

TECHNICAL APPENDIX FOR: POSSIBLE PARANORMAL COMPONENTS OF ANTICIPATION: PSYCHOPHYSIOLOGICAL EXPLORATIONS

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TECHNICAL INFORMATION--SERIES I AND II

Procedure

The subject was seated in a comfortable armchair in an electrically shielded, sound attenuated room. The visual stimuli were three lights (amber, green, and red) mounted on a small box about 1.5 meters from the subject. A fixed foreperiod reaction time procedure was used in which the subject received the (1/4 sec.) amber warning light (S1) and 1.25 seconds later for S2, either a red or green light flashed. For Series I, the green light flashed for 1/4 second; for Series II, the green light came on until the subject responded. The time from the onset of S1 to the onset of S2 was 1.5 seconds. The decision whether S2 was to be red or green was made by a Schmidt binary ENG immediately prior to S2 delivery.

The subject was instructed to press a telegraph key with his favored hand as quickly as possible when a green light was delivered and to not react when the red light flashed. For the first three subjects in Series I, the absence of the green light indicated no response rather than a red light. Also, a few of the first subjects used a hand-held push button rather than the mounted telegraph key. In Series I, the minimum inter-trial interval was three seconds with an average of 5.5 seconds. For Series II, the minimum was four seconds with an average of 6.5 seconds leading to 250-300 trials collected for the approximately 30-minute experimental run. The random intervals were determined by a complicated logic circuit utilizing a timing sequence and a second binary Schmidt RNG. The time length of the run was fixed rather than the number of trials. For all series subjects were asked to try to refrain from blinking during the S1-S2 interval.

Physiological Recording

The vertex EEG was measured using a Gilson Medical Electronics CH-CBPP single ended chopper DC amplifier, 750 K input impedance, modified to a 7.5 second time constant (high frequency response flat to 17 HZ). The amplifier was set at its maximum sensitivity of 20 uV/CM. Beckman regular reversible silver, silver-chloride cup electrodes were attached to the vertex (CZ) and linked mastoids. A few subjects in Series I referenced to right mastoid only. The electrode sites were scratched (not drawing blood) to avoid skin potential artifacts and all electrode impedances were under 5K. Eye activity was monitored on all subjects with a Gilson

EEG amplifier (1/2 amplitude frequencies .5 and 40 HZ). It would have been better to measure eye potentials using a longer time constant but this was not possible.

For all subjects in Series II and some in Series I, integrated frontalis EMG was recorded. The output of a hybrid amplifier (1/2 amplitude at 1 and 500 HZ) was integrated by a lag circuit with a .2 sec. time constant. EMG activity on each trial was measured by averaging the amplitude over a .5 second period preceding S2. This amplitude was measured relative to a one-second baseline preceding S1. EEG alpha activity was measured by a Fast Fourier transform power spectrum on the 128 points (1 sec.) preceding S2. On each trial the log transform was taken of the average amplitude of the power spectrum in the range 9-12 HZ.

A PDP/11 computer system was used to record and analyze the data. Polygraph data, including button presses and RNG decisions were sampled continuously at 128 points per second and stored digitally (14 bits) on magnet tape for later analysis.

CNV Amplitude Measure

The amplitude of the CNV was measured for each trial by finding the average amplitude of the EEG for about 1/3 second (45/128 sec.) immediately preceding S2. Following the most widely used procedure (Tecce, 1972; Donchin, 1973), the amplitude of the CNV was measured relative to a baseline level determined by averaging the EEG over a one-second period immediately preceding S1. For each trial, the analysis program looked at a window of 512 points (4 seconds) with the onset of S2 aligned at the three second point,

The mean amplitude of the CNV for all the selected trials was found and predictions for individual trials were made relative to this level. For any analysis, the mean amplitude cutoff level, was found by averaging only the particular trials for which predictions were to be made. Thus the practice and experimental runs were analyzed separately, and an analysis of the first 40 experimental trials used the mean amplitude of only the first 40 trials as the cutoff. The analysis was based on whether the green light came on or not and any trials in which the subject made response errors were included. Most subjects made, at the most, 2 or 3 erroneous responses. However, one subject in Series II made over 30 erroneous responses.

Artifact Rejection

The algorithm for rejecting movement artifacts was to find the average amplitude of the EEG for each of the six .5-second periods in the three seconds preceding S2. If the absolute value of the difference between any sequential .5-second average was greater than the criterion value, the trial was rejected for analysis on all polygraph channels. Combining practice and experimental trials for Series II:

Criterion A rejected no trials.

