Explorations into using brain signals to predict random future conditions

Jacob Jolij & Dick Bierman
University of Groningen

Abstract

Three studies are reported using a face-detection task where faces are presented (or not) with a dynamic noise mask, while the participant's EEG was measured. Each participant was exposed to 240 stimuli either 'a face buried in noise' or 'just noise, no face'.
Four templates were created by averaging the EEG before and after stimulus presentation for face and no-face conditions. These templates we called anticipatory-before-face template (AF), anticipatory-before-noface template (ANF) and similarly response-to-face (RF) and response-to-noface (RNF) template
These templates were used to classify a specific EEG signal as being associated with the face or no-face (random) condition.
When using the templates constructed from the EEG signals measured after stimulus presentation (RF and RNF) this classification had an accuracy of 80%. While using the EEG patterns before the stimulus condition (AF and ANF) resulted in an accuracy of ~53%, where 50% is expected by chance ($p << 0.001$).
In order to explain this apparent anomalous effect where we can use anticipatory signals to predict the random future stimulus condition, randomness tests were performed on the sequence of conditions that the subject had been exposed to. Only 1 subject had been exposed to a significantly non-random condition sequence. Also the digital filter that had been used, was excluded to be the source of the anomaly. When using the trial number as a factor in the analyses there are no interactions with that factor and hence there are no significant inclines in accuracy within a subject. This suggests that no learning (of patterns) occurred.
In all three studies there is a positive correlation between the anticipatory accuracy and the response accuracy suggesting that there is some form of symmetry. Further analyses of these symmetries are in progress in order to differentiate between retrocausal and forward causal triggered correlations.

Introduction

In recent years several authors reported anomalous correlations between physiological measurements during a pre-stimulus period and the random conditions of the subsequent stimulus. (Mossbridge et al, (2012)). These findings suggest either experimental errors and the use of 'questionable research practices' or a retrocausal effect. The phenomenon has been reported for many different physiological variables, most notably with dermal activity variables. But also variables like BOLD, ECG and pupil dilation have been shown to correlate with random futures.

In the philosophy of science such a series of observations, apparently not fitting in the currently accepted world view, has been referred to as 'an anomaly'. This particular anomaly has been called 'presentiment' in the parapsychological literature.

Retro-causality in the physical world is an increasingly discussed topic. Ever since the end of the previous century publications on retrocausality have exponentially exploded (see figure 1). In Newtonian physics there seems to be no place for retrocausality but in the theory of relativity time travel into the past is not excluded while in almost all modern descriptions of the physical world, most notably in the theory of electromagnetism (EM) time-symmetry is clear from the mathematical descriptions. Time symmetry is however not identical to retrocausality.

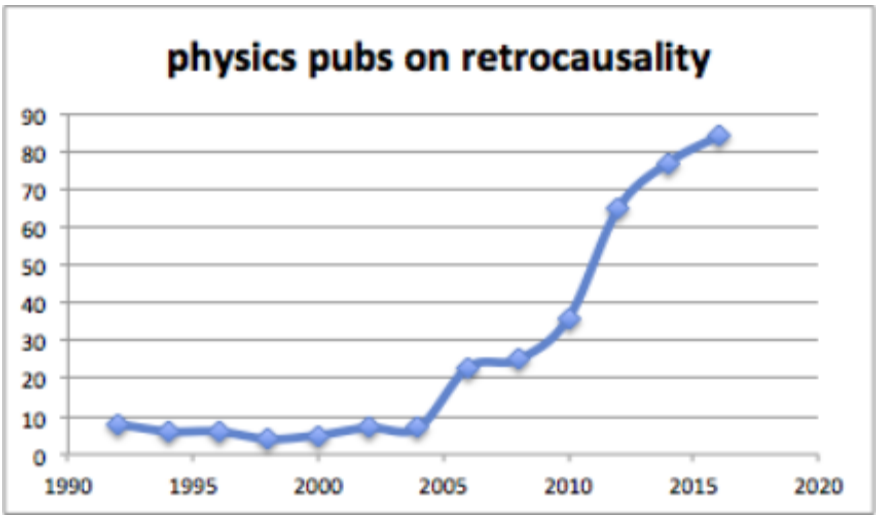

Figure 1: Number of publications per 2 year on retrocausality in physics journals

