CONDITIONING OF PATELLAR REFLEX AS A FUNCTION OF ANXIETY: AN EXPERI- MENTAL INVESTIGATION

ASHOK NAGPAL AND ANIMA SEN

Department of Psychology, University of Delhi

An attempt towards exploring the relation between level of anxiety and the classical defense conditioning rate of much-neglected patellar reflex, materialised in the form of present biphasic experimental investigation. The IPAT Anxiety Questionnaire Scale was administered to 90 university male students and out of the total range of raw scores obtained thereby, 32 students, half each from the 2 poles of high anxiety (Percentile Range: 89-97) and low anxiety (Percentile Range: 8-33) were sorted out to undergo the single-session experiment; the data being collected in a 2 (manifest anxiety levels) $\times$ 2 (differential instructions) factorial design by employing Purdue knee-reflex apparatus. The findings of the acquisition phase indicated a significant pacing up of the conditioning rate under the impact of high anxiety and anxiety-orienting instructions, independently. Another measure in the same phase, namely, amplitude of the knee-reflex was significantly higher in the highly-anxious subjects as compared to their lowly-anxious counterparts. Analysis of the data of a transient extinction phase revealed that anxiety, be it manifest or induced, did not have any influence over either of the 2 aforesaid measures.

Literature is replete with investigations probing the impact of anxiety over the conditioning of various reflexes; prominent amongst them being eye-lid reflex. Tracing the course of development of interest in this field, one perceives a rapid process of change undergone by the theoretical dispositions, mainly as a result of supplementation of knowledge from the field of physiology (Tuttle & Schotellius, 1969; Miller & Leavell 1972). The ironical aspect of this course is that patellar reflex or knee-jerk has lagged far behind its sister-reflex—the eye-lid reflex, in receiving the attention of psychologists. Undoubtedly, two reflexes differ in terms of activity levels of the background from which they emerge, having different adaptive functions and in a number of other features, nonetheless they have a striking similarity in being controlled by the somatic nervous system—SNS. The void in literature is evidenced when one fails to find any systematic follow-up of Schlos-

berg's thorough investigation dating way back to 1928. Thereafter, Courts (1939) has studied patellar reflex as a measure of muscular tension. Much-desired revival of scientific interest in this area has been the aim of the present research work.

As pointed earlier also, number of research works have been carried out in the domain of classical defense conditioning of eye-lid reflex (Taylor, 1951; Spence & Taylor, 1951; Spence & Farber, 1953; Spence & Taylor, 1953; Baron & Connor, 1960; King & Kimble, 1961; Gorman & King, 1961; Spence & Goldstein, 1961; Ominsky & Kimble, 1966), which lean heavily upon the Hullian theory of learning (1939). Undoubtedly, this theory has regressed from the zenith of an empirical acclaim to the extent of being almost outmoded in the face of innumerable experimental findings in this field (Marx, 1970), nevertheless the above-mentioned references point towards the direction that the motivational factors identified by Hull

could perhaps be gainfully applied to a classical conditioning set-up. Therefore, from Hullian proposition (1943) which states that Habit Strength (H) and Drive (D) interact multiplicatively to determine the strength of the Learnt Response (R), an analogy was deduced that acquisition of conditioned patellar reflex would be a function of drive level. Furthermore, as an inference from a theory by Spence and Spence (1966) which counts upon a similar basic mechanism as proposed by Mowrer (1939) and Miller (1951) in connection with their work on acquired drive of fear, anxiety was presumed to be the major underlying factor directly contributing towards different drive levels. Accordingly, the present study attempted to examine the facilitative influence of higher manifest anxiety levels on the acquisition of conditioned patellar reflex.

On parallel lines, it was hypothesised that experimentally-induced anxiety through instructions would also significantly augment the process of acquisition. Akin to the present experiment in major aspects, stand the prolific studies of Taylor and her associates (see Sanford & Capaldi, 1967) which have culminated in some fruitful findings on the conditioning of eye-blink reflex. Patellar reflex, although far more specific on stimulus-dimension of its elicitation (Martin & Levey, 1969), was assumed to exhibit a similar trend in the process of conditioning under the impact of anxiety variations. In this context, it is worth-mentioning that Schlosberg (1928) also observed a facilitation of acquisition asymptote of this reflex in "quick nervous" type of subjects.