Criterion B (about 21uV) rejected about 6%

Criterion C (about 18 uV) rejected about 12%

Criterion D (about 14uV) rejected about 27%

Criterion E (about 11 uV) rejected about 47%

Also, on any channel, if the polygraph record in the six seconds prior to S2 went off scale on the A-D converter, the trial was rejected for that channel. In general, the EMG went off scale more than the EEG, thus there were fewer usable EMG trials.

TECHNICAL INFORMATION — SERIES III AND IV

Procedure

As described in the text, the S1-S2 interval was three seconds for Series III and IV. The amber warning light came on for .5 seconds and 2.5 seconds later either the red light flashed or the green light came on until the subject responded. Presentation of stimuli was handled by the computer with the inter-trial interval uniformly randomly distributed from 5 to 11 seconds (determined by system FORTRAN RAN function). The S2 decision was made immediately before display by a Schmidt binary RNG interfaced with the computer.

The response button was a push button that clicked when pushed rather than the telegraph key. The button was one of three mounted on a 7" X 5" X 2" aluminum box and several other experiments under computer control used the same equipment.

For the GESP condition, the experimental program was modified to pick S2 at the time S1 was being displayed. During the S1-S2 interval, one of two lights notified the agent as to which S2 would be displayed. For the alternating condition, the S1-S2 interval was inadvertently made 3.5 seconds rather than 3.0.

Physiological recording

The chopper amplifier used previously was not optimal for CNV recording (Survillo, 1971). For Series III and IV, a preamp using an Analog Devices AD 521 Instrumentation amplifier was built by Jim Davis. This was located in the testing room, was battery operated, had 22 Megaohms input impedance, was differential input, and responded from DC to down 3db at 2 KHZ. The preamp had a gain of 100 and fed into the chopper amplifier (set at 2 mV/cm) through the 7.5 second time constant. The polygraph data were recorded digitally at 100 points per second. The amplitude of the CNV was measured by averaging 35 points immediately preceding the onset of S2.

The vertex electrode was referenced to linked ear lobes (Beckman miniature electrodes) since the mastoid site has been shown to be susceptible to skin potential artifacts (Rath & Kopell, 1974; Corby, Picton & Hillyard, 1972). The vertex potentials were also recorded on another channel for frequency analysis with a Gilson EEG amplifier, 1/2 amplitude at .5 and 40 HZ. Eye blinks were monitored (1/2 amplitude at .5 and 40 HZ) by an electrode placed horizontal with the right eye, referenced to linked ear lobes.

The integrated EMG (.2 sec. time constant, 1/2 amplitude at 3 and 500 HZ) was recorded from the subjects' right arms. All subjects responded with their right index finger although 2 were left handed and one was ambidextrous. For EMG recording, regular Beckman electrodes were attached to the inner wrist and forearm. The exact electrode sites were determined by visual inspection of muscle contraction when the subjects pressed with their right index fingers. EMG activity was again measured over a .5 second pre-S2 period relative to a pre-S1 one-second baseline. Alpha activity was estimated using the power spectrum of the 128 points preceding S.

Baseline Measures

Several factors could have contributed to the poor sensitivity of standard CNV measurement procedure. Previous workers have suggested the pre-S1 baseline may sometimes be confounded by a negative potential shift in anticipation of S1 itself, thus camouflaging the actual CNV magnitude (Loveless & Sanford, 1974; Donchin et al., 1975). Also, with long S1-S2 intervals, the pre-S1 baseline may be dissociated beyond an acceptable degree from the pre-S2 level (Sanford & Loveless, 1973). Movement artifacts during the baseline period present another possible source of error.

Investigation of Movement Artifacts

The movement artifact algorithm was the same as before except the eight (instead of six) .5 second periods before S2 were compared, (nine .5 second periods for the alternating condition). As discussed later, the rejection rate was much higher in Series III than in the other three series.

Various selection procedures were compared using the alternating trials data in order to clarify the role of movement artifacts. The eye channel was checked over the .5 second period before S2 (signified E1) and over the 1 second pre-S1 baseline period (E2). If the absolute value of the ocular potentials was above a cutoff value, the trial was discarded from analysis. One cutoff value was used for all subjects although the sensitivity to eye movements may have varied somewhat between subjects. The data for series I were recorded with a higher amplification on the eye channel so these data were not included in the comparison.

For the alternating trials, the discrimination results with various combinations of the two eye checks and conditions B and D of the previous selection algorithm are shown in Table 8. With the absolute CNV measure the strongest effect came by including all trials. Any selection procedure lowered the significance, but the overall discriminating ability was still less than .01 until criterion E2 was applied. Apparently, the most striking trials have eye artifacts during the baseline period.

