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SALIVARY RESPONSE TO LEMON JUICE AS A MEASURE OF INTROVERSION

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Summary.—50 men and 50 women were administered the EPI and tested with respect to the increment in salivation produced by putting 4 drops of pure lemon juice on the tongue for 20 sec. It was found that in both groups introversion correlated approximately 0.7 with increase in salivation; there was no correlation with neuroticism. When a commercial product was substituted for pure lemon juice, all correlations became insignificant, possibly due to the weaker concentration of the product. The results are explained (and were predicted) in terms of an hypothesis relating introversion to cortical arousal.

The hypothesis has been put forward (Eysenck, 1963, 1964, 1967) that introverts are characterized by a state of higher cortical arousal; it appears that there is both direct evidence, e.g., from EEG studies (Savage, 1964; Marton & Urban, 1966) and indirect evidence (Eysenck, 1967) to support this notion. One deduction from such an hypothesis would lead one to expect that under conditions of equal stimulation effector output would be greater for introverts than extraverts. Several studies have in fact verified this deduction, among them an experiment by Corcoran (1964) in which he showed that salivary output of introverts in response to stimulation by four drops of lemon juice placed on the tongue was significantly greater than salivary output by extraverts. This interesting study is suggestive rather than conclusive because of the small number of *Ss* employed (two groups of 11 and 12 *Ss*, respectively, were used) and because of the uncertain status of the personality inventory used (the Heron two-part personality measure). Furthermore, the correlations found (0.62 and 0.70 for the two groups, using Kendall's *tau* and Spearman's *rho*, respectively) are unusually high for physiological measures when correlated with personality variables. In addition, Corcoran failed to find any differences between introverts and extraverts when using citric acid instead of lemon juice, although this stimulant was as effective as lemon juice in promoting salivation. In view of all these possible criticisms it seemed desirable to repeat Corcoran's study with adequate numbers of *Ss* and with a more widely recognized measure of personality.

First Experiment

Subjects

Fifty male and 50 female volunteers, paid for their services, constituted our sample; these *Ss* had come to the laboratory for the day in order to carry out a

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variety of experimental studies and knew nothing about the purpose of this experiment. Ages ranged from 20 to 40, with the mean slightly below 30; most were employed (in the case of the men) or housewives (in the case of the women). Few were students. All had been given the EPI (Eysenck & Eysenck, 1964) routinely on entering the laboratory, and the tester did not at any time know the scores achieved. No measure of intelligence was given, but from previous testing of similar samples it was surmised that their IQ would have been around 110 on the average.

Procedure

The experimental procedure was adapted from that used by Corcoran. Standard cotton-wool dental swabs were used throughout. One of these was picked up with a pair of tweezers and placed on *S*'s sublingual salivary gland. It was removed after a period of 20 sec., placed in a class container and put aside. Another swab was then positioned, 4 drops of lemon juice dropped on *S*'s tongue, and the pad removed after 20 sec. and placed in another glass container. Both containers were then weighed with, and later without, the swabs inside, the difference constituting the score. The swabs were very uniform in weight, with a mean of .2134 gm. ($SD = .0001$ gm.).

Results

Mean salivation of the 100 *S*s in the experiment was 0.3091 gm. on the first trial, and 0.7541 gm. on the second trial, giving a mean difference score of 0.4450 gm. Extraversion and neuroticism scores were correlated with first trial salivation (without lemon), second trial salivation (with lemon), the difference between trials, i.e., additional salivation due to lemon juice and the ratio of first and second trial. The product-moment correlations are given in Table 1. It will be seen that men and women give very similar results, so that the combined correlations may be taken as representative. None of the correlations between salivation and N are significant, while all the relevant correlations with E are significant at the .001 level. Figures relating to the first trial indicate slightly greater salivation of the introverts; this may be due to the presence of the swab,

TABLE 1

PRODUCT-MOMENT CORRELATIONS BETWEEN E AND N AND AMONG FOUR SALIVATION SCORES

	E			N		
	Women	Men	Combined	Women	Men	Combined
First Trial	−.12	−.44†	−.24*	−.10	−.11	−.08
Second Trial	−.68‡	−.76‡	−.71‡	−.21	−.04	−.09
Difference	−.74‡	−.73‡	−.73‡	−.18	.00	−.06
Ratio	.44†	.62‡	.52‡	−.08	−.01	−.08

*$p < .05$. †$p < .01$. ‡$p < .001$.

