Person. & Individ. Diff. Vol. 2, pp. 61 to 83
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0191-8869/81/0101-0061$02.00/0

PERSONALITY AND THE TOPOGRAPHY OF THE CONDITIONED EYELID RESPONSE

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(*Received* 15 *June* 1980)

Summary—One-hundred and four women were tested on an eyelid conditioning paradigm in a 2 × 2 × 2 factorial design where two levels of US intensity (1 vs 3 p.s.i.) were balanced against two rest pause interpolations (after 25 and after 50 trials), and the presence or absence of a warning stimulus prior to CS–US presentation. Subjects were later classified as high, low or intermediate extraverts on the basis of a personality questionnaire. A very detailed analysis of conditioned responses was carried out, using both simple and composite measures including work-ratio, utility-ratio, CR frequency, peak latency, peak amplitude, response area and effective response area, degree of avoidance amplitude and latency, etc. Major findings related to similar effects of high intensity US vs low intensity US, and introversion vs extraversion; introverts react as if they were responding to more intense stimuli than extraverts. This finding cuts across other parameter variables, and supports Eysenck's formulation of personality-conditioning relationships in terms of higher cortical arousal in introverts as compared with extraverts.

This study was designed to examine the relation between personality (extraversion–introversion, or E) and eyeblink conditioning within a context of parameter variation, including specifically US intensity, positioning of rest interval between occasions, and presence or absence of a warning signal. The importance of such parameter studies in relation to personality has been emphasized by Eysenck and Levey (1972), who showed that varying the intensity of the US, the CS–US interval, and the reinforcement schedule altered not only the strength but also the direction of correlation between CR and personality. The literature relating to the general theory here tested has been surveyed in considerable detail by Levey and Martin (in press), and we will not do so again beyond noting that the prediction states that CR frequency and other measures of conditioning should be negatively correlated with E under conditions of low intensity US.

Interest in CR frequency has prejudiced efforts at arriving at a better understanding of the dynamics of conditioning, and little information as to what happens to the CR during development can be gleaned from such a limited approach. Martin and Levey (1969) distinguish between response likelihood (probability or frequency) and the development and stabilization of response characteristics. This approach stresses the essentially adaptive aspect of conditioning, so that the developing CR is seen as being shaped as a result of a biologically adaptive mechanism. The authors postulate various 'end points' towards which the CR is aiming, and which will be reflected in the topography of the response. Interest in the relation between personality and the achievement of these adaptive responses is the central point of this experiment.

Martin and Levey (1969) presented results which showed that the composite measures of response efficiency tend to group into two areas, relating either to integration of the CR and UR or to avoidance of the air-puff. It was found that a relatively strong US intensity led to maximisation of the avoidance measures whereas a weak US produced a response pattern indicative of a fine integration of the CR and UR. The evidence of a decreasing UR latency as conditioning progresses (Martin and Levey, 1966), and reduced UR amplitude during CS–US pairings (Kimble and Ost, 1961), both of which have been shown to be good predictors of conditioning performance, suggest that the UR comes

* This report is based on a Ph.D. thesis by J. Jones accepted by the University of London. The research was supported by a grant from the Bethlem–Maudsley Research Fund.

under the influence of the total CS–US complex. In the early stages a weak, long latency CR is often observed, and this becomes progressively integrated with the UR. This blending of the CR and UR where the two responses seemingly 'grow' into each other strongly suggests that both responses are operated on by a stimulus complex as a whole. The authors conceive of this process as working through internal models of both the stimulus complex and response requirements. Clearly, from this standpoint it is illogical to consider specific CS or US individual response characteristics in isolation, but more apposite to consider them as interdependent changes. The CR–UR response configuration adjusts and stabilises to the requirements of the relevant end point.

In addition to US intensity, two other parameters were studied, in the hope of throwing some light on the general problem of CR genesis. One of these was the introduction of a rest pause, to provide evidence for or against the hypothesis of reminiscence in eyeblink conditioning (Eysenck and Frith, 1977). The interpolation of programmed rest pauses during the elaboration of a CR has not been systematically or widely studied, and the effect of massing or spacing of practice, as denoted by length of the inter-trial interval, has been considered only in terms of its influence on continuous performance. Such work as is relevant has been summarized by Jones (1975). The other parameter studied was the presentation of a warning signal to the subject prior to the CS–US, as compared with its omission; here too the evidence has been summarized by Jones (1975), and here too there is little unambiguous to report by way of conclusion.

THE EXPERIMENT

Design

In a simultaneous test of the main hypotheses, subjects were assigned to the cells of a $2 \times 2 \times 2$ factorial design where two levels of US intensity (1 and 3 p.s.i.) were balanced against two rest pause interpolations of 24 hr (after 25 or after 50 acquisition trials), and the presence or absence of a warning signal prior to CS–US presentation. After elimination of certain subjects for reasons to be given, random assignment of subjects to cells resulted in a total of 13 subjects per cell, making a total N of 104. Ss were later classified as high, low or intermediate Extraversion (E) scorers on the basis of the PEN inventory (an early form of the EPQ: Eysenck and Eysenck, 1975), if their scores were above, below, or within approximately 1 S.D. of the mean score of the total group. Questionnaires were not scored until after testing had been completed.

Subjects

The subjects were 115 paid female volunteers drawn from a variety of sources, all of whom had little knowledge of psychology in general or eyelid conditioning in particular. They were drawn from three main sources: student nurses, secretarial and clerical staff of a large training hospital, and housewives. The experimenter saw all subjects prior to any testing and gave a brief explanation of the experiment. Eleven subjects had to be rejected. Three gave responses impossible to record due to uncontrolled eye-movements contrary to instruction; two failed to turn up for the second testing; four exhibited persistent voluntary eye-closure during the CS–US presentation; and two found the experiment unpleasant due to noxious effects of the air-puff, and refused to continue. The other subjects did not find the experiment unpleasant, as shown later in questioning.

Apparatus

This study employed the conditioning set-up which has been in use at the Institute of Psychiatry for several years; for a description see Bluffield and Holland (1964).

The subject was seated in a large comfortable chair opposite a panel which held a red light that acted as a fixation point or a warning signal. The subject wore a pair of modified goggles which carried a source light, photo-cell transducer and air-puff delivery tube and a pair of earphones through which the CS (tone) was delivered. The test room was effectively sound proofed from the stimulus-delivery and recording equipment which was located in a separate room. The tone (CS) was supplied by a standard audio-signal generator and the air puff (US) by means of a specially constructed air reservoir system with a solenoid valve attachment, all of which were controlled by a series of millisecond timers and switching gear.

Closure of the eyelid resulted in a decreased reflection of light from the eye surface so that eye-closure was linearly represented in the photo-cell transducer output. The latter was passed through a two-stage amplifier and fed to a mingograf paper-chart recorder and also to an Instrumentation Tape Recorder in analogue form by means of frequency modulation (FM). A detailed account of this system may be found in Law (1971). Subsequent processing of the records was achieved by means of a Linc 8 computer with an inbuilt analogue–digital converter, and will be described in the section on scoring.

Procedures

The subject was seated in the test-room and a brief explanation of the experiment was given, to the effect that the experimenter was interested in recording the normal eye-reactions displayed whilst some tones and occasional air-puffs were presented. This was given in a relaxed, matter-of-fact manner in order to try to avoid arousing any anxiety or nervousness in the subject. Eysenck (1965), amongst others, has pointed out that the experimenter's manner and the formality of the testing situation may well influence the level of conditioning attained indirectly by increasing the arousal of the subject.

The goggles and earphones were then fitted and the air-puff delivery tube was adjusted so that the nozzle was located at a distance of approximately 1 cm from the surface of the cornea. The following standardised instructions were then given to the S:

"I want you to fixate that red bulb that you see in the panel in front of you. This may go off and light up again on different occasions but I want you to keep looking at the bulb at all times. Try not to move your eyes or head about because this may distort the recording. You will hear some tones and maybe feel a puff of air paired with them from time to time, but I just want you to act normally. When you hear the tone do not close your eye deliberately to try and avoid the air-puff, but do not try to resist blinking either. Just relax and keep looking at the red bulb. Now when I leave the room the red light will go off a few times and come on again. For these first few times that it goes off I want you to close your eyes and count up to ten, and then open them, OK? After that I will come in again and just check that everything is all right for the main recording."

The experimenter then left the room and carried out the calibration procedure which was designed to standardise the amplitude output for full eye closure across subjects. When this was completed he returned to the test-room and re-checked that the goggles, earphones and connections were satisfactory, and completed the instructions as follows: "That's fine, from now on just keep looking at the red-bulb at all times, regardless of whether it is on or off. Are you comfortable? OK! We'll carry on then."

There is considerable evidence that the nature of the instructions to the subject can affect the rate of conditioning and extinction of the eyelid reflex (e.g. Hartman and Ross, 1961). These present instructions were drawn up with three main aims in mind. Firstly, to communicate the main requirements for an adequate recording to the subjects; secondly, to relax them and alleviate any stress which might differentially affect their conditioning; and thirdly to eliminate as far as possible any voluntary responding.

