Anticipation of Random Future Events

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Abstract. I will present the evidence, albeit apparently paradoxical, that some seconds before the perception of random events of different arousal levels (e.g. a pleasant or an unpleasant sound), our neuro- and psychophysiological systems, show a reaction correlated with them. In this chapter we will describe the phenomenon, review the available evidence, the attempts to explain this phenomenon and the possible practical applications.

Keywords: anticipation; random; prediction; probability; psychophysiology

1 Physiological anticipation of future events

The study of anticipation is now a multidisciplinary theme and there is a significant body of evidence in psychology and neurobiology, indicating the presence of several anticipatory mechanisms in the brain and our psychophysiological system. Soon, Brass, Heinze, and Haynes [1] and a review by van Boxtel and Böcker [2], highlight the crucial role of anticipation in a large array of cognitive functionalities such as vision, motor control, learning, and motivational and emotional dynamics.

If a sequence of events follows a rule, then the autonomic and neurophysiological systems can learn this rule before the person can discover it overtly. An important characteristic of this phenomenon is that the anticipation of future events is a completely unconscious process because these anticipatory responses are too weak for participants to detect using introspective cognitive means. This implicit learning capacity of the human autonomic and neural systems has a clear adaptive value that allows us to prepare our behavioral and cognitive responses, depending on whether future events may be dangerous or useful [3].

What happens however if events do not follow a rule and instead occur at random? In this case, implicit learning is not possible and only more or less sophisticated guessing strategies can be employed, such as the "Gambler's Fallacy" strategy [4].

Since the late 1990s, some authors have attempted to discern whether anticipatory responses can be observed, even when implicit learning is not possible. If such

adfa, p. 1, 2011.

anticipatory responses could be observed, this would demonstrate that our autonomic and neurophysiological systems possess a more sophisticated capacity to predict future events than was previously thought and consequently, are set up to help us predict events that are generally thought to be essentially unpredictable.

1.1 The phenomenon

Imagine an individual must open one of two doors. Behind one door there is a safe event; behind the other a dangerous event. The individual has no way of knowing which door opens to which event and cannot use his or her previous experiences for guidance. It is a sort of roulette game with your life to play for.

Figure 1: A crucial task: if you open one door you are safe or dead.

Is this choice a real 50-50 bet? Only if we cannot change this probability that is, if we cannot anticipate the future event at least partially. As strange as it may appears, a consistent evidence has been accumulated supporting this possibility. In the following paragraphs we will summarize the psychophysical and behavioral evidence accumulated to date, supporting the possibility that it is possible to increase the probability of anticipating future random events beyond the expected chance.

1.2 Neuro- and psychophysiological evidence

There is evidence that our neuro- and psychophysiological systems can react differently before the perception of two classes of events presented randomly, characterized by different strength of reactions (i.e. heart rate, electro-dermal response, EEG activity, etc.), that is before their perception, as presented in Figure 2.

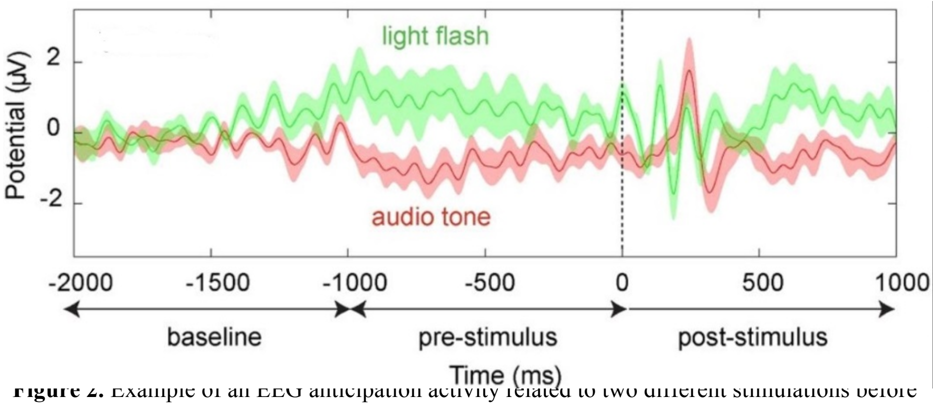

Figure 2. Example of an EEG anticipation activity related to two different stimulations before (pre-stimulus) their perception (post-stimulus).

In a meta-analysis covering all available studies published up to 2010, Mossbridge, Tressoldi and Utts [5] estimated a weighted effect size *d* = 0.21; 95% Confidence Intervals =0.15 to 0.27, from a pool of 26 experiments selected because they possessed sufficient information related to the similarities between the pre-stimulus and post-stimulus effects. After excluding methodological and statistical artifacts and the expectancy effect[1], as being the cause of this result, the authors summarized these finding as follows: "*In sum, the results of this meta-analysis indicate a clear effect, but we are not at all clear about what explains it*".

If real, this phenomenon could be a demonstration that this anticipatory predictive ability is an important adaptive tool that is always at our disposal. Even though it operates at an unconscious level, it may be sufficient to prepare our defense or avoidance reactions.

In an attempt to estimate the prediction accuracy of these effects, Tressoldi and collaborators [6][7][8], devised a series of experiments to study the percentage of correct prediction of two different events by analyzing the anticipatory reactions of pupil dilation and heart rate. Figure 3, demonstrates an example of pupil dilation prediction accuracy related to two different events, a smile and a gun associated with a shot audio clip, with respect to the expected chance of 50%.