According to Popper, science can make major steps once an anomaly is established (Popper, (2005)). However the status of the database of this type of presentiment experiments is far from 'well-established'. The beauty of this particular anomaly is that it should be measurable in almost every psychophysiological experiment with conditions that are truly randomly assigned. In this paper we will re-analyze three straightforward EEG studies on face detection that were done during the last years at the Heymans lab

of the University of Groningen. In the 'presentiment' literature there are 6 studies that have used EEG measurements (Hartwell (1978), Don et al (1998), Bierman et al (2006), McDonough et al (2002), Hintenberger et al (2006), Radin et al (2007)). Most of these have not been incorporated in the 2012 meta-analysis because that analysis excluded studies that didn't report a significant response effect. The rationale for exclusion can be found in the paper and is shortly discussed in the section 'Is there time-symmetry' in this paper.

Reviewing these EEG studies is near impossible because in each of these studies there was freedom to select eeg-channels or select sub-groups from the tested population. From the reports it is unclear if this occurred post hoc. Almost all studies reported SOME effect. But we cannot combine these studies because of the mentioned danger of over-analysis but also because of large differences between the studies. In some studies the subject was totally passive while in others the subject had an active role. So these results should be taken with a grain of salt because they may be due to publication bias and other questionable research practices. In a recent simulation of another paradigm in the parapsychological literature it was found that under reasonable assumptions with regard to the incidence of QRPs about 60% of the overall effect could be explained away (Bierman et al,(2016)). Therefore it is mandatory to eventually do these experiments that are suggestive of an anomaly in the context of a pre-registered multi lab replication project with measures and standardized procedures that would exclude any questionable research practice. Over-analysis can be excluded by first analyzing a part of the trials and use the effects therein as a predictor for the other trials.

The three face detection studies in this paper all use a procedure where for each subject a part of the trials is used to predict the effect in the remaining trials using a procedure that does not allow for any post hoc selection by the experimenter. These three are all the studies on this topic done at our department and no subjects were removed post hoc. The number of subjects was not precisely fixed before the study but was set by other criteria unrelated to the results. The studies were not pre-registered and should be considered to be explorative.

We wondered if these studies would also show a presentiment effect and if so what the effect size would be.

A major methodological question in these analyses is if the pre-stimulus EEG patterns that are predictive for the future stimulus condition vary per subject or if there is a general pattern across subjects. In almost all studies to date the latter is assumed. We intend to compare two methods, the traditional presentiment method based upon defining a single criterion across subjects to predict or a method that is based upon establishment of criteria per subject. In the latter case we should be able to analyze the eeg before stimulus exposure for a single trials and predict the condition of the upcoming stimulus.

This methodological approach using prediction accuracies has been tried already (Tressoldi et al (2011)) but the statistical efficiency of both methods hasn't been compared yet.

Methods

General

We present data from three different studies which each used the same visual stimulation protocol, but differed in procedure and general context. The visual stimulation protocol is identical to Jolij and Meurs (2011), and Jolij, Meurs and Haitel (2011) and described in detail below. Data for the three studies has not been published elsewhere yet, but is aimed at analyzing stimulus processing related activity. In this paper, we report anomalous EEG activity during the pre-stimulus period in each of these three experiments that seems to be related to anticipation of future random conditions.

The three studies have been carried out between 2014 and 2016 at the University of Groningen, in the lab of the first author of this paper. The first study was about the effects of mood and caffeine consumption of visual perception, and will be called the 'Coffee' study from hereon; the second study dealt with the effects of hypnosis on visual perception, from hereon the 'Hypnosis' study'; the final study was about the effects of social influence on visual perception in romantically engaged couples, from hereon the 'Couples' study.

Participants

Table 1 gives the particulars of the participants in each of the three studies.

Study	**Year**	**N-blocks**	**N-male**	**N-female**	**Population**	**mean age**	**Sd age**
Hypnosis	2015	8	12	15	Freshman students	20.4	1.6
Couples	2016	8	27	27	Couples (students)	22	2.6
Coffee	2014	6	11	10	Freshman students	21	1.6
total	-		50	52	students	21.5	2.2

Table 1: A review of the face detection studies. In the coffee-study 30 channels were used whereas in the hypnosis and couples study only 8 channels are used.One block equals to 120 trials.