Stimulus schedule

The CS was 1,000 c.p.s. tone at 65 dB presented bi-aurally and lasting 500 ms. The US was a puff of air of either 1 p.s.i. or 3 p.s.i. which onset at 460 ms from CS onset and lasted 40 ms, so that the CS and US terminated together. The inter-trial intervals varied randomly between 10 and 25 s, the lower limit being imposed by the recycling time required for later computer processing of the records. The no-warning signal condition involved continuous presentation of the red-light for fixation by the subject. The warning-signal condition involved switching on the red bulb at random intervals varying between 3 and 10 s prior to presentation of the CS–US, and terminating 2 s afterwards.

Three test trials of two tones alone and one air-puff alone in the order T, P, T were given to test the equipment and then the conditioning proper was commenced. Subjects, according to assignment, received either 25 or 50 paired CS–US trials on the first testing, followed by a 24 h rest period and presentation of a further 25 or 50 CS–US trials so that all Ss received a total of 75 conditioning trials over the two test periods. After completion of this schedule the recording apparatus was switched off and the goggles and earphones removed from the subject. The latter was then asked some questions about her reactions during the experiment.

Questions to subject:

1. How did you find the experiment?
2. Did the puff of air disturb or annoy you in any way?
3. Did you consciously close your eye on hearing the tone?
4. Have you any comments or suggestions about the experiment?

Measures

This section summarises the basic response elements and derived (composite) measures to be used in this experiment. Abbreviation of terms and a brief description of the quality indexed by each measure is also given. The reader is referred to Martin and Levey (1969, pp. 44–70) for a fuller discussion of response measurement. The units of measurement are given after each term.

Response elements

The basic parameters of the responses may be sub-classed as frequency, latency and amplitude estimates. Abbreviations are given before the name of each measure.

Frequency

OR Fr(%): orienting (or 'alpha') response frequency (probability). The simple occurrence or non-occurrence of a response (to the CS) within 100 ms of CS onset.

CR Fr(%): Conditioned response frequency: occurrence or non-occurrence of a CR in the time period 250–500 ms.

Latency

Latency estimates are given with reference to either CS onset or US onset (thus latency of the UR is given as the difference between US impact (460 ms.) and onset of the response). Peak latency refers to the point in time at which a response attains its maximum amplitude.

CROL (ms): conditioned response onset latency in milliseconds from CS onset.
CRPL (ms): conditioned response peak latency (from CS or US).
UCROL (ms): unconditioned response onset latency.
UCRPL (ms): unconditioned response peak latency.

Amplitude

Amplitude estimates are given as the amount of deflection from a stable baseline with reference to onset of stimuli or the maximum deflection given.

CRAUSO (% of full eye-closure): amplitude of the conditioned response at the point (in time) of US impact (460 ms).
CRAURO (%FC): amplitude of the CR at the point of onset of the UR.
CRPA (%FC): peak amplitude of the CR.
URPA (%FC): peak amplitude of the UR.

Composite measures

Levey (1972) divides the following measures into three subclasses: (i) *target measures* which index the time factor by which peak latency misses the developing endpoint; (ii) *utility measures* which estimate the extent to which amplitude of the CR is used to attain an endpoint; (iii) *anticipatory measures* which index the extent to which the CR accomplishes the function of the UR. No assumptions are made at present regarding the degree of dependence of measures, and the order of presentation below does not imply any fundamental relation between the measures. The measures to be described are all derivations of the basic response elements and are calculated as ratios of these estimates.

WR: *work-ratio* (%). This is the ratio CRAUCRO/UCRPA, which is the amplitude of the CR at UR onset over peak UR amplitude. This is felt to be an estimate of the degree of integration of the CR and UR and reflects the amount of 'work' taken over by the CR from the UR.

UR: *utility-ratio* (%). The ratio CRAUCRO/CRPA or amplitude of the CR at UR onset over peak CR amplitude, which is regarded as a direct estimate of the efficiency with which the CR itself is employed.

RA: *response area* (*FCM's—unit of 'full-closure milliseconds'*). May be expressed as CRPA × (CRPL − CROL) and represents a combined function of peak amplitude of the CR and rise-time (the difference between peak and onset latency of the CR). It reflects the degree of 'coverage' of events (e.g. US impact) within its duration.

ERA: *effective response area* (*FCM's*). The ERA refers to the amount of response area remaining when the discrepancy in amplitude and latency in relation to puff onset has been subtracted. This will be at a maximum when the peak of the CR coincides with US impact, and reflects the degree to which the eye is effectively closed in relation to the latter.

CR slope (*tangent of the slope angle TSA*). This represents the speed of eye-closure, i.e. of the conditioned response.

US slope (*TSA*). Speed of the unconditioned response.

Slope ratio (%). This is the ratio CR slope/UCR slope and reflects the differential in the speed of closure of the two responses.

DAA: *degree of avoidance, amplitude measure* (%). This indexes the proportion of CR amplitude which is effective in avoiding the air-puff, and is similar to the UR % but refers to how the response is used in avoiding the air-puff.

DAL: *degree of avoidance, latency measure* (*ms*). This is simply the time by which CR peak amplitude misses US impact and will be zero when the two coincide.

The exact method of computation of all these measures will be found in Jones (1975). The 75 trials were divided into 3 blocks of 25 trials and averages and linear trends were obtained for each of these measures for the 3 trial blocks.

RESULTS

A. Intensity of US

Scores of subjects on the personality test variables were similar to those in the original standardization sample, and the random allocation to groups was successful in producing only insignificant differences between groups. We shall first discuss the major effects of US intensity. The 3 p.s.i. group showed a marked superiority over the 1 p.s.i. group from an early stage; rate of acquisition was similar, but asymptotic level of performance was superior for the high intensity group.

Mean CR onset latency (CROL) was significantly longer for the 3 p.s.i. group for the first block of trials only. Peak latency (CRPL) of the CR was significantly longer for the 3 p.s.i. group for all 3 blocks of 25 trials; this means that this group exhibited longer duration responses than the 1 p.s.i. group. The mean CRPL was 540 ms which indicates that the maximum amplitude was gained well beyond the point of US impact (460 ms), so that the CR peak amplitude of the low p.s.i. group was better 'placed' in relation to the US.

Regarding UCROL and UCRPL (mean UR onset and peak latencies), the 3 p.s.i. group had consistently lower UCROLs (though only significant in the first block) and significantly lower UR peak latencies for blocks 2 and 3. Mean amplitudes of the CR at US impact and UR onset (CRAUSCO and CRAUCRO) were significantly higher for the 3 p.s.i. group; so was mean CR peak amplitude (CRPA).

US effects on response efficiency were as follows, using estimates of individual mean levels and trends for the 3 successive 25 trial blocks. Work-ratios were consistently higher for the 3 p.s.i. group, though the effect was only significant ($p < 0.001$) in the final block. The WR continued to increase throughout the acquisition series, with the 1 p.s.i. group levelling off within the second block of acquisition trials, and the 3 p.s.i. group showing increases between blocks 2 and 3. The utility-ratio (UR %) also showed higher mean scores for the 3 p.s.i. group.

The 3 p.s.i. treatment resulted in significantly higher response area (RA) scores for all 3 blocks, with very large differences becoming apparent. The same was found for the Effective Response Area (ERA). CR and UR slopes were significantly higher for the 3 p.s.i. group, but there were no differences in the slope-ratio measures. There were no significant differences in degree of avoidance (DAA), but the lower DAL scores for the 1 p.s.i. group indicated superior 'placement' of the CR with reference to the US.

Overview of UCS intensity effects. Table 1 summarises the main significant differences in the measures of conditioning due to US intensity. The direction of the differences and the blocks of trials on which these were manifested are indicated, as are the possible implications of the trends.

Table 1. Summary of UCS effects (significant differences)

Measure	Group	Change	Implication
CROL	3(p.s.i.)	$*B^1$	Longer initial latency
CRAUSO	3(p.s.i.)	B^1, B^2, B^3	Higher amplitude (stronger response)
UCROL	3(p.s.i.)	B^1	Lower initial latency
CRAURO	3(p.s.i.)	B^1, B^2, B^3	Higher amplitude
CRPL	3(p.s.i.)	B^1, B^2, B^3	Poorer placement in relation to UCS
CRPA	3(p.s.i.)	B^1, B^2, B^3	Higher amplitude
UCRPL	3(p.s.i.)	B^2, B^3	Lower latency
UCRPA	3(p.s.i.)	B^1	Higher amplitude
WR %	3(p.s.i.)	B^3	Better CR/UCR integration initially
UR %	3(p.s.i.)	B^2, B^3	Higher efficiency in later acquisition
RA	3(p.s.i.)	B^1, B^2, B^3	Greater 'coverage' of events
ERA	3(p.s.i.)	B^1, B^2, B^3	Greater 'coverage' of crucial (UCS) events
CRSL	3(p.s.i.)	B^1, B^2, B^3	More rapid response (low rise-times)
UCRSL	3(p.s.i.)	B^1, B^2, B^3	More rapid response (low rise-times)
DAL	3(p.s.i.)	B^1, B^2, B^3	Less efficient placement of CR in relation to UCS
CR.Fr.	3(p.s.i.)	B^1, B^2, B^3	Greater response production

* B = Block of trials, 25 trials per block.