Intending to extend the scope of the present investigation, a second measure, namely amplitude of the patellar reflex, in addition to number of trials, was also taken into account. Tuttle and Schotellius (1969) expound that conditions bringing about an elevation in the muscle tonus, such as mental excitement, hyperexcitability of the nervous system etc., also increase

the magnitude of the knee-jerk. Thus it is conceived that higher levels of manifest anxiety and anxiety-oriented instructions (independent of one another) would produce higher amplitudes.

METHOD

Design of the Study

Execution of two independent variables in the present study, namely (a) the manifest anxiety (drive) level of the subjects and (b) induced anxiety through instructions—necessitated its biphasic set-up. In the first phase called "Screening", the factor of manifest anxiety was tapped out at two different levels comprising of High-Anxiety Group and Low-Anxiety Group, through the administration of a questionnaire scale. These two groups were then subdivided into two each with comparable means (High-Anxiety Group—Mean Raw Scores: 46.25 and 45.00; Low-Anxiety Group—Mean Raw Scores: 21.87 and 21.50), to be randomly allocated to two different sets of instructions, one aimed at inducing anxiety in the subjects while another one designed to be neutral in its impact.

In the second phase of the study termed as "The Experiment", the resultant 4 subgroups (2 from the high-anxiety group and 2 from low-anxiety group) underwent the conditioning experiment in a 2×2 factorial design. Thus, with the factors of manifest anxiety and differential instructions at two levels each, four treatment conditions resulted such as: High Anxiety with Neutral instructions (HAN), High Anxiety with Anxiety-oriented instructions (HAI), Low Anxiety with Neutral instructions (LAN) and Low Anxiety with Anxiety-oriented instructions (LAI).

Screening

The IPAT (Institute of Personality and Abilities Testing) Anxiety Scale Questionnaire (Self-Analysis Form; Revised Form, 1963 with a supplement of 1967) designed by Cattell and Scheier (1963) was used which consists of 40 questions, each one of them having three alternative answers. The questionnaire was admin-

istered individually to each of 90 university male students (Mean Age 20 years ; Age-Range 17–24 years). On the basis of the raw scores obtained for the group collectively, two clusters of the individuals—one each at either end of high anxiety and low anxiety—were sorted out to act as subjects in the subsequent phase of experimentation.

It is worth mentioning that a peculiar trend was noted in the performance of psychology students on the questionnaire scale, in that, all of them (totalling 9) without any exception obtained very low scores. Moreover, voluntary stubbornness exhibited by a psychology student in the process of getting conditioned during one of the three preliminary investigations, buttressed the need of excluding such students from the experiment.

The Experiment

Subjects. Eventually 32 subjects from the previous phase, half each of which belonged to the two poles of High Anxiety (Mean Raw Score : 45.83 ; Percentile Range : 89–97) and Low Anxiety (Mean Raw Score : 21.73 ; Percentile Range : 8–33) respectively, were sorted out. As has been mentioned earlier, these two groups were then subdivided into two each for four experimental treatment conditions.

Apparatus. It chiefly comprised of Purdue Knee-reflex apparatus, bearing a hammer of Unconditional Stimulus (UCS) on it with a semi-circular scale showing its degree of fall and another vertical scale for recording the magnitude of the resultant knee-jerk in cms. The pointer of the latter scale is attached by means of a thread to a circular, extensible steel clamp which has to be fixed on the foot of the leg being struck with the hammer. A 220-volt buzzer served as Conditional Stimulus (CS). A Universal Timer was used to maintain the time-schedule of onset of CS, UCS and inter-trial lapse.

Procedure. Instructions had a very crucial role since in HAI and LAI conditions, anxiety levels were supposed to be elevated by threatening the subjects with an electric shock of considerable intensity which could be initiated any time during the experiment. Naked electric

wires running from a battery via a tapping key were fastened around the first and middle fingers of the left hand of subjects belonging to LAI and HAI only, so that they should anticipate the shock althrough. Under the control conditions of LAN and HAN, no such threat was given to the subjects.