A total of 102 students (50 women, 52 male, mean age 21.5 years), generally recruited from the first year psychology programme of the University of Groningen, participated in these 3 studies. All participants reported normal or corrected-to-normal vision, no history of physical or mental health problems, and gave written informed consent to participate. These studies were approved by the local Ethics Committee ("Ethische Commissie van het Heymans Instituut voor Psychologisch Onderzoek") under codes 13057-NE (Coffee), ppo-013-042 (Hypnosis), and ppo-015-053 (Couples)

Stimuli and apparatus

The visual stimuli were identical in all three studies, and were presented using a Windows 7 PC with a 22" Iiyama TFT screen, running Matlab R2011a (The Mathworks, Natick, USA) and Psychophysics Toolbox version 3 (Brainard, 2003). Stimuli were schematic faces embedded in dynamic noise. Every trial was a short clip of 9 frames, each frame presented for 100 ms. Every frame contained an array of white noise, resulting in an animation of moving noise. The middle frame could either contain a schematic face or be left blank, and was accompanied by an rectangle around the the array of noise serving as a cue that the critical stimulus could appear in this frame (See figure 2). The time from the end of a trial to the beginning of the next one is jittered between 3.5 and 6.5 seconds, including the response time of the participant. And the response time-out is 3 seconds. Between the blocks subjects were requested to rest for about 4 minutes (3 minutes minimum).

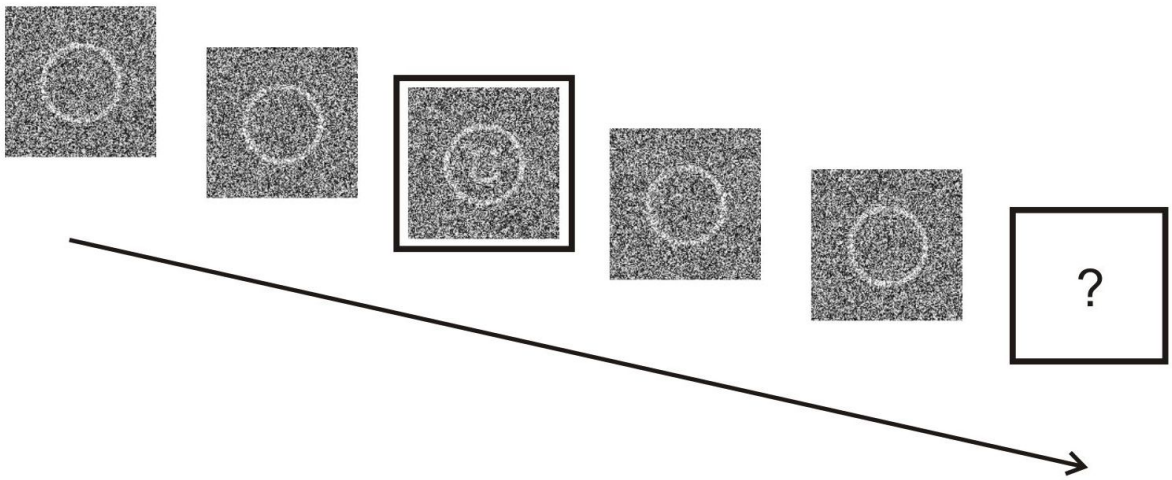

Figure 2: Schematic example of one face detection trial over time. Rather than showing

all noise frames (4 before and 4 after the critical frame) only 2 frames, before and after, are shown. The cue (rectangle around the frame) indicates the critical frame. The question mark indicates the subject has to respond ‘face seen’ or ‘no-face seen’.

Per trial, presentation of a target was triggered by drawing a random number from either the built-in pseudo random number generator of Matlab, based on the Mersenne Twister (‘Coffee’ study), by drawing a random number from the TrueRNG2 (ubuild.it, USA), a hardware number generator based on quantum avalanche noise in a diode circuit (‘Hypnosis study’), or by means of a Geiger counter-based RNG (‘Couples’ study). When the drawn number was even, a blank trial was presented, when the number was odd a face trial was presented, resulting in an overall target probability of 50%.