It is evident that the high US intensity groups (3 p.s.i.) showed considerable superiority over the low US groups in terms of the amplitude estimates of both the CR and UR, which implies that the strength of the response (or magnitude of eye-closure) is directly related to strength of the US. Again, they appeared to have a better 'coverage' of the stimulus events as indexed by their higher scores on both the RA and ERA measures throughout acquisition. The rate of response (CR slope and UR slope) and the general level of efficiency as indexed by the UR % were higher under the high US intensity condition, which also produced a higher overall level of response production (CR frequency). On the other hand, the high US intensity condition resulted in a poorer placement of the CR in relation to the stimulus events, as indicated by higher CRPLs (CRPA with reference to CS onset), and DALs (CRPA with reference to US impact). Thus, the maximal amplitude of the CR appears to miss the target (US impact) to a greater extent where a relatively high US intensity is employed. This would appear to be due to the rapid rate of eye-closure (higher CR slope) obtained under this condition, and the general greater inconsistency of the onset latencies of these responses. It is clear that these changes are reciprocal in nature. The response elements appear to adjust their relative contribution to the overall shape of the response as a function of US intensity and the amount of stimulation associated with varying degrees of eye closure.

B. Rest-pause interpolation

We next turn to a brief discussion of the effects of the rest pauses interpolated between blocks 1 and 2, R^1 Group, or 2 and 3, R^2 Group.

There was no clear-cut effect of rest on CR frequency in the present experiment. Since almost all of the studies reviewed used this measure as their index of conditioning performance there is little to be gained by attempting to relate the present results to these, which were not specifically designed to examine the effects of rest in any case.

Table 2. Summary of rest-pause effects. Block 2 Comparison

Measure	R^1 Group	R^2 Group	Implication
CROL (ms)	346	374	Backward shift in onset latency
CRPL (ms)	498	536	Backward shift in peak latency
CRAUSO (% full eye closure)	14.8	10.2	Higher CR amp. at UCS onset
WR (%)	52.0	69.0	CR and UCR less well integrated
UR (%)	82.0	93.0	Lesser proportion of CR present at UCR onset
Sl. Rat. (%)	23.5	18.6	Greater similarity of CR and UCR slopes
DAA (%)	62.0	54.0	Greater proportion of closure at UCS onset
DAL (ms)	48	77	Shorter time from UCS onset to maximum closure

A summary of the effects of an early rest in acquisition is given in Table 2. It is clear that there was better avoidance of the US by the CR following the rest, as indexed by lower CRPLs and DALs and high DAAs. There was also less integration of the CR and UR as shown by lower WR scores and a reduction in the efficiency with which the CR was utilised (lower UR %). It is tempting to conclude from these results that interpolating a rest period early in acquisition changes an original strategy of increasing the end-points of integration and efficiency to one of avoidance of the US. It is possible that this is a switch in emphasis by the Ss, and seems to be temporary in so far as the efficiency measures in general show increments later in the session following the rest. Of course, not all Ss showed this trend of switching to avoidance, and most displayed increases in both the measures indexing efficiency and avoidance sooner or later in the acquisition phase. This reaffirms Martin and Levey's (1969) view that subjects attempt to cover all eventualities by increasing the parameters of different end-points, and optimising one or other of these depending on the particular stimulus conditions in any experimental procedure. In this sense reminiscence, or improvement following rest (derived from studies of simple motor skills), consists of a switch in strategy rather than an increase in the pre-rest level of efficient responding.

It is possible that the rest period 'sensitized' the Ss, as a very low latency, high amplitude first response occurred following the rest. The consequence may be one of a need for greater avoidance until the S adapts to the situation once more (or becomes 'desensitized'), when integration and efficiency can also be developed. These notions are essentially speculative, but it is evident that rest does have an effect on conditioning performance.

The method of analysis employed in the study involved averaging the responses over 25 trials, and though some measures (e.g. CRPA) showed increments in the first few trials over rest, these were evidently averaged out to non-significance. This illustrates the lack of appropriate units of measurement of rest-effects (or 'reminiscence') and the obvious need to clarify what is appropriate. This is an empirical matter and requires a careful testing out of alternatives—should changes over single trials or the first 5 or 10 trial blocks be compared or individual trends rather than group average scores etc? These questions must be tackled, but remain outside the scope of the investigation reported here.

The adoption of single-case methodology and intensive intra-individual analysis of change in the CR over time may offer another avenue of approach. The application of time-series analysis and other variants of individual trend analysis to the data of single conditioning records might be fruitfully pursued.

C. Warning signal

A summary of the effects of presentation of a warning-signal and some of the implications following from these is given in Table 3. These effects apply to the first block of 25 trials only, and generally reflect a superior performance by Ss who received a WS. The basic estimates of amplitude were higher in the WS group and represent a considerably stronger CR in terms of amount of eye-closure. Integration of the CR and UR (WR) was better in the WS group, as was the degree of coverage of events or area of closure as indexed by the RA and ERA measures. The speed of response (CR slope) was also superior in the WS group.

Table 3. Summary of warning signal effects. Block 1 differences.

Measure	Group No WS	Group WS	No WS Group: implication
CRAUSO (%)	6.7	9.6	2.9% lower amp. at UCS impact
CRAURO (%)	8.3	12.1	3.8% lower amp. at UCR onset
CRPA (%)	22.0	33.8	11.8% lower peak amp. of CR
UCRPA (%)	40.0	49.0	Lower amplitude of UCR
CRPL (ms)	472	524	Better placement of CR in relation to UCS impact (460 ms)
UCRPL (ms)	176	186	Lower UCR latency
WR (%)	33.0	58.3	Poorer integration of CR and UCR
RA	41.0	64.0	Less coverage of stimulus events
ERA	22.6	34.0	Less effective coverage of crucial events (UCS)
CRS1.	0.16	0.22	Slower rate of eye-closure
DAL (ms)	48	72	Better CR placement in relation to UCS

Two measures which reflect the efficiency of placement of the CR, namely CRPL and DAL (CRPA in relation to the CS and US onset) indicated a superiority of the group which did not receive a warning-signal. However, since the magnitude of the CR (amplitude and degree of coverage) was much superior in the WS group there is evidently a wider tolerance of inefficient placement. This is to say that the CRs of the WS subjects are so much stronger (relatively) that there is less need for them to be precisely placed in time in relation to the stimulus events.

There were no significant differences between the groups at any stage of acquisition in terms of CR frequency, which is in line with Spence and Weyant's (1960) findings but not those of McAllister and McAllister (1960a, b) who found that the absence of a WS lead to better conditioning.

The present experiment showed that the warning-signal does change the pattern of development of the CR though it seems to have little influence on the overall level of CR production. The effect would appear to be transitory and not to fundamentally alter the overall level of performance achieved on completion of the total number of conditioning trials. Thus, the routine use of a WS in conditioning studies (Hilgard and Campbell (1936), Spence (1956) and his co-workers), is not to be recommended until the specific effects of this procedure in relation to other variables is better understood, as McAllister and McAllister (1960b) recommend.

D. Personality effects

All subjects in the present experiment completed the PEN inventory and were assigned to the previously randomised test conditions so as to achieve an equal distribution of personality scores across conditions. Correlation coefficients were calculated between all the measures and the personality scores on E (extraversion), N (neuroticism) and P (psychoticism). The correlations between N and P and the measures did not reveal any significant differences over and above those expected by chance, and these factors will not be considered further.

Table 4 gives the significant correlations between the measures and E for the three successive trial blocks for all the Ss ($N = 104$). It is evident that a large number of the measures are negatively correlated with E, indicating a general superiority for Ss scoring on the introverted end of the E scale. It is interesting to note that CR frequency showed the highest correlations with E, and that the *r*s became higher in the third block (last 25 trials of the acquisition series) indicating a divergence of the personality groups. This measure will be considered later in the appropriate section.

Table 4. Significant overall correlations between the measures of conditioning and extraversion

Measure	Block 1. (Trials 1–25)	2. (Trials 26–50)	3. (Trials 51–75)
OR.Fr	−0.25	−0.22	
CROL			
CRAUSO	−0.36	−0.31	
UCROL	−0.31	−0.24	−0.26
CRAURO	−0.37	−0.35	−0.30
CRPL	−0.25	−0.28	−0.28
CRPA	−0.24	−0.29	−0.27
UCRPL			
UCRPA			
WR %	−0.27		−0.40
UR %		−0.23	
RA	−0.24	−0.31	−0.27
ERA	−0.31	−0.34	−0.21
CRSl.			
UCRSl.			−0.21
Sl	−0.23		
DAA		−0.21	
DAL	−0.23	−0.31	−0.33
CRFr.	−0.38	−0.38	−0.52

Significance levels: r $0.20 = p < 0.05$ ($n = 104$); r $0.27 = p < 0.01$ ($n = 104$).

It should be remembered that these measures of conditioning are themselves correlated to some degree—and this fact will be discussed in the next section—but the table of correlations is strongly suggestive of a relationship between E and conditioning.

In order to examine more closely the effect of extraversion and conditioning it was necessary to maximise the differences between groups in terms of their scores on E. To this end the total group of subjects was reduced such that only Ss scoring 9 or less (introverts, $N = 28$) and 15 or more (extraverts, $N = 29$) were included.