After the requisite set of instructions had been given, the experiment started with a few practice trials of hammer blows on the bare knee-cap of the left leg. This step helped in the location of region and its consequent marking, minimising thereby the chances of it being missed by the hammer during the progress of the experiment. First of all, the buzzer (CS) was presented alone for five trials for a duration of 3 sec each, in a bid to ascertain its neutrality. After this, the paired presentations of buzzer and hammer blow began with the hammer following almost simultaneous to the finish of the buzzer which sounded everytime for 3 sec. The hammer was always lifted to a height of 60° on the scale, to maintain an optimum constant intensity of the blow with all the subjects. The amplitude of the knee-jerk was recorded against every trial from the vertical scale throughout the session. The inter-trial time-lapse was kept at 12 sec and after every 75 trials, a rest-pause of 3 min was allowed to the subject. In accordance with the unusually rapid decay of conditioned patellar reflex, as revealed in all of the preliminary investigations, the criterion of CR was kept at the first measurable appearance of the knee-jerk occurring prior to the hammer blow. The experiment continued even after the establishment of the conditioned knee-reflex, to the extent of its extinction. The session varied for different subjects depending upon their rates of conditionability ; the range being 60–120 min.

Finally, experimental data of 28 subjects could be recorded since 4 subjects with a striking coincidence of one belonging to each of the treatments, could not be successfully experimented upon when they failed to show any knee-jerk during the practice trials. A precaution with an objective of minimising the fluctuations owing to thermal variations, was abided by completing this phase within the autumn season.

TABLE 1
Means and SDs of the data in terms of acquisition trials

	HAN (High anxiety; neutral instructions)	HAI (High anxiety; anxiety-inducing instructions)	LAN (Low anxiety; neutral instructions)	LAI (Low anxiety; anxiety-inducing instructions)
<i>N</i>	7	7	7	7
<i>Mean</i>	176	163	262	233
<i>SD</i>	17.25	18.37	32.55	23.82

TABLE 2
Means and SDs of the data in terms of mean amplitudes (in CMS.) of acquisition trials

	HAN	HAI	LAN	LAI
<i>N</i>	7	7	7	7
<i>Mean</i>	9.3	9.7	8.2	8.4
<i>SD</i>	0.63	0.17	1.36	1.31

RESULTS

Analysis of the data (collected in terms of two measures viz. number of trials and amplitude) resulted in the following findings which could be categorised into (a) Findings for Acquisition Phase and (b) Findings for Extinction Phase.

Findings for Acquisition Phase

Table 1 cites the statistical descriptions calculated for the measure of number of trials as required by the subjects for acquiring the conditioned reflex under the four treatment conditions. ANOVA carried out with the data (summary of which is cited in Table 1) shows that high-anxiety group was conditioned significantly much earlier ($F=63.63$; $df=1,24$; $p<.001$) than the low-anxiety group. A negative and highly significant value of $r_{bis.}$ ($-.81$) computed between anxiety scores and number of trials indicates an inverse relationship between the twin; thus espousing the above finding. Similarly for the next main effect, that of instructions, F -value was found to be significant ($F=4.83$; $df=1,24$; $p<.05$) implying thereby a facilitation of the occurrence of condi-

tioned reflex under the impact of anxiety-inducing instructions. However, no significant interaction was found between the two independent variables ($F<1$).

For the second measure of amplitude of pre-conditioning trials, though there was overlapping in the magnitudes in four different sub-groups, on the whole it was observed that subjects scaled as highly anxious (from HAN and HAI) consistently exhibited more smooth, rapid and larger amplitudes in comparison with the amplitudes of the lowly-anxious subjects (from LAN and LAI). Analysis started with the mean amplitude over trials in each case. The resultant data further yielded other statistical descriptions (given in Table 2). ANOVA showed a highly significant F -ratio between Anxiety groups ($F=8.11$; $df=1,24$; $p<.01$) confirming that high anxiety group stands markedly higher in terms of mean amplitudes. A value of 0.32 for $r_{bis.}$ computed between the anxiety-scores and mean amplitudes is also suggestive of a positive correlation. The results, however, do not show that anxiety-oriented instructions have any significant effect on the amount of mean amplitudes of acquisition trials ($F<1$). Alike first measure, interaction between the two main

TABLE 3
Mean amplitudes (in CMS.) of the various treatment conditions summated
on different extinction trials

No. of Trials	Treatment conditions				
	HAN	HAI	LAN	LAI	Mean
T ₁	3.8	4.1	3.3	3.4	3.65
T ₂	1.6	1.1	1.2	1.7	1.40
T ₃	0	0.2	0	0.1	0.07

effects was again not significant ($F < 1$).