EEG data collection and processing

In the Hypnosis and Couples studies, EEG data was collected using a Porti 8 channel system (TMSi, Enschede, The Netherlands). Electrodes were placed at 10/20 locations T7, T8, P7, P8, Pz, O1, O2, and Oz. Data was sampled directly into Matlab with a sample-rate of 250 Hz and stored to disk on a trial-by-trial basis. Stimulus onset was marked using a digital trigger; to avoid possible ‘contamination’ of the EEG signals before stimulus onset the same trigger value was used for ‘face’ and ‘blank’ trials. For the Coffee study, data was collected using a TMSi ReFa 32 channel EEG system (TMSi, Enschede, The Netherlands). Electrodes were placed at the standard 10/20 locations, plus Oz. Data was recorded using Portilab version 2.0 (TMSi, Enschede, The Netherlands), and analyzed in Matlab.

Trials were filtered between .01 and 12.5 Hz using a zero-phase digital second-order causal Butterworth filter, baseline corrected (baseline from 800 ms to 600 ms pre-stimulus), and DC-detrended. To ensure that there were no artefacts produced by this filter we checked the temporal distortion by the filter. This was done by filtering a block signal; the filtered signal did show a minor pre-stimulus distortion from t = - 40 to 0 ms; therefore we may assume the prestimulus classification window that spans the interval from -600 till -100 millisec was not affected by any filter artifacts. Trials with a peak amplitude >35 uV were excluded from analysis.

Binary data classification was done using a nearest-mean classifier using all available channels (see Bandt et al., 2009; Jolij et al., 2011; Jolij et al., 2012). For this method, two templates are computed, one for the face category, the other for the blank category. These templates are essentially the evoked potentials associated with a face and a blank stimulus presentation. For classification of an individual trial, the trial is multiplied with the difference of the two templates on a sample-by-sample basis; subsequently, these values are averaged. In formula form:

$$S(x) = (1/T)\Sigma(f(t) - b(t)) \cdot x(t)$$

S(x) is the classification value for trial *x*, *f* denotes the template for the face trials, *b* denotes the template for the blank trials. Whenever S(x) exceeds a threshold *C* the trial is classified as 'face', otherwise it is classified as 'blank'. To determine *C*, we use:

$$C = (S(f) - S(b)) / 2$$

Classification templates were constructed using a 'leave-one-out' approach, i.e., for every trial a new classification template was computed, excluding the trial to be classified. This way, a trial is never included in the template used to classify that trial.

For multi-channel classification, we used the same procedure, but now based on spatial instead of temporal information. For example, suppose we are using four sensors, the classification results can be represented as a vector, e.g. [1 1 0 1], meaning that sensors 1, 2, and 4 classify the trial as a 'face', but sensor 3 classifies the trial as 'blank'. If we average these vectors for both stimulus conditions, this will yield a template vector for both conditions, e.g. [.70 .70 .50 .60] for the 'face' condition, meaning that in sensor 1, 70% of all face trials are classified as face (i.e., the hit rate), etc., and [.25 .40 .50 .30] for the 'blank' condition, meaning that in channel 1, 25% of the 'blank' trials are classified as 'face' (i.e., the false alarm rate), etc. The difference between these vectors is now indicative of which sensors, and therefore the specific scalp distributions, are most different between the 'face' and 'blank' conditions. For every individual trial, we can now, using the same nearest mean classification procedure, compute a classification score based on the spatial templates, but now by multiplying the trial's classification vector (e.g., [1 1 0 1]) with the difference between the templates, and averaging the result. This will give us one single classification score based on the spatio-temporal information present in the evoked potential, to which channels contribute according to their informational value.

For post-stimulus classification, we used the window between 100 ms and 600 ms after stimulus presentation; pre-stimulus period classification was done on the window from 600 ms to 100 ms before stimulus presentation.

Procedure

Participants were welcomed into the laboratory, and were briefed on the task.

In the hypnosis study they started with a brief practice session of 10 trials during which no data was recorded. After this, they did two blocks of 120 trials as a control measurement; subsequently they did two blocks after listening to a prerecorded suggestion of 'blurred vision' (e.g., they were given the suggestion "no faces are to be

seen", even though in 50% of trials faces were presented); two blocks after listening to a prerecorded suggestion of 'clear vision' (e.g., they were given the suggestion "every trial contains a face", in reality this was 50%); the session was concluded with two blocks as a post-measurement. The order of suggestions was counterbalanced between subjects.