Table 5 summarises the significant differences between the groups for the three trial blocks. It is evident that many of the measures were significantly different for the two groups, and that these differences became larger in the third block of trials i.e. late in the acquisition series. In general, only the measures showing large differences between the I and E groups will be discussed, since these reflect the greatest differential in performance due to E within the context of the present experimental conditions.

Having summarized the major findings in Tables 4 and 5, the best way of discussing the data is by reference to diagrammatic representations which include both the personality variable and the intensity of US variable, jointly. Figure 1 illustrates CR frequency, demonstrating the clear superiority of the introverts on this measure. Figure 2 shows differences in peak latency, with introverts clearly showing longer latencies. These results were paralleled by differences in UR onset latencies (Figure 3). Differences in amplitude estimates are shown in Fig. 4 (CRAUSO—mean amplitude of the CR at US onset) and Fig. 5 (CRAURO—mean amplitude of the CR at UR onset). Figure 6 shows the different

Table 5. Summary of significant differences in mean level ($\bar{X}$) and Linear Trend (LT) due to 'Extraversion' in the selected introvert (I) and extravert (E) groups

	Block					
	1. (Trials 1–25)		2. (Trials 26–50)		3. (Trials 51–75)	
Measure	$\bar{X}$	LT	$\bar{X}$	LT	$\bar{X}$	LT
OR Fr.	0.03		0.04			
CROL						
CRAUSO	0.01		0.01	0.03		
UCROL	0.02				0.05	
CRAURO	0.01		0.01		0.01	
CRPL			0.01		0.01	
CRPA	(0.06)		0.03		0.02	
UCRPL						
UCRPA					0.02	
WR %					0.001	
UR %			0.02		0.04	0.01
RA			0.01		0.01	
ERA	0.03		0.01		(0.07)	
CRS1.	0.05					
UCRS1					0.03	
S1R.	(0.06)					(0.06)
DAA			0.02			
DAL			0.01		0.001	
CRFr.	0.01		0.001		0.001	

(Total N = 57).

amplitude levels exhibited by the introvert and extravert groups receiving high or low intensity puffs (CRPA).

Turning next to composite measures, Fig. 7 shows the work ratios, indicative of the superiority of the introvert group and Fig. 8 shows the utility ratios, suggestive of a similar superiority of the introverted group. Figure 9 shows the response area differences, while Fig. 10 shows the effective response area differences; again introverts were clearly superior. These composite measures are important because personality differences along these lines have not previously been published.

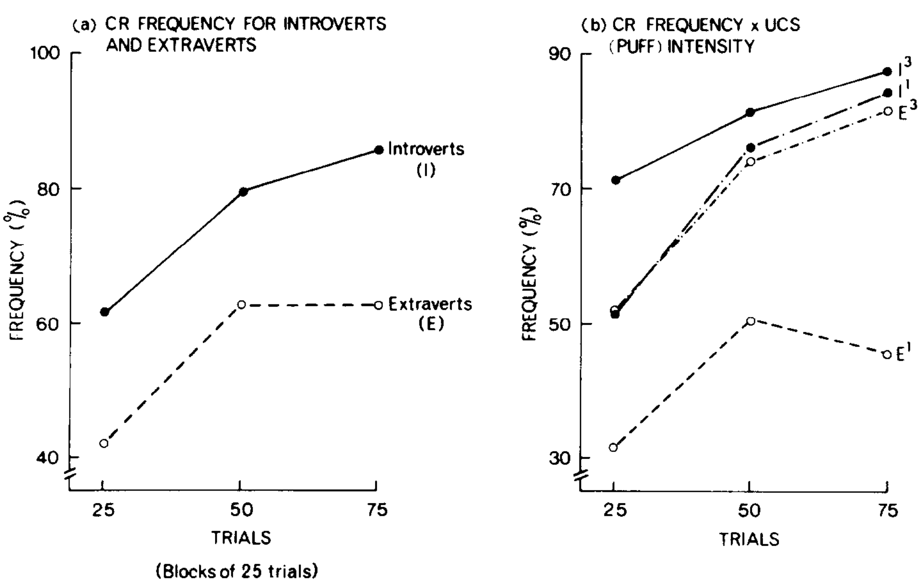

Fig. 1. (a) CR frequency for introverts and extraverts; (b) CR frequency for personality × US intensity.

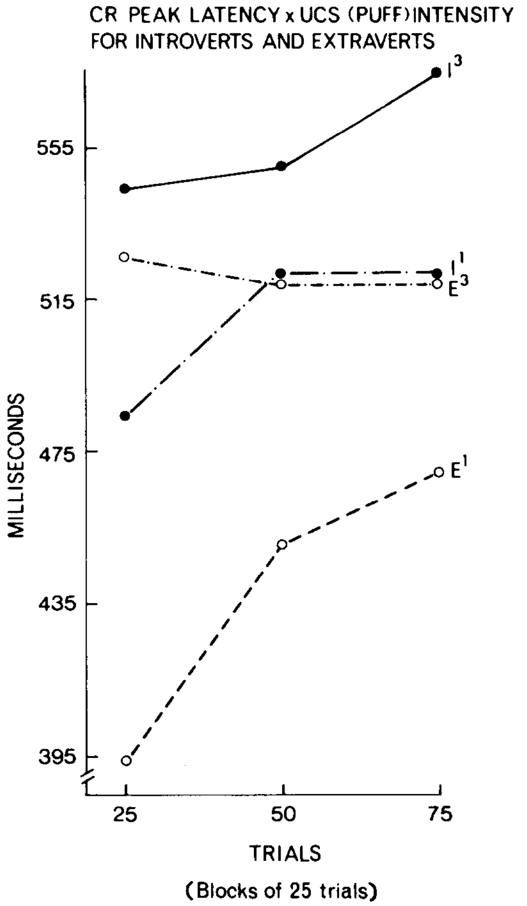

Fig. 2. CR peak latency for personality × US intensity.

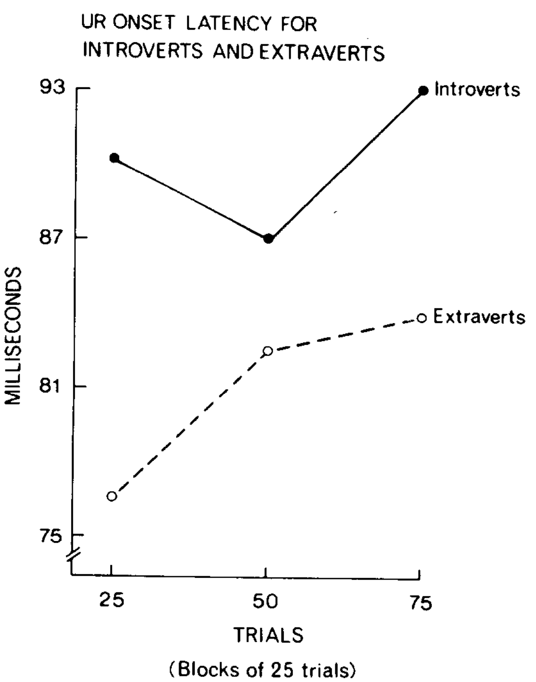

Fig. 3. UR onset latency for introverts and extraverts.

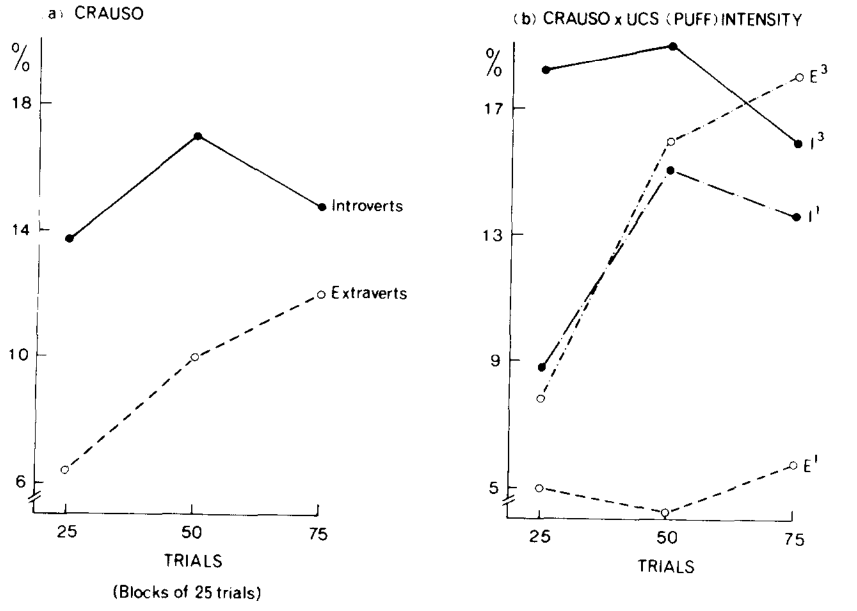

Fig. 4. Mean CR amplitude at US onset (a) for introverts and extraverts; (b) for personality × US intensity.

Differences in amplitude (DAA) are shown in Fig. 11, and degree of avoidance latency (DAL) in Fig. 12; a high score in the latter implies poor placement, thus the low intensity US group was superior to the other groups in terms of CR placement.