The consistent decrease in significance with increased selection suggests that movement artifacts did not dilute the effect and, perhaps, even contributed to it. Using the pre-S1 baseline, the strongest--yet not quite significant--effect occurred with criterion B alone. Although artifacts during the baseline period apparently contributed much to the poor discrimination with the standard CNV measure, other less obvious factors may also have important effects.

To further evaluate the role of movement artifacts, the rate of trial rejection for all conditions was found with the various selection procedures. As shown in Table 9, with criterion B, Series III had a much larger rejection rate for the ESP trials than in the other three series. Also, with most selection procedures, the alternating trials had a higher rejection rate than the other trials. The baseline eye check (E2) clearly discards many more trials than either B or E1, which affirms that many trials are contaminated during the baseline. Most of the trials discarded with B are also rejected by E1+E2 (compare E1+E2 with E1+E2+B), but D throws out many trials accepted by E1+E2.

This indicates that B discards contaminated trials while D is doing something more. Perhaps D is sensitive to artifacts that do not show up on the eye channel, but more likely it is rejecting CNVs with particular features. At present, it is not clear that the effort needed to clarify this matter in the present data is warranted.

Even with these analyses, there is still no way to determine which baseline procedure is best for Series I and II, or to what extent the findings in the alternating condition can be applied to the ESP trials. Since the alternating trials gave the best results with no artifact selection, the rest of the data were analyzed in the same manner. There were no noteworthy changes in results. Even the practice trials in Series III had essentially the same outcome as before (i.e, not significant overall with eight out of nine subjects in the expected direction).

Re-analysis of the Series II practice trials (standard baseline) incorporating the E1+E2 selection procedure seemed pertinent since this check was more stringent than the algorithm for B and D. In line with the previous findings, the effect became stronger with the added selection (see Table 10).

OTHER ANALYSIS CARRIED OUT

Physiological Trends

The sensitivity of basing predictions on the mean amplitude could be severely limited if the physiological records show strong monotonic trends over time. Such trends are common, particularly with EMG monitoring and this proved to be the case here. For the vast majority of subjects in all series, EMG activity showed some type of dramatic chronological trend across each run. Measuring EMG activity relative to the pre-S1 baseline for the most part corrected this problem.

For the long runs in Series I and II, the absolute CNV amplitude also showed significant chronological trends for the majority of the subjects and using the pre-S1 baseline corrected for this in most cases. In the shorter runs of Series III and IV, few subjects showed noticeable chronological trends in CNV amplitude. Due to the difficult nature of DC recording, trends in the absolute CNV amplitude probably resulted from extraneous variables such as amplifier drift, as well as physiological activity.

The figures presented in the paper have no correction for trends. However, the total results for the experimental runs were still not significant (with or without the pre-S1 baseline) when the mean amplitude cutoff analysis was applied to smaller sequential divisions rather than the run as whole.

The significant results obtained with subject J.E. in Series I appear to be enhanced somewhat by a chronological trend in CNV amplitude. The amplitudes of the CNVs in the second half of the data are larger than in the first half ($t = 2.05$, 142 df, $p < .05$, 2-tailed). Also, the second half has a bias for green lights (61.11%, CR = 1.77, $p < .08$, 2-tailed). The increase in CNV amplitude cannot be attributed to ESP since the discrimination results for the second half alone are not impressive. Apparently, the predictive effects of his data were enhanced by the interaction between the green light bias and the increase in CNV amplitude.

Correlations Between Physiological Parameters

For all subjects correlations were carried out between the physiological parameters CNV amplitude, EMG activity, amount of alpha activity and, for the .5 second prior to S2, maximum amplitude on the eye channel. Although certain individuals showed significant correlations between physiological parameters, overall the results were so sporadic (both within and between

subjects) that no general group trends could be identified for ESP trials. Significant correlations between the eye potentials and CNV amplitude were the most common but were absent much more often than present. However, on the green light only runs, eye amplitude did tend to correlate with EEG amplitude preceding S2.