In the Coffee study, participants were tested on two separate sessions; on one of the sessions they were given decaffeinated coffee, on the other session regular coffee. 45 minutes after coffee administration, they did six blocks of the task. Two blocks were recorded after a positive mood induction; two blocks were recorded after a negative mood induction, and two blocks were recorded in a neutral mood. Because mood is known to affect expectancy processes in this task (see Jolij and Meurs, 2011) we only analyzed the neutral block (i.e., two blocks).

Finally, in the couples study, participants came in pairs. Each individual was seated behind their own computer, but would see the same stimuli. However, first participant A would see the stimulus, and then respond, subsequently participant B would see A's response as cue, and then the stimulus. After one block, the order would reverse, and B would go first, etc. For the results presented here, we of course only analyze the uncued trials (i.e., trials in which the participant would be first to respond). In total, participants did eight blocks of trials.

Data analysis

After single trial classification, we computed the proportion correctly classified trials per subject (i.e. face trials classified as face, and blank trials classified as blank), both for the prestimulus and for the post-stimulus intervals. Proportions were tested against chance level (mu = .50) using a single value t-test to assess classifier accuracy. Moreover, we computed Pearson correlation coefficients between pre- and post stimulus classifier accuracy.

Results

Predictive accuracy

The results of the three studies are presented as Accuracy values (table 2). The accuracy value is the percentage of correctly predicted future conditions. Chance level is at 50%.

Study-name	**N-Ss**	**Accuracy**	**t-value (accuracy compared with 50%)**	**Effect-size per subject**

		pre	post		
Hypnosis	27	52	58	2.3338(df=26) *	0.93
Couples	54	56	60	7.1205 (df=53) **	0.49
Coffee	21	60	75	15.18 (df=20) **	0.46
TOTALS	102	53			

Table 2: Accuracy of predictions based upon the pre-stimulus derived classifier and the post-stimulus derived classifier. T-values for a study are calculated using the prestimulus classification accuracies per subject with MCE = 50%. * = p< 0.01, ** = p << 0.0001

To control for classifier bias, we re-ran the classifcation analyses on pseudolabeled data. For all three experiments, classification performance was at chance level for pseudolabeled data for both pre- (.50 in the Hypnosis experiment, .50 in the Couples experiment and .51 in the Coffee experiment), and post-stimulus (.50, .50, and .51, respectively) classifiers.

When using the trial number as a factor in the analyses there are no interactions with that factor and hence there are no significant inclines in accuracy within a subject over the trials, suggesting that no learning occurred.

Explorations

Exploring ERP differences

The stimuli used for these studies results in a very specific ERP pattern, of which an example is given in figure. The dynamic noise induces a strong 10 Hz oscillation, starting 500 ms before cue onset, which can easily be identified in the waveform for both blank and face trials. Presentation of a face results in a negative going wave approximately 200 - 300 ms after stimulus onset in the right parieto-occipital channels, and a positive wave starting approximately 300 ms after stimulus onset in the more centro-parietal channels. This so-called N2-P3 complex is typically associated with visual awareness (see Jolij, Meurs, and Haitel, 2011) and indeed covaries with subjective perception of the face. Moreover, this evoked potential can be reliably classified on the single trial level (see Jolij et al., 2011; Jolij, 2012).

For the analysis presented in this paper, however, we used a single-trial classification procedure on the pre-stimulus period. We have chosen an interval of 600 ms to 100 ms prior to stimulus onset for a theoretical reason: Bierman's CIRTS model (Bierman, 2010) predicts that anomalous effects are the result of time symmetry around stimulus presentation. Because the interval 100 - 600 ms post-stimulus yields the best

classification performance for the 'classical' analysis, we have simply flipped this interval to be symmetrical around stimulus presentation.

A simple visual inspection of the ERP presented in figure 3 shows that indeed we find more negative going activity in the 600 - 100 ms prestimulus window. However, a future analysis using a sliding time window will have to reveal whether this is indeed the most predictive window.