Levey (1972) suggested that Es might show higher avoidance and possibly higher CR frequency than introverts under certain conditions, but that the efficiency of their responding would nevertheless be inferior. The response area and degree of avoidance measures might be considered to reflect avoidance of the air-puff rather than efficiency in terms of CR–UR integration (work-ratio) or utilization of the CR (utility-ratio) as such. If this were so, it might be expected that Es would be superior to Is on these measures

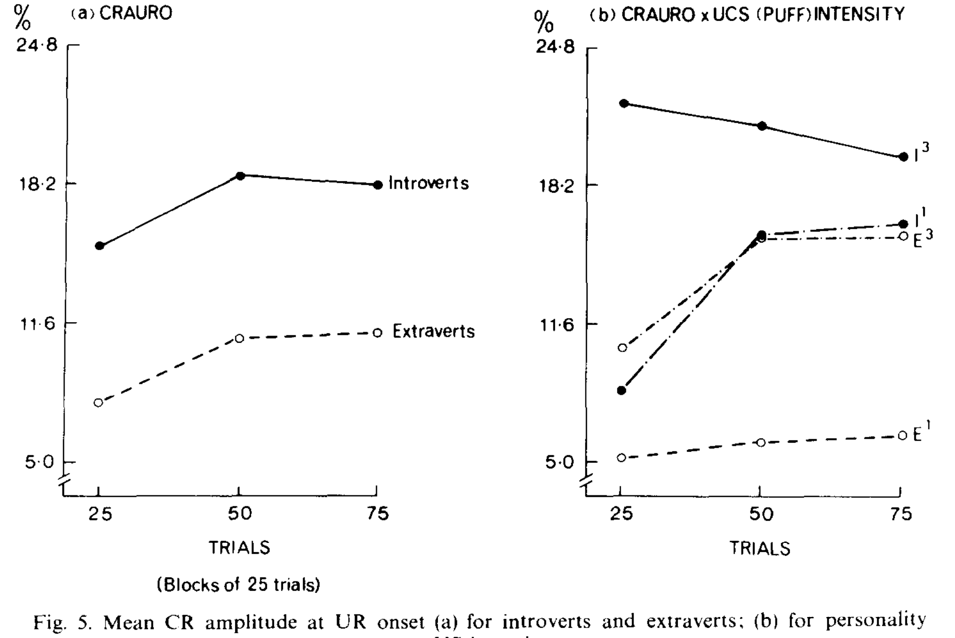

Fig. 5. Mean CR amplitude at UR onset (a) for introverts and extraverts; (b) for personality × US intensity.

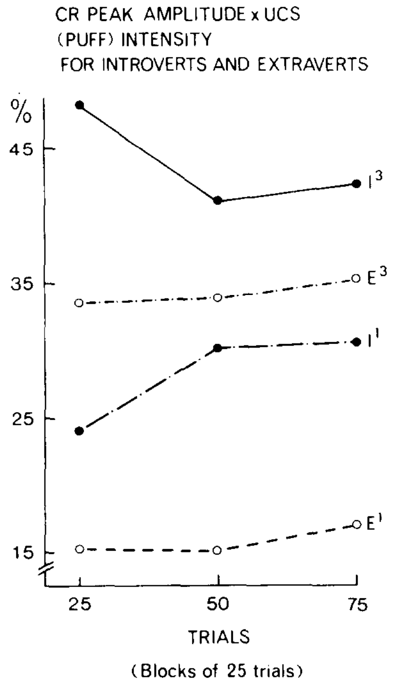

Fig. 6. Mean peak CR amplitude for personality × US intensity.

under certain conditions, or that the difference between the groups would be less than it was on the WR % and UR % measures.

The results of the present experiment show that, in fact, introverts were generally superior to extraverts in terms of the response area and DA amplitude measures. The extraverts, however, had lower DALs which indicates superior avoidance in terms of early placement of the CR (this trend was reflected in the CROL and CRPL measures also). On the whole, however, the introverts displayed a superior avoidance (apart from CR placement) compared to extraverts, under the conditions of this study.

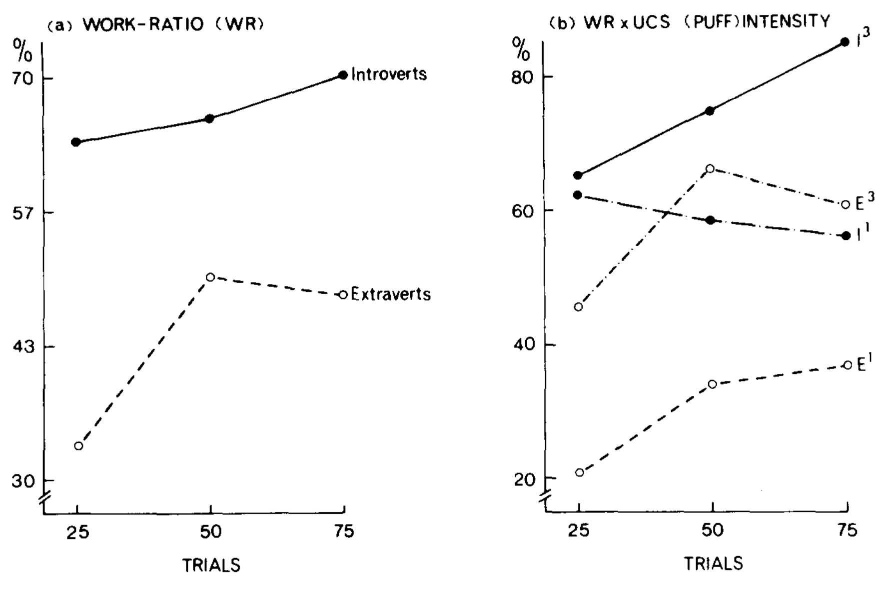

Fig. 7. Work-ratios (%) (a) for introverts and extraverts; (b) for personality × US intensity.

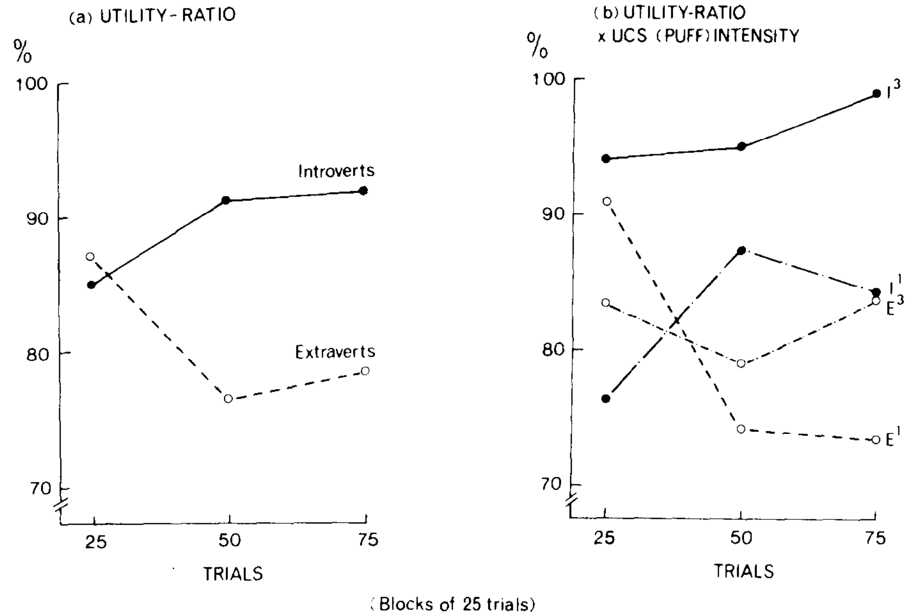

Fig. 8. Utility-ratios (%) (a) for introverts and extraverts; (b) for personality × US intensity.

A summary of the main differences between introverts and extravert groups is given in Table 6. It is apparent from this that introverts were generally superior to extraverts in frequency of responding, magnitude of CRs, efficiency and avoidance.

It was noted that the conditions of the present experiment generally favoured introverts, so that the considerable inferiority of the Es is not unexpected. It is possible that under conditions favouring extraverts, the latter might display superior performance both in terms of CR frequency and efficiency. It may be that extraverts would only reveal a tendency to greater avoidance under conditions where efficiency and avoidance were possible alternative end-points, but where conditions are so little conducive to conditioning, there results an overall depressed level of performance. When considering individual

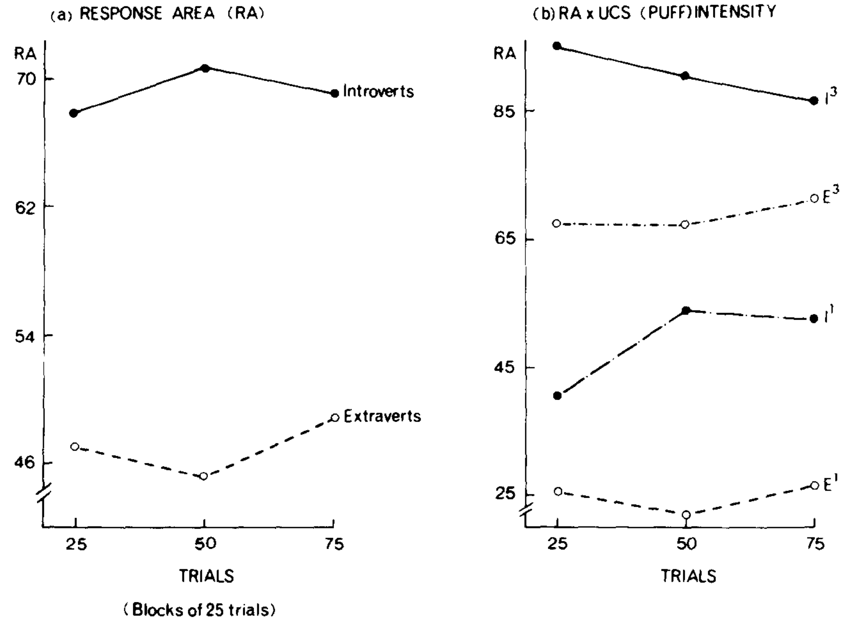

Fig. 9. Response area (a) for introverts and extraverts; (b) for personality × US intensity.

