concluded that future random feedback correlates with the earlier response times, a controversial effect that hitherto was mostly associated with emotional events. However, the Necker cube switching is a non-emotional phenomenon and the one-second feedback is hardly noticed by the subjects, and above all there is no reason to assume that this feedback induces any emotional response in the subject. Therefore it might be concluded that this finding supports the idea that apparent retrocausal effects do occur in all events, neutral or emotional. Also, the percepts from above and from below are conscious percepts rather than non-conscious physiological states. Thus we might conclude that these anomalous effects might also induce correlations between future conditions and a conscious state.

We did not formally compare stable with unstable systems, because the Necker cube switch is by definition a phenomenon due to instability. One could argue that when the mean switching time is small the (brain) system is even more labile than when the mean switching times are larger. We therefore correlated the relative effect size for each subject with the mean switching time of that subject. This correlation was very small and far from significant. Thus this study does not lend support to, nor contradict, the idea that more labile systems are more sensitive for these apparent retrocausal effects.

An alternative paranormal explanation is that the study results are an example of an analyzer psi effect: Choosing the analysis criteria precisely in such a way that a significant outcome arises; although a counterargument is that this freedom of choice was constrained by adhering to the parameters that gave the best result for the pilot series in the confirmatory studies. The analyzer effect "explanation" has been put forward in a number of anomaly research studies. The idea is that the analysis is also a future condition, although it is further in the future than the feedback per trial, and a more complex task.

Another explanation that does not resort to an anomaly is that the code that was executed for time measurement is in some way different for the two future pictures. We tested this by simulating key-presses using an independent timer. The mean response times for the two future pictures thus obtained did differ by 2.4 msec (not significant). This difference is a factor of 50, smaller than the differences obtained in this experiment.

Finally there could be a problem with data integrity. However, a copy of the raw data stayed at Groningen University and can be compared by independent researchers to the data that finally entered into the formal analysis.

The studies reported here are generally classified as para*psychological*. That is a misnomer. There is nothing in Psychology that prohibits these anomalous effects from occurring. The term *anomaly* solely refers to the accepted interpretation of physics. If anything, these studies should be classified as para*physical*. However, as was argued in the Introduction, current physical frameworks do not really prohibit advanced phenomena. The nature and the arrow of time is still a very open issue in physics. Therefore, the anomaly refers to the fact that in physics advanced phenomena haven't been observed (yet).

It is important to develop the time-symmetry model further in order to produce testable hypotheses. Most notably, future work might focus on individual differences and correlate these with the coherence aspect of states of consciousness.

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