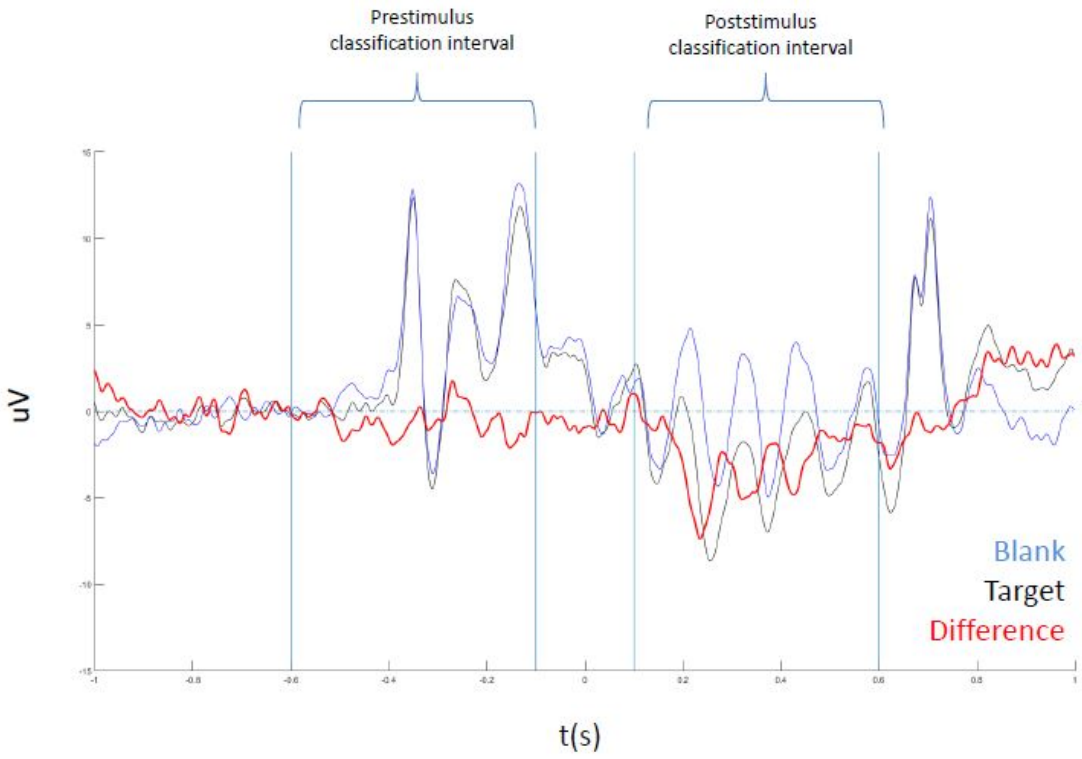

Figure 3: Templates of the P8 channel for the coffee study. The difference between the template before face and before no-face condition is in red. Note that in the classification algorithm all channels contribute.

Is there time-symmetry?

The reported effects do support earlier findings in the presentiment literature. Most of the effects reported in that literature use as random future conditions an emotional versus a neutral one. In a study on the effect of future feedback on the duration of one of two (spontaneously switching) percepts of Necker cube, Bierman support that emotion apparently needn't to be involved in retrocausality (Bierman, 2011).

In models that use arguments about (broken) time-symmetry like in CIRTS (Bierman, 2010) one wouldn't expect that this kind of 'retrocausal' effect are limited to futures

where emotion is one of the alternatives. However one would expect that if the EEG responses differ strongly in the face and the no-face condition this would also be the case for the presponses (an alternative name for the activity during the pre-stimulus period). We therefore calculated the correlation between the pre-stimulus derived and the post-stimulus derive (response) accuracies. The results are given in table 3.

Study	N	R(psi_A, response_A)
Hypnosis	27	.2670
Couples	54	.4814 *
Coffee	21	.3451
Meta-analytic *r*	102	.4037 **

Table 3: Correlations between accuracies based upon the pre-stimulus derived templates (psi_A) and the accuracy based upon the response templates (response_A). Meta-analytic correlation is computed using the DerSimonian-Laird meta-analytical approach. * = p<0.001, ** = p <0.0001.