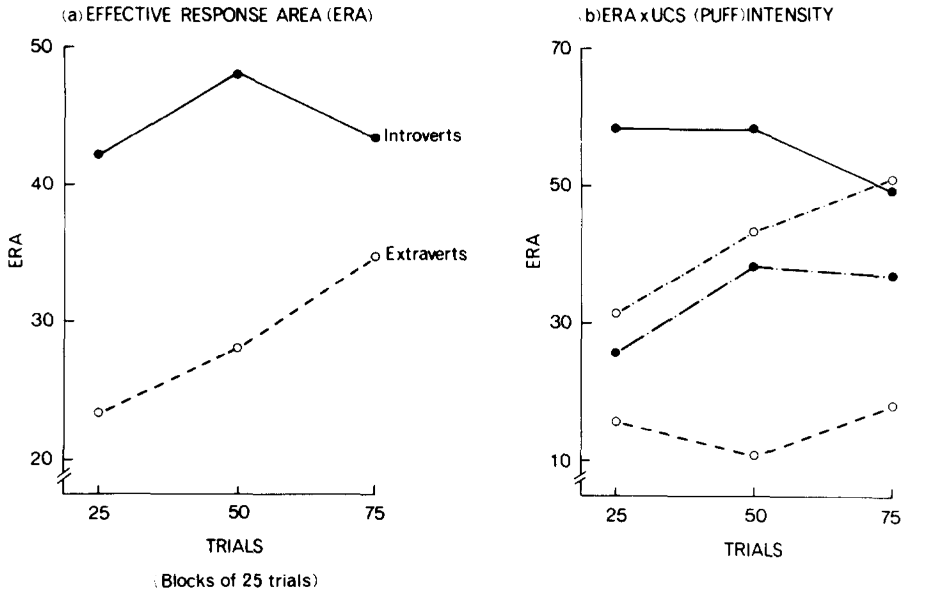

Fig. 10. Effective response area (a) for introverts and extraverts; (b) for personality × US intensity.

differences in conditioning, therefore, it is necessary to balance conditions such that optimisation of alternative end-points becomes a possible 'choice' for the S; under these conditions, any difference in strategy of responding would be more likely to emerge.

E. Intercorrelations between the measures of performance

Correlation coefficients were computed for all subjects ($N = 104$) between the measures on all three blocks of trials. Seven measures at a time (drawn from the basic response elements and composite measures) were intercorrelated. This limitation on the number of intercorrelations resulted from the practical consideration of job size of the

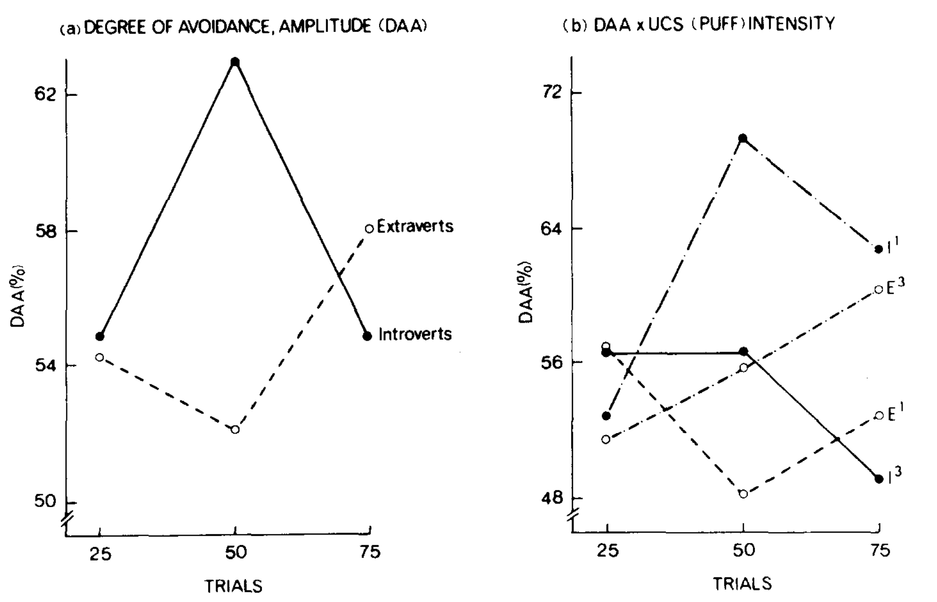

Fig. 11. Degree of Avoidance Amplitude measure (%). (a) for introverts and extraverts; (b) for personality × US intensity.

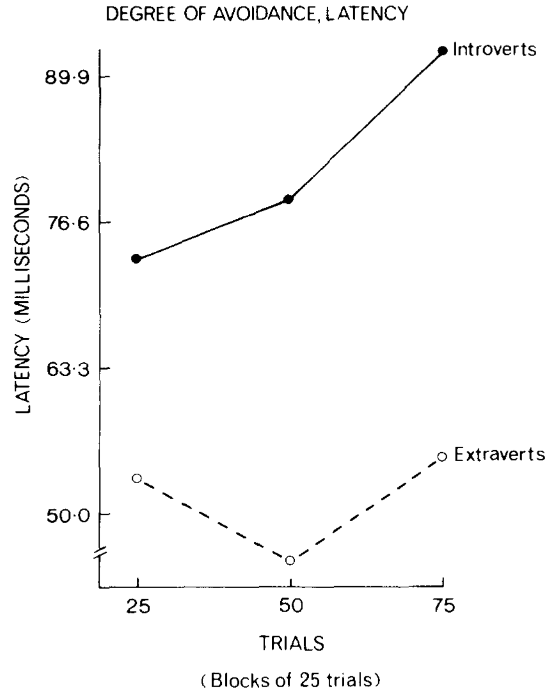

Fig. 12. Degree of Avoidance Latency (ms) for introverts and extraverts.

computer program package (multivariance, version 5) by means of which the intercorrelations were obtained. Mean levels and linear trends of the measures on the three blocks were entered into the computation. Thus, with seven measures at a time this yielded a 42 × 42 correlation matrix (2 estimates × 3 blocks × 7 measures). It is obviously desirable that all the measures be intercorrelated with each other, but the present results nevertheless yield considerable information worthy of discussion at this stage.

The three sets of intercorrelations (7 measures at a time) are given in Table 7, 8 and 9. Rather than discuss the correlations individually it is deemed more fruitful to pick out certain issues concerning the mooted relationships between the measures and to discuss the present results in the light of these.

Table 6. Summary of differences between the introvert (I) and extravert (E) groups

Measure	Blocks			Implication
CRFr.	1	2	3	Higher response production in Is
ORFr.	1	2		L Higher orienting response production in Is
CROL				NS
CRPL		2	3	Better placement of CR in Es
UCROL	1		3	Lower UCR latency in Es
UCRPL				NS
CRAUSO	1	2		Higher amplitude (magnitude) CR in Is
CRAURO	1	2	3	Higher amplitude (magnitude) CR in Is
CRPA		2	3	Higher amplitude (magnitude) CR in Is
UCRPA			3	Higher amplitude UCR in Is
WR %			3	Greater CR/UCR integration in Is
UR %		2	3	Greater efficiency (utilization of CR) in Is
RA		2	3	Greater 'coverage' of events in Is
ERA	1	2		Greater effective 'coverage' of events in Is
CRSI.				NS
UCRSI.				NS
SIR.				NS
DAA		2		Greater avoidance in Is
DAL		2	3	Greater avoidance (latency) in Es

Table 7. Intercorrelations: $r = 0.20$ ($p < 0.05$), $r = 0.27$ ($p < 0.01$)

Variables: Blocks of trials:	ORF 1	ORF 2	ORF 3	CROL 1	CROL 2	CROL 3	CRAUSO 1	CRAUSO 2	CRAUSO 3	UCROL 1	UCROL 2	UCROL 3	CRAURO 1	CRAURO 2	CRAURO 3	DAL 1	DAL 2	DAL 3
ORFr.																		
CROL	+0.04	−0.13	−0.22															
CRAUSO	+0.10	+0.27	+0.28	−0.09	−0.20	−0.28												
UCROL	+0.03	+0.25	+0.20	−0.02	−0.15	−0.06	+0.60	+0.42	+0.34									
CRAURO	+0.17	+0.31	+0.30	+0.02	−0.14	−0.22	+0.76	+0.87	+0.77	+0.51	+0.47	+0.27						
DAL	−0.04	−0.05	−0.14	+0.34	+0.31	+0.31	+0.02	+0.19	−0.01	+0.10	+0.14	+0.07	+0.19	+0.32	+0.25			
CRF	+0.19	+0.32	+0.11	+0.21	+0.05	+0.05	+0.48	+0.51	+0.42	+0.44	+0.39	+0.30	+0.62	+0.55	+0.44	+0.25	+0.35	+0.24