Findings for Extinction Phase

The data collected herein were again viewed in terms of two measures, namely, number of extinction trials and amplitude of extinction trials. In terms of number of trials, a very transient extinction phase invariably appeared for all the subjects irrespective of the experimental condition they belonged to (Range=1-3). The almost identical means obtained for different treatment conditions (HAN=1.7, HAI=1.7, LAN=1.4 and LAI=1.9) demonstrated that the number of extinction trials was not at all affected by either the factor of manifest anxiety or that of instructions.

Magnitudes of conditioned responses, unlike UCRs, failed to differentiate between two anxiety-groups and the data for them were cast into a 4 (Treatments) $\times$ 3 (Conditioned trials) factorial design. Table 3 cites the mean amplitudes of an entire treatment condition trialwise, over which the analysis of variance was carried out. ANOVA made it evident that various treatments did not have any significant impact over the amplitude of conditioned trials ($F < 1$); showing thereby that neither high anxiety nor anxiety-induced instructions were effective on amplitude, once conditioning was established. Amplitudes, however, tended to decline over the number of trials ($F = 66.05$; $df = 2, 72$; $p < .001$). Tukey Test (Ryan, 1950) was applied on mean amplitudes of all the treatment conditions for different conditioned

trials which revealed that all the three means differed from each other significantly.

DISCUSSION

The foregoing section illustrating the results upholds all the major hypothesised derivations except the one which anticipated higher amplitudes under the impact of anxiety-oriented instructions. Amongst the accepted ones, the first hypothesis predicting faster rates of acquisition with higher levels of manifest anxiety, is clearly evidenced by a significant difference in the required number of trials (Mean number of trials for high-anxiety group=169.5 and for low-anxiety group=247.5; $F = 63.63$; $df = 1, 24$; $p < .001$). Furthermore a very high and negative value of biserial correlation ($r_{bis.} = -.81$) computed herein, points towards the same direction. The theoretical crux of this speculation, as already outlined, is basically incumbent upon Hull's predication (1943) which seeks drive levels to be directly proportional to the strength of the learnt response. Since anxiety has a direct correspondence with the drive levels in case of human beings, higher anxiety levels would entail higher drive levels. Summing it up, a direction strongly pointed out is that of higher anxiety scores resulting in earlier establishment of conditioned response, i.e. lesser number of acquisition trials, which is precisely existent in the present finding. A number of studies like those by Spence and Taylor

(1951), Spence and Farber (1954), Baron and Connor (1960), Ominsky and Kimble (1966) offer the according results, though the reflex investigated upon was that of eye-blinking.

Regarding the factor of inducement of anxiety through verbal cues, one should infer yet another way of facilitating the process of acquiring conditioned reflex by such instructions and this was substantiated by a significant F -value obtained ($F=4.83$; $df=1,24$; $p<.05$). Here it is worth mentioning that although all the hypotheses were dissectional in their predictions, yet the probability levels were compared with those for two-tailed ones; thus there is a scope of further strengthening the assertions made by the findings.

The interaction factor between anxiety level and differential instructions was not significant, though it could have been expected that anxiety-oriented instructions might have an augmented impact on highly anxious subjects. However, the other possibility that the physical threat coming in the form of an apprehension of electric shock, might have had similar effects on the subjects irrespective of their status on a manifest anxiety scale, cannot also be ruled out. Probably, a picture of the inner dynamics, as pointed out by Bridges (1973), is a more reliable source, well deserving a halt before arriving at any definite conclusion.

The second measure employed, namely, the amplitude on the acquisition trials, unto this moment is having a complex and dubious pattern of interaction with the measure of number of trials. Woodworth and Schlosberg (1954) support the presence of slight correlation between these two measures of UCR and CR; imparting thereby a sense of uncertainty in predicting the variations in the amounts of amplitude corresponding to higher anxiety levels. Seeking an interdisciplinary approach, however, has thrashed out this problem since physiologists Tuttle and Schottelius (1969) conclude the impact of

excitation of higher centres (as during anxious states) of nervous system over the magnitudes of knee-jerk in the latter getting increased in turn. Basing on this phenomenon, hypotheses were forwarded predicting the augmentation occurring in amplitudes under the conditions of high-anxiety and anxiety-oriented instructions respectively. A highly significant F -value of 8.11 ($df=1,24$; $p<.01$) for anxiety groups clearly supports the hypothesis that high-anxiety group would exhibit higher amplitudes. However, contrary to the prediction, the anxiety-oriented instructions failed to reveal any differentiation from neutral instructions ($F<1$) in their impact on amplitude. Apparently, differential instructions acted as the weaker variable than manifest anxiety in their influence over the measure of amplitude. Findings of the present study strongly favour number of trials as a better and more reliable index of conditioning over the amplitude.