It should be noted that in all physiological data there are forward correlations between the physiological signals before and after the stimulus. For instance during an experiment the spontaneous activity may vary and periods with large variability will be interspersed with periods with lower variability. Thus a correlation analysis over trials will produce a positive 'forward' correlation. It is impossible to disentangle a potential retrocausal driven correlation from this normal correlation. What we did here is correlating the accuracy obtained using the pre-stimulus derived classifier with the accuracy obtained using the post-stimulus derived classifier. The situation then is less clear. One can argue that since the classifier is based upon EEG signals for which there are normal correlations, the classifiers themselves will be correlated and hence one should expect a correlation between the accuracies obtained using these classifiers. So we are not sure about the inferences one can draw from these correlations. We intend to do a separate analysis for trials where the subject did not correctly indicate the stimulus condition (face or no-face). Within CIRTS it is assumed that conscious experience is required to enable time-symmetrical effects. Thus we would expect that there is no psi in these trials and correlations between the accuracies must be normal forward correlations. However this analysis only makes sense if indeed the assumption of a required conscious experience is true.

Discussion

Alternative normal explanations

These three studies do show anomalous correlations between the brain signals and random future conditions. Before concluding that this is really anomalous, normal causal explanations have to be ruled out. We checked therefore possible patterns in the randomization of these future conditions, patterns that would allow the subjects to infer what the upcoming condition would be. No problems with randomization and also no signs of learning (and hence improving performance) were found. We also checked if the filter that was used to filter the raw EEG-data produced a response in the past as many digital filters do. Indeed we found that an impulse signal passing through the filter produced a signal that started about 40 milliseconds before the start of the original signal. However the interval that we used to 'predict' the upcoming stimulus condition was much earlier (-600 till -100 msec). To be sure, we also ran analyses using no filtering and no DC-detrend at all and results, although slightly weaker, were still quite significant. There is of course a question if the assumed MCE of 50% accuracy is correct. As one of the reviewers put it: "….Pattern classifiers may be over-generous…. (so have a MCE > 50%)". We therefore repeated classification but we now used pseudolabeled data, which should should result in chance performance in absence of classifier bias. This procedure confirmed the MCE of 50%.

The fact that all 3 studies showed the same effect can be interpreted as a sign for the robustness of the effect. It could also be a sign that there is an undetected software problem. Therefore the same face detection paradigm will be used for an independent and pre-registered replication at the University of Padova.

The robustness of the results

The robustness of the data is partly due to the number of trials in these studies. Generally, psi experiments do not use that many trials because there is a belief that boring experiments will not work. So 6-8 blocks of 120 trials per subject is really a lot. Just to illustrate: in Ganzfeld-telepathy experiments there is generally only one trial per subject.
But the effect size seems also to be rather large compared with other paradigms. We have wondered why this might be the case for these *unselected* subjects. A speculation is that this is due to the visual noise in which the face is embedded. This noise is dynamic (10 frames per second!). And there are signs that this dynamic visual noise induces a special alpha like brain. state. This speculation could be tested using different visual noise masks (dynamic and static).

Can we fool nature

Taken at face value we may conclude that in 3% (53-50) of the cases the signal before the stimulus is 'determined' by the future condition.
What happens if we use this information to exclude the future that seems to be predicted? This is called bilking and it is one of the basic arguments used in the discussion on time-travel (Krasnikov, S. (2002))

However if we introduce such a real time algorithm it becomes impossible to infer presentiment effects because the face-noface condition is correlated to the anticipatory signals by the predictive algorithm. Therefore in a bilking experiment we have to infer the effect thereof by using 3 conditions. In the first condition no bilking occurs. In the second condition bilking may occur. The decision if bilking occurs will be a quantum based random decision. This creates 2 arms. In one arm again no bilking occurs (condition 2a) and in the second bilking is being performed (condition 2b). Note that condition 2a is identical to condition 1 but a trial in condition 2a *could* have been in 2b and we speculate that therefore in that condition we might experience the effect of bilking. Note that the decision if a trial is in condition 1 or 2 will be non-random (and certainly not dependent on a quantum process).