Table 8. Intercorrelations: $r = 0.02$ ($p < 0.05$); $r = 0.27$ ($p < 0.01$)

Variables: Blocks of Trials:	CRPL 1	CRPL 2	CRPL 3	CRPA 1	CRPA 2	CRPA 3	UCRPL 1	UCRPL 2	UCRPL 3	UCRPA 1	UCRPA 2	UCRPA 3	WR 1	WR 2	WR 3	UR 1	UR 2	UR 3
CRPL																		
CRPA	+0.33	+0.41	+0.39															
UCRPL	+0.19	+0.14	+0.11	+0.16	+0.04	−0.09												
UCRPA	−0.09	+0.07	+0.14	+0.74	+0.78	+0.64	+0.21	+0.12	−0.03									
WR %	+0.21	+0.28	+0.50	+0.30	+0.21	+0.55	−0.02	−0.03	−0.03	+0.04	−0.01	+0.13						
UR %	+0.34	+0.57	+0.60	+0.06	+0.06	+0.18	+0.14	+0.02	+0.05	−0.14	−0.06	+0.07	+0.08	+0.09	+0.51			
CRF	+0.38	+0.42	+0.37	+0.20	+0.25	+0.30	+0.06	−0.01	+0.04	−0.06	−0.02	+0.17	+0.34	+0.33	+0.60	+0.21	+0.30	+0.28

Table 9. Intercorrelations: $r = 0.20$ ($p < 0.05$); $r = 0.27$ ($p < 0.01$)

Variables: Blocks of Trials:	RA 1	RA 2	RA 3	ERA 1	ERA 2	ERA 3	CRS1. 1	CRS1. 2	CRS1. 3	UCRS1 1	UCRS1 2	UCRS1 3	SL.Rat. 1	SL.Rat. 2	SL.Rat. 3	DAA 1	DAA 2	DAA 3
RA																		
ERA	+0.84	+0.90	+0.92															
CRS1.	+0.67	+0.74	+0.57	+0.69	+0.60	+0.52												
UCRS1.	+0.51	+0.72	+0.64	+0.61	+0.75	+0.70	+0.62	+0.69	+0.44									
SL. Ratio	−0.01	+0.02	−0.12	+0.15	+0.16	+0.01	+0.10	+0.14	+0.07	+0.07	−0.05	−0.07						
DAA	−0.12	−0.09	−0.05	+0.13	+0.21	+0.21	+0.09	−0.16	+0.03	−0.02	+0.06	+0.13	+0.30	+0.34	÷0.32			
CRFr.	+0.24	+0.32	+0.33	+0.33	+0.42	+0.36	+0.09	+0.07	+0.12	+0.16	+0.24	+0.29	+0.70	+0.46	+0.44	+0.27	+0.30	+0.24

The question of the degree of relatedness of the various measures poses a considerable problem since there is little systematic evidence from previous studies which have generally opted for one measure in particular (usually CR frequency) to the exclusion of others. An exception to the rule is the work of Humphreys (1943), who carried out a factor analysis on several measures of conditioning (trials to criterion, amplitude, latency, magnitude and frequency). He obtained two factors, one determined primarily by acquisition latency, extinction frequency and latency in extinction. The second factor was determined by acquisition amplitude, extinction amplitude and magnitude of the response to the air-puff. Thus, there would appear to be two main factors relating to amplitude or to latency of the response. Prescott (1964) carried out a more comprehensive analysis on various electrodermal measures of conditioning, and confirmed Humphreys' finding of the relative independence of latency and amplitude, and reported a closer relationship between frequency and latency rather than amplitude of responding.

The Humphreys' study is limited in so far as it employed relatively few measures of conditioning, some of which are of doubtful consistency and reliability (e.g. CR onset latency). The present study used 10 basic response elements and 9 derivations of these, which should afford a far more comprehensive description of the response waveform. Some sort of principal components analysis or factor analysis is desirable in the long run, but for the present a discussion of correlations between the measures could be suggestive of their relatedness.

Correlations between 'related' measures

Some measures are highly related in so far as they estimate similar aspects of the response or use substantially the same response elements in computing a composite measure of performance. Thus CRAUSO and CRAURO were highly correlated in all three blocks of trials, as indicated in Table 7. These measures are estimates of CR amplitude at UCS onset and UCR onset respectively, which are amplitude points on the response separated by less than 100 ms on average.

Table 9 shows that response area (RA) and effective response area (ERA) were highly correlated as might be expected, since they reflect the coverage of events to a general or more specific degree and use basically the same elements in their derivation.

The correlations between CR slope and the response area measures were very high, as indicated in Table 9. The reason for this may be less obvious than is the case of measures using similar elements in their computation. However, assuming that CROL and CRPL remain relatively constant, it is evident that a more rapid closure of the eye (i.e. steeper response slope) will result in a greater area being subsumed between these points. Evidence has been presented elsewhere that CROL shows inconsistent changes over trials whilst CRPL tends to get longer over trials (Jones, 1975). Thus the correlations between these elements might be expected to be attenuated.

Correlations between 'unrelated' measures

Correlations between various estimates of the UR and other measures of the CR might be expected to be low on *a priori* grounds, and this was true of the present findings. Thus, UCROL and DAL were not significantly correlated, and UCRPL yielded low correlations with the WR % and UR % measures (Table 8). Again, UR slope showed little or no relation with DAA as shown in Table 9.

From previous work it might be expected that amplitude and CR latencies would be relatively independent, but this was not the case in the present study. Table 7 shows that CROL and CRAUSO were correlated in blocks 2 and 3, and CROL and CRAURO were significantly related in block 3. Examination of the group mean shows that a low CROL was associated with higher amplitude estimates of the CR, which indicates a 'shift' backwards of the CR rather than a lower slope or longer duration of the response.

Martin and Levey (1969) suggested on the basis of their investigations that CR frequency might be an aspect of CR production which is relatively independent of other descriptive parameters of the CR such as amplitude, latency or efficiency. If CR frequency is completely independent of the other parameters it might be expected that the correlations between them would be low and generally non-significant.

The present results indicate that most of the measures did, in fact, correlate with CR frequency. Table 10a shows the measures that correlated most highly ($r > 0.4$) with frequency; Table 10b outlines those measures that were significantly correlated with frequency but which were relatively low ($r > 0.2$); and Table 10c gives the measures which yielded very low correlations with frequency. Thus, in practice and within the context of the present study, CR frequency appears to be correlated with a substantial number of other parameters of the CR.

Table 10. Level of intercorrelations between CR frequency and other measures

(a) Measures highly correlated with CR frequency ($r > 0.40$)
CRAUSO
CRAURO
Slope Ratio
UCROL
WR %
ERA
(b) Measures showing significant (but relatively low) correlations with CR frequency (r 0.20 < 0.30)
OR frequency
DAL
UCRSI
UR %
RA
DAA
(c) Measures showing low and generally non-significant correlations with CR frequency ($r < 0.20$)
CROL
UCRPL
UCRPA
CR slope
CRPA

Though a large number of measures were correlated with frequency, the r's in general were rather low. Of the seven measures which yielded the highest correlations, most were around 0.4, which only accounts for 16% of the variance associated with the measurement. Thus it is meaningful to consider frequency as being on a dimension relatively independent of indices of magnitude or efficiency of the CR. It is clearly necessary systematically to partial out the dependencies of the measures and to clarify the relationships between them but the precise means by which this can be achieved is a matter for further exploration.

It is noteworthy that two highly related measures such as the RA and ERA were correlated to different degrees with CR frequency. Table 9 shows that the correlations between frequency and ERA were relatively higher than those between frequency and RA in the three blocks of trials. Thus, effective coverage of events would appear to be more dependent on the number of CRs than the total 'size' or area of the response as represented by the RA measure.

The correlations between the work-ratio and CR frequency were significant but low in blocks 1 and 2 and high in block 3 ($r = 0.60$). The WR measure, it will be remembered, shows a positive linear increase over trials and attained an optimal level only in the later series of trials, so that it is to be expected that the correlation with frequency would be higher in the third block of trials.

The estimates of slope of the response (CR slope, UR slope, and slope-ratio) showed some interesting relationships with CR frequency. Table 9 shows that CRSL and UCRSL were highly correlated, but that their ratio (slope-ratio) was lowly correlated with each. CR slope yielded many low *r*'s with CR frequency, whilst UR slope gave significant but relatively low correlations with frequency in blocks 2 and 3. Slope-ratio, however, was highly correlated, especially in block 1, with CR frequency. Thus, it would appear that though neither CR slope nor UCR slope on its own is dependent on frequency, the ratio of the two *is*! A possible explanation for this might be seen in the relative degree of blending of the CR and UR as a function of CR frequency. It is commonly observed that early in the acquisition series two distinct responses (CR and UR) are given, but that later in the series the CR and UR blend to a certain degree until only one response (labelled 'the CR') is given. This observation was confirmed in the present study where the CR was found to move forward and the UR backwards over trials. It was also found that UR slopes were much higher than CR slopes in the initial blocks of trials, but the difference was lower in the final block. Thus CR slope and UR slope appear to get progressively more alike (i.e. UR slope drops to the lower level of CR slope).