Table 8

ALTERNATING TRIALS PREDICTION RESULTS FOR VARIOUS ARTIFACT PROCEDURES*

CONDITION	ABSOLUTE BASELINE					STANDARD BASELINE				
	PREDICTED NOT GREEN	PREDICTED GREEN	TOTAL	χ^2 (1df)**	NO. POSITIVE	PREDICTED NOT GREEN	PREDICTED GREEN	TOTAL	χ^2 (1df)**	NO. POSITIVE
All trials	31/96 32.29%	69/104 66.35%	100/200 50.00%	21.82	5/5	45/103 43.7 %	55/97 56.7 %	100/200 50.00%	2.88	4/5
E1	32/86 37.21%	65/94 69.15%	97/180 53.09%	17.18,	5/5	44/90 48.9 %	53/90 58.9 %	97/180 53.9 %	1.43	4/5
B	30/79 37.97%	54/79 68.35%	84/158 53.16%	13.45	5/5	37/82 45.1 %	47/76 61.8 %	84/158 53.2 %	3.78	5/5
E1+B	31/73 42.47%	51/74 68.92%	82/147 55.78%	9.38	5/5	36/75 48.00%	46/72 63.9 %	82/147 55.8 %	3.14	5/5
E2	22/48 45.83%	37/56 66.07%	59/104 56.73%	3.53	3/5	27/55 49.1 %	32/49 65.3 %	59/104 56.7 %	2.15	5/5
E1+E2	22/42 52.38%	35/52 67.31%	57/94 60.64%	1.59	3/5	26/48 54.2 %	31/46 67.4 %	57/94 60.6 %	1.21	5/5
B+E2	20/41 48.78%	31/48 64.58%	51/89 57.30%	1.66	4/5	23/44 52.3 %	28/45 62.2 %	51/89 57.3 %	.54	5/5
E1+B+E2	21/38 55.26%	28/44 63.64%	49/82 59.76%	.30	3/5	21/39 53.9 %	28/43 65.1 %	49/82 59.8 %	.66	5/5
D	25/49 51.02%	30/47 63.83%	55/96 57.29%	1.13	3/5	27/48 56.3 %	28/48 58.3 %	55/96 57.3 %	.00	2/5
D+E2	16/30 53.33%	18/30 60.00%	34/60 56.67%	.07	2/4***	16/29 55.2 %	18/31 58.1 %	34/60 56.7 %	.00	3/4***
D+E2+E1	17/27 62.96%	15/26 57.69%	32/53 56.60%	.01	2/4***	14/23 60.9 %	18/30 60.00%	32/53 60.4 %	.05	2/4***

(footnotes on next page)

Table 8 (continued)

*This table presents data from the one subject in Series III with an alternating condition combined with the four subjects from Series IV. E1 is eye channel checked over the .5 second preceding S2. E2 is eye channel checked over the 1 second baseline preceding S1. B and D use the selection algorithm described previously.

**For $P = .01$, $X^2(1 \text{ df}) = 6.63$; for $p = .05$, $X^2(1 \text{ df}) = 3.84$.

***One subject had only one acceptable trial and was not counted.

Table 9

PERCENT TRIALS DISCARDED WITH VARIOUS ARTIFACT SELECTION
PROCEDURES

	SERIES I	SERIES II Practice & Experiment	SERIES III Practice & Experiment	SERIES III Green Only	SERIES IV Practice & Experiment	SERIES IV Green Only	ALTERNATING 5 subjects
No.Trials*	629	2709	772	591	320	159	200
B	3.18%	5.54%	16.45%	13.87%	6.25%	8.18%	21.00%
D	16.53%	27.02%	47.02%	39.26%	33.75%	32.08%	52.00%
E1		9.67%	3.11%	14.04%	5.31%	13.84%	10.00%
E1+E2		39.42%	20.85%	28.09%	35.31%	35.85%	53.00%
E1+E2+B		40.27%	30.31%	33.67%	38.44%	38.99%	59.00%
E1+E2+C		49.94%	53.89%	48.22%	56.88%	52.20%	73.50%

*Total trials that did not go off scale on the A-D converter prior to S2.

Table 10

PREDICTION RESULTS FOR SERIES II
 PRACTICE TRIALS WITH FURTHER
 ARTIFACT SELECTION PROCEDURES*

CONDITION	PREDICTED NOT GREEN	PREDICTED GREEN	TOTAL	NO. POSITIVE	X ² DIFF.	p(2-tailed)
B	33/78 42.31%	46/80 57.50%	79/158 50.00%	5/9	3.06	p < .10
D	22/62 35.48%	37/62 59.68%	59/124 47.58%	6/9	6.34	p < .02
E1 + E2	20/56 35.71%	34/60 56.67%	54/116 46.55%	6/9	4.30	p < .05
E1+E2+B	18/52 34.62%	35/62 56.45%	53/114 46.49%	6/9	4.58	p < .05
E1+E2+D	13/44 29.55%	31/51 60.78%	44/95 46.32%	7/9	8.06	p < .01

*Standard baseline used. See Table 7 for description of terms.

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