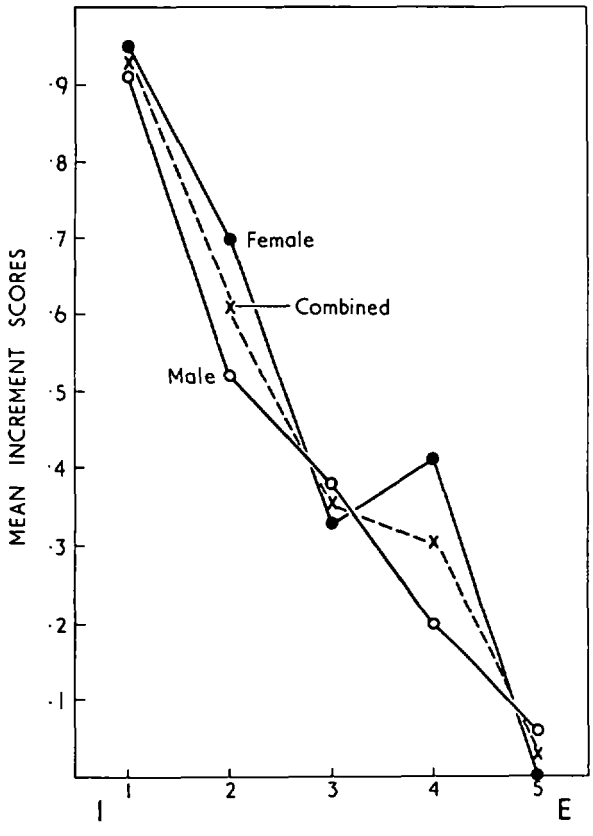

FIG. 1. Mean increase in salivation scores from Trial 1 to Trial 2 as a function of introversion-extraversion, for 50 males, 50 females, and the combined group

acting as an extra stimulus. The values for the second trial indicate that the presence of the lemon juice has stimulated introverts far more than extraverts. Correlations involving the difference between first and second trial are no higher than those involving the second trial alone; this suggests that the first trial might have been dispensed with. Ratios are less discriminative than are differences, or second-trial values by themselves; this is not surprising in view of the fact that first- and second-trial correlations are negative.

Inspection of the scatter plots failed to suggest any departure from linearity of regression. Fig. 1 shows the relation between extraversion and difference (mean increment) scores in diagrammatic form. The E scores for males and females separately were arranged in order and divided into 5 groups from low to high; these 5 groups were numbered from 1 to 5 and are shown on the abscissa. Their mean increment scores are shown on the ordinate. Male Group 1 was then combined with female Group 1, male Group 2 with female Group 2,

and so forth up to male group and female Group 5; these constitute the combined groups in the figure. It will be seen that there is a very regular progression of incremental scores with greater introversion, and it will also be seen that sex differences are quite small; none were in fact statistically significant. Our results, therefore, are in good agreement with those reported by Corcoran (1964).

Second Experiment

Method

Corcoran (1964) reported high reliabilities for the test, although it is not clear from his paper whether these apply to first testing, second testing, or both. In any case, his *Ss* were small in number ($N = 11$). It seemed desirable to carry out another study to investigate the retest reliability of the procedure. Twenty-four *Ss*, similar in every way to those described in connection with the first experiment, were tested twice, with a period of exactly 24 hr. intervening.

Results

Product-moment correlations were calculated and gave the following results: for the first trial $r = 0.33$; for the second trial $r = 0.71$; for the mean difference scores, $r = 0.60$. These values are rather lower than those reported by Corcoran and are if anything rather lower than the correlations between salivation scores and E scores. It is possible that here, as often in the case of psychophysiological measures, repetition introduces new variables which make the value of retest reliability determinations suspect. On the first occasion *Ss* did not know that they were to be given lemon juice, so that its administration may have had some shock effect; on the second occasion they did, of course, know what was coming, and this knowledge might have some effect on their behaviour. One might postulate that repeated administration could have the effect of conditioning *Ss* to think of lemons and imagine the administration of lemon juice even on the first trial of the second administration; this might be the case particularly with introverted *Ss* who have been reported to form conditioned responses more easily (Eysenck, 1967).

For the sake of completeness another experiment concerned with reliability should be mentioned, although this was planned rather as a trial run for the study just described. *Ss* were largely members and students in the Department, and it seemed likely that their knowledge of the properties of lemon juice and in some cases the purpose of the experiment would make their responses more variable than might be the case with naive *Ss*. This proved to be the case; for 25 *Ss* the product-moment correlations were as follows: for the first trial $r = 0.48$; for the second trial $r = 0.50$; for the mean difference $r = 0.47$. All these values are significant at the $p < .02$ level, but, except for the first, they are lower than those of the other reliability study. It is, of course, not known

whether the professional knowledge of many of these *Ss* was indeed responsible for these low reliabilities, or whether some other source was influential; it seems clear that further work on repeated administration of the test, directed at disclosing some of the reasons for its low reliability, would be in order. At the same time, it must of course be realized that lack of high retest reliability in a test does not prevent reasonably high validity of that test on the occasion of its first administration. Validity cannot exceed reliability only when the repeated administration of the test does not involve new factors working against the recurrence of identical scores.