It would appear that UR onset latency is being pulled backwards towards the CR but that UR peak latency remains relatively stable. The result of this is evidently to lower the slope of the UR, so that the degree of interdependence of CR slope and UR slope increases later in the acquisition series as a function of the number of responses given.

DISCUSSION

One of the general questions which the study posed was whether composite measures of response topography add any additional information to the understanding of eyelid conditioning in the context of the variables included in the design. The answer to this question must be in the affirmative, but it is also true that the approach introduces many additional problems of interpretation since it goes beyond the traditional concepts employed previously.

It has been seen that the US intensity, rest-pause, warning signal, and personality differences produced complex differences in the behaviour of the composite measures of conditioning but with few clear-cut general effects. A high US intensity produced considerable differences in avoidance and response as compared with a low US intensity, whilst an early rest-pause produced an increase in degree of avoidance amplitude and latency. These findings emerged in the context of a myriad other findings, however, which are very likely a function of the number and complexity of variables involved in the design. Thus, though it was confirmed that extraverts conditioned very poorly at a low US intensity, they showed considerably better 'placement' of the CR in relation to the US compared with introverts under the same condition. It is clear that the approach is very much in its infancy and improved methods of measurement are likely to increase its efficacy.

It may be of value to consider some of the general issues raised by the study concerning the specific variables included in the experiment. It is evident that conditioning to quite a high level was attained even at the very low US intensity value of 1 p.s.i. This tends to confirm the findings of the Kimble *et al.* (1966) and the Leonard *et al.* (1967) experiments and also identifies adaptation of the UR as a factor related to strength of the US.

The contention of Suboski (1967) amongst others that removal of 'non-conditioners' and high-adaptation-level Ss would considerably reduce the asymptotic differences produced by different US intensities did not become a serious issue in this study. There were virtually no non-conditioners as such, and the removal of the few low level performers would not have significantly altered the results.

Turning to the effects of interpolating a rest-pause in acquisition, it is evident that this had a considerable effect on conditioning performance. It was seen that an early rest especially produced considerable differences in terms of several of the measures. Little interpretation of the results in the context of previous work is possible because of the conceptual and methodological difficulties associated with these. The present study may be of some value, though, in that it has clarified to some extent some of these difficulties.

It would appear that there is no neat explanation of the rest-pause effects obtained in the present experiment to be gleaned from the various theories of reminiscence. It was found that the early rest had a greater overall effect on conditioning performance than the late rest; however, explanations of improved performance invoking concepts such as reactive inhibition would suggest that the greater amount of pre-rest practice given to the late rest group should produce greater performance increments following the rest.

The data of the present experiment relating to the effects of presenting a warning-signal in the conditioning series indicated that presence of the WS generally enhanced early conditioning (increased amplitude, greater efficiency and avoidance) for the first 25 trials but produced no overall differences later in acquisition. Explanations of the role of a WS in conditioning have been rather weak, possibly because of the considerable contradictions found in different studies of its effects. Findings of inhibition of performance by inclusion of a WS have opted for some such explanation along the lines of inhibition of the tendency to respond to the CS by a perseverating tendency to respond to the WS (e.g. McAllister and McAllister, 1960a,b). Explanations of the positive or enhancing effects of a WS have invoked concepts such as increased drive or 'arousal' as a function of the attention demanding properties of a WS.

It would seem reasonable to suggest that the presentation of a WS would increase the alertness of the S and thereby increase performance, but the present schedule required fixation of a continuous red-light even in the no warning-signal group, and this in itself would demand a high level of attention and a resulting higher level of 'arousal' than if no fixation light at all were used. Future experiments might fruitfully attempt to introduce a less attention demanding control that would nevertheless meet the technical requirement of eliminating gross eye-movements—possibly through instruction to look straight ahead at a blank screen and to avoid looking around the test room. The switching on and off of the red fixation light in the WS condition, however, did appear to produce some greater reaction in the Ss given this procedure. Thus, occasional blinks to the WS and an apparent movement of the eyes might indicate a 'startle' response which might increase arousal. Even so, it is surprising that the WS produced such a strong initial effect, and it appeared to affect the efficiency as well as the probability of responding.

Another question that might be asked of the data is why the effect of presenting the WS died out after the initial trials. One possible reason for this might be that the subjects adapted to the onset of the WS after 20 or so trials with a consequent reduction in their level of arousal which reduced their conditioning performance. Such a 'blanket' explanation is not very satisfactory, however, and a thorough approach to the problem would require a much more detailed examination of the concomitant changes due to the WS accompanying changes in conditioning performance (e.g. recording of electrodermal and other physiological changes) than was possible in the present experiment.

The present study provides striking evidence for the hypothesised differences in conditioning due to degree of extraversion. It will be recalled that introverts were superior to extraverts on almost all the indices of conditioning used. One exception to this was the DAL measure indexing the placement of CR peak amplitude relative to US impact. The extraverts displayed consistently better placement of the CR in these terms, but the frequency, magnitude and efficiency of their responses were considerably inferior. This may suggest that the better placement of the CR in extraverts was a compensatory strategy, i.e. they made the best possible use of their inferior CRs by optimising their placement to achieve at least a partial avoidance of the air-puff.

The measure which showed the greatest difference between the I/E groups was CR frequency. This was true of the total group and the reduced groups of extreme scorers. One possible conclusion that might be drawn is that extraverts, under certain conditions, are relatively worse at CR production (the final stage in the Martin–Levey model of conditioning) compared with the registration and formation stages of conditioning. There is insufficient evidence from this and previous studies to make this more than a tentative suggestion, however. CR production may be dependent to some degree on the prior stages of conditioning, but the relationship may not be the same for the different personality groups. Thus, it may be that extraverts would require a considerably higher degree of CR formation than introverts before the response appears in overt behaviour. The evidence for higher sensory thresholds in extraverts makes it quite plausible that they have higher thresholds for emergent response patterns. Again, one of the suggested factors that determines CR production is the relative degree of 'arousal', and it is likely that the extraverts, because of their higher thresholds, were at considerably lower levels of arousal. There was strong evidence that the extraverts (especially those given the 1 p.s.i. US) showed continued adaptation throughout the acquisition series as indicated by their lower UCR peak amplitudes. Thus, though there may well be some conditioning taking place in the extraverts, this is unlikely to emerge until conditions are salient enough to trigger the acquired responses. Whilst this may be true it is also evident that the degree of CR formation achieved by extraverts never attained the level reached by the introverts under the conditions of the present experiment. In general, the notion here is that introverts and extraverts differ both in terms of their *learning* processes *and* the mechanisms determining performance.

One of the findings of interest in the present study was that pertaining to the analysis of response slopes. Three measures were developed initially; CR slope, UCR slope and slope-ratio. It was found that the ratio of the slopes (CR SL)/(UR SL) tended to increase as a function of the number of acquisition trials given. It is suggested that this indexed the gradual blending of the CR and UR into one response as a function of practice.

The slope-ratio measure as interpreted above rests on the assumption that the UR slope is always greater than the CR slope, which is reasonable on *a priori* grounds. Visual examination of records and a comparison of raw scores (slopes of the CR and UR on a trial by trial basis) indicated that the reflex blink to the air-puff (UR) had a considerably higher rate of closure (slope from onset to peak of the response). Some pilot experiments suggested, further, that voluntary closure of the eye (in response to CS) yields a considerably lower slope than that attained by a reflex blink, though generally higher than that of a CR. A slope-ratio measure, based on the averaged values of the first five URs (Hartman and Ross, 1961) in order to identify voluntary (V-form) responding has been frequently used in eyelid conditioning studies, but has the disadvantage that it is limited to categorising subjects as either V-responders or not. If the measures described above can be satisfactorily developed they will afford a method of tracing the development of V-form responding throughout the acquisition series.

In sum, we may say that the major predictions that can be made from Eysenck's (1967) theory have been verified. Introverts are superior to extraverts on nearly all measures of conditioning, and this superiority is almost exactly equal to that of a high intensity US (3 p.s.i.) to a low intensity US (1 p.s.i.). With much higher intensity USs we would of course expect a reversal, due to Pavlov's law of transmarginal inhibition (Eysenck and Levey, 1972), but below that point extravert–introvert differences should mirror low intensity–high intensity differences. This parallel was apparent across parameter changes in rest-pause placement and warning signal programming. No correlations were observed between conditioning and the personality traits of neuroticism and psychoticism; this is in line with previous work when experimental conditions are not threatening or anxiety provoking (Levey and Martin, in press).

The experiment extends the empirical basis of the theory into response areas not previously investigated, and indicates that the conditioning superiority of introverts is not confined to the variable of response frequency examined in earlier studies. Under conditions of low to optimal arousal it is clear that factors of stimulus processing, stimulus and response integration and the adaptive integration of response elements tend in general to favour introverts. Elaboration of the extended theoretical framework which these results imply is not justified at this point on the basis of a single experiment, particularly in the face of the complex interactions which were found. This task must wait upon further experimentation and is reserved for the future. Two experiments are nearing completion in our laboratories and it is our hope that other investigators will be stimulated to pursue this promising line of investigation.

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