Such an experiment might shed some light on the the theoretical models that have been proposed to account for the elusiveness of parapsychological results. In two of these models, the MPI model and the Generalized Quantum Theory model (von Lucadou (1991), Filk et al (2012)) the claim is that no classical signals are allowed and any time one tries to use the anomalous correlation to transmit a classical signal the correlations will disappear. In the CIRTS model this restriction is weakened to the requirement that classical signals are not allowed only when they might be usable to create a paradox.

A bilking experiment using the face detection paradigm is currently underway and results will be available at the time of the conference.

Acknowledgement

We thank James Spottiswoode for checking the manuscript on form and content.

NOTE
Ethics restrictions prohibit public data sharing, but all data is available upon request from the authors, and will be deposited in the Heymans Institute Data Archive. The

data-acquisition and the analysis software is available upon request, and will be published online via the Open Science Framework after publication.

References

Bandt, C.,Weymar, M., Samaga, D., & Hamm, A.O. (2009). A simple classification tool for single-trial analysis of ERP components. *Psychophysiology*, **46**, 747-757.

Bates, D., Maechler, M., Bolker, B., Walker, S., Christensen, R. H. B., Singmann, H., ... & Rcpp, L. (2015). Package 'lme4'. convergence, 12, 1.

Bierman, Dick J. (2011) "Anomalous switching of the bi-stable percept of a Necker cube: A preliminary study." *Journal of Scientific Exploration*, 25.4 p. 721.

Bierman, Dick J. (2010). "Consciousness induced restoration of time symmetry (CIRTS): a psychophysical theoretical perspective." *The Journal of Parapsychology,* 74.2: 273.

Bierman, D.J., Spottiswoode, J., Bijl, A. (2016)., *PLOSONE*, accepted manuscript

Bierman, D.J. & Ditzhuijzen, J. (2006). Anomalous slow cortical components in a slot-machine task. *Proceedings of the 49th Annual Parapsychological Association Convention*. 5-19.

Brainard, D. H. (1997) The Psychophysics Toolbox, Spatial Vision 10:433-436.

Don, N., McDonough,B., & Warren, C. (1998). Event related potentials (ERP) indicators of unconscious PSI: a replication using subjects unselected for PSI. Journal of Parapsychology, 62, 127-145.

Filk, T. & Römer, H. (2012). Generalized Quantum Theory: Overview and Latest Developments. http://arxiv.org/abs/1202.1659

Hartwell, J. (1978). Contingent negative variation as an index of precognitive information.. *European Journal of Parapsychology*, 83-103.

Hintenberger, T., Studer, P., Jager, M., Haverty-Stacke, C. & Walach, H. (2006). The slide-show presentiment effect discovered in brain electrical activity. The proceedings of the Parapsychological Association Convention, 1-14.

Jolij, J., Scholte, H. S., van Gaal, S., Hodgson, T. L., & Lamme, V. A. (2011). Act quickly, decide later: Long-latency visual processing underlies perceptual decisions but not reflexive behavior. *Journal of Cognitive Neuroscience*, 23(12), 3734-3745.

Kuznetsova, A., Brockhoff, P. B., & Christensen, R. H. (2015). Package 'lmerTest', version 2.0-20.

Krasnikov, S. (2002). Time travel paradox. *Physical Review D*, 65(6), 064013.

von Lucadou, W. (1991). Some remarks on the problem of repeatability of experiments dealing with complex systems. In *Information Dynamics* (pp. 143-151). Springer US.

Mossbridge, J., Tressoldi, P. E., & Utts, J. (2012). Predictive physiological anticipation preceding seemingly unpredictable stimuli: a meta-analysis. *Frontiers in Psychology*, 3, 390.

McDonough, B., Don, N., & Warren, C. (2002). Differential event related potentials in targets and decoys in a guessing task. *Journal of Parapsychology*, 16, 187-206.

Popper, K. (2005). The logic of scientific discovery. Routledge.

Tressoldi, P.E., Martinelli, M., Semenzato, L. & Cappato, S. (2011). Let Your Eyes Predict: Prediction Accuracy of Pupillary Responses to Random Alerting and Neutral Sounds. *SAGE Open*, DOI: 10.1177/2158244011420451, 1-7.

Radin, D. & Lobach, E. (2007). Toward understanding the placebo effect: investigating a possible retrocausal factor. *Journal of Alternative and Complementary Medicine*, 13, 733-739.