Third Experiment

Method

Corcoran (1964) failed to find any relationship with E scores when using citric acid instead of lemon juice, and it seemed desirable to discover whether other substances than fresh lemon juice would have similar effects, or whether the effect was rather specific. The experiment described at the beginning of the paper was therefore repeated twice more, on samples of 27 and 20 *Ss* respectively, using a commercial preparation of lemon juice called "Jif," bottled in a plastic container resembling a lemon. This product consists entirely of pure lemon juice preserved with sulphur dioxide, 450 parts per million. The juice is of Mediterranean origin and appears subjectively weaker than the fresh juice used in Exps. 1 and 2, possibly because of dilution by the preservative.

Results

The two experiments with the "Jif" juice differed slightly one from the other. In the first, four drops were used and a 20-sec. period of measurement was retained; this experiment was an exact replica of the first (pure lemon) experiment. The product-moment correlation of the difference score with E was —0.02; none of the correlations of first or second trial with either E or N was significant. In the second experiment, 6 drops were used for a period of 30 sec., on the hypothesis that perhaps the "Jif" juice was weaker than fresh lemon juice and therefore had less effect. The correlation between difference score and E was again insignificant ($r = -.12$), as were all the other correlations with E and N. It does not seem that "Jif" juice produces the same effect as does fresh lemon juice, and in this respect it resembles citric acid. It is not at all clear why there should be such marked differences among substances superficially alike, at least as far as their taste and their salivation-instigating properties are concerned, and further work on the classification of such substances, and their relations with personality, is obviously required. Until this point is cleared up the value of the original hypothesis on which these studies were based must remain in some doubt.

Is the hypothesis tenable that perhaps the "Jif" juice was too weak to produce sufficient salivation to be effective? The mean increment in salivation

(difference score) produced by the pure lemon juice was .4450 gm. for the 100 *S*s of our first experiment; 4 drops of "Jif" on the tongue for 20 sec. produced .2372 gm. of saliva, and 6 drops of "Jif" on the tongue for 30 sec. produced .4354 gm. For the 20-sec. group the hypothesis of too weak a solution might thus be tenable; for the 30-sec. group the position is not altogether clear. *Total production* of saliva due to extra stimulation is equal to that of the pure lemon group, but *rate of production* of saliva is, of course, only ⅔ as great, as equal amounts are produced over a period 50% longer. If rate is the crucial variable, then weakness of the solution may be the correct explanation of our data. This explanation would not, however, apply to Corcoran's citric acid data, where salivation produced appears to have been just as strong over unit time as when pure lemon juice was used.

Discussion

The data are too straightforward to require much discussion. Our results bear out Corcoran's findings and demonstrate that introverted *S*s react more strongly with salivation to stimulation of the taste buds with pure lemon juice; they also tend to show a marked similarity of reaction in men and women, and a linear regression over the whole range of extraversion scores. The correlations are remarkably high, even higher than Corcoran's, possibly due to the fact that a better measure of extraversion was used in our studies. As our study was in many ways a replication of his (in fact a double replication, as we used two independent samples, one of men, the other of women), and as he replicated his original findings himself, there seems to be little doubt that the findings are not a chance effect but deserve to be taken seriously. As a personality measure this test has many obvious advantages; it is objective, quick, easy to perform, and has low visibility, in the sense that few *S*s would guess the purpose of the procedure, which could be incorporated with medical checks or other procedures. Another advantage seems to be that it is quite independent of neuroticism and may thus be regarded as a relatively pure measure of extraversion-introversion.

It should perhaps be emphasized that the technique of administration of the test, although not difficult, has to be learned. *S*s have to be taught to curl their tongues upward, so that the drops of lemon juice do not roll off; swallowing the juice during the experiment produces interesting effects (Eysenck & Eysenck, 1966) but ruins the measurement of personality. Care has to be taken to avoid mentioning the word "lemon" or leaving actual lemons visible in the room. A very accurate chemical weighing scale is required, and the routine of weighing practiced. Swabs have to be inserted accurately and quickly, and timing has to be accurate in spite of preoccupation with other activities, such as inserting the swab, etc. Utmost precision is required because of the very slight differences in weight with which one is dealing. Disturbing influences have to be kept to a minimum, as spatial inhibition (Eysenck, 1957) is very powerful in reducing salivary secretion (Eysenck & Yap, 1944). Care has to be taken

that the swabs used are nearly identical in weight. It is only when all sources of error are carefully removed that experimental results can be replicated.

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