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[1] Expectation bias arises when a random sequence including multiple repetitions of the same stimulus type (e.g. five non-arousing stimuli) produces an expectation in the participant that the next stimulus should be of another type (e.g. an arousing stimulus). Expectation bias can also arise when experimenters use non-equiprobable stimuli in an attempt to account for known emotional adaptation effects (e.g. a 2:1 ratio of calm to emotional images).

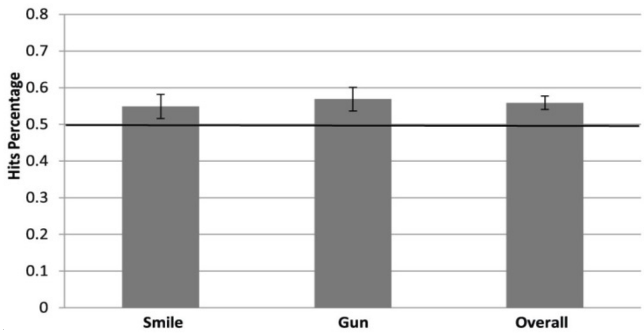

Figure 3. Prediction accuracy of anticipatory pupil dilation related two different events

The overall prediction accuracy of both the anticipatory pupil dilation and heart rate observed by Tressoldi et al. [6][7][8], ranged from 4 to 15% above the expected chance of 50%.

1.3 Behavioral evidence

In the paper titled "Feeling the future: Experimental Evidence for Anomalous Retroactive Influences on Cognition and Affect" published in 2011, Daryl Bem [9], directed the scientific attention towards a counterintuitive phenomenon, that is, that future perceptions, cognitive or behavioral experiences have an implicit "retrocausal" influence on behavioral decisions. For example, it was demonstrated that participants can chose above chance the side behind which an emotional picture was presented randomly or that presenting a congruent priming after a picture, (i.e. a smiling girl followed by the word "smile"), reduced the reaction times in the detection of a pleasant versus unpleasant picture with respect to an incongruent post-priming (i.e. a smiling girl followed by the word "sad"). As expected these findings aroused a huge number of comments and methodological, statistical and theoretical criticisms. Although the results of some experiments were not replicated [10], in a meta-analysis of all retrievable studies related to these effects, Bem et al. [11], supported Bem's [9] evidence even if the purported retrocausal or anticipatory effects, were moderated by the type of tasks (i.e. priming, reinforcement, practice, etc.).
It is important to point out that similarly to the psychophysiological effects, these behavioral effects are very moderate. In term of standardized effect sizes. The higher values are *d*= 0.14; 95% Confidence Intervals =0.08 to 0.21.

2 Tentative Interpretations

Are these phenomena caused by anticipation, retrocausation or entanglement in time? In relation to the neuro- and psychophysiological effects, the term "anticipation of future events" was used whereas for the behavioral effects, the term "retrocausal". However what all these effects have in common is that they are correlations between events measured in two different time frames. How is it possible that events (physiological, perceptual or behavioral) can be correlated in time? In quantum physics it has been theoretically defined [12] and empirically demonstrated [13] how, by entangling two photons that exist at separate times, the time at which quantum measurements are taken and their order has no effect on the outcome of a quantum mechanical experiment.

Is such a type of entanglement also possible between mental events? This possibility is under investigation and there is already some support for it [14]. Our provisional theoretical interpretations of all phenomena described above is that what we measure, both psychophysiological and behavioral variables at time-1 and what we measure at time-2, can be correlated because they are entangled in time. This entanglement is due to the shared, complementary relationship between the events at time-1 and events at time-2 (e.g. heart rate and future emotion).

3 Practical applications

It may be possible to exploit these correlations between events separately in time for practical applications? For example is it possible to detect the neuro-psychophysiological reactions measured at time-1, to avoid negative events at time-2? Mossbridge et al. [15] and Bierman [16] discuss this possibility from a theoretically point of view and it is under investigation by Tressoldi et al. [17]. These last authors for example, have devised a portable apparatus, named CardioAlert, to measure heart rate; it is connected via Bluetooth with a smartphone that can be tailored to individual differences, to produce an alert when a potential random negative event is going to happen. An image of this apparatus is presented in Figure 4.

Figure 4: Image of the CardioAlert prototype. On top left, the heart rate recorder that receives the changes in the hemoglobin detected by a led sensor connected to an individual's finger. This signal is filtered, amplified and elaborated to obtain the heart rate by using an Arduino microcontroller. On bottom left, is the smartphone which receives the data from the microcontroller by a Bluetooth connection.

After measuring of the heart rate baseline, the operator can set the level of the alarm (a sound), by changing the CardioAlert software installed in the smartphone. In a pilot study, Tressoldi et al. [17] used as the alarm threshold a change in the baseline heart rate above or below 1.5 the value of the standard deviation of beat-to-beat intervals. The choice of this parameter is particularly delicate because it is necessary to find the optimal value to reduce false alarms and the false negative responses to a minimum.

4 Final comments

The naïve idea that random events are unpredictable must be corrected. Some seconds before a future emotion, even if triggered by a random event, it is possible to detect an anticipation of its psycho- and neurophysiological correlates. Even if this anticipation is of a smaller level than its future manifestation preventing its conscious awareness, it can be easily be detected by electronic apparatuses and exploited to devise experimental and practical applications by the integration of bioengineering and neuro- and psychophysiological skills.

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