The experiment, though mainly designed to investigate the precise nature of the influence of anxiety, either manifest or induced, on the establishment of conditioning, was continued to a stage of extinction as well. The most conspicuous observation was that of a very short-phased extinction (maximally 3) in the present set-up which is tangible in the light of claims forwarded by Schlosberg (1928), Hilgard and Marquis (1940) and Spence (1966). Irregularity and instability of knee-jerk and above all, semi-voluntary nature of conditioned patellar reflex, account for the transient extinction phase as specifically commented upon by Schlosberg (1928) and Hilgard and Marquis (1940) whilst Spence (1966) assigns a more crucial role to cognitive and drive factors in the extinction of the conditioned eye-blink in human subjects. According to Spence, detection of non-reinforcement of CS on extinction trials is extremely precipitous in human beings which eases out their apprehensions of the noxious UCS result-

ing in a drop in the drive levels. He conceives further that human beings connive with the inhibitory sets formed at this stage of discrimination. However, most illuminating reflection upon the relationship between peculiarities of the conditioned patellar reflex and irregularity of innate reflex comes from another viewpoint held by Martin and Levey (1969). In their revolutionary monograph, they have strongly appealed against the endemic orientation of learning experimentalists to study CRs in isolation from corresponding UCRs. By focussing upon the adaptive significance of the reflexive responses, they have presented a cogent formulation of the relation of acquisition rate and magnitude of the CR with (a) the impact of the level of cortical as well as autonomic arousal concomitant to the aversive nature of UCS, (b) the magnitude of the UCRs, and finally (c) the subtle individual differences in the reflexes which otherwise are popularly thought of being stereotyped and inflexible. Furthering the argument requires a general observation of spontaneous and steady activity which is going on in most of our physiological systems e.g. heartbeat, GSR, muscle tonus, eye-blinking etc. One can not overlook the fact that UCR sensitivity in these modalities is remarkably enhanced to accomplish their inherent biological meaningfulness. In sharp contrast to these stimulus-generalised autonomic systems, we have highly stimulus-specific systems i.e. Patellar and Plantar reflexes. It is this very low turbulence in the nervous system coupled with a much higher threshold of UCR sensitivity which results in a comparatively disharmonised appearance of patellar reflex. Not only this, cognizance has to be taken of the UCR-CR transfer pattern which predicts easier and more stable CRs whenever UCRs are more conspicuous. In the backdrop of these disparities existing between patellar and eye-blink reflexes, any attempt towards comparing their rates of conditioning seem to be unfounded and as

a matter of fact, in 1938, Campbell did demonstrate that findings of eye-lid conditioning did not predict the conditionability of patellar reflex. Since mean number of conditioned trials under the four treatment conditions were approximating each other, it implied that the two variables did not exercise a significant influence in producing any variations in the results. However, highly significant mean differences of amplitudes within a range of 1-3 trials ($F=66.05$; $df=2,72$; $p<.001$) were conveyed. Tukey Test (Ryan, 1950) applied to the mean amplitudes combined for all the treatments against the trials showed significantly plummeting magnitudes due to non-reinforcement. A sharp decline just after the first extinction trial ($p<.01$) strongly suggests that subjects, no matter to which ever treatment they belonged, had a very rapid discrimination of the disappearance of UCS and their having responded to the sound of the buzzer (cf. Spence, 1966).

Conditioning of patellar reflex demonstrates, in a very clear-cut fashion (a) the process of its acquisition, (b) its anticipatory avoidance of UCS and finally, (c) its overt, gradual strengthening to measurable limits. It was noted that quite early in the experimental session, the sound of the buzzer started invariably producing tremors in the leg being struck which intensified until UCS was administered. Complete absence of the tremors during the inter-trial interval as also all through exemption of the other leg from them consolidated the anticipatory character of CR. In addition, the possibility of any other contaminating factor e.g. volitional kicking or shivering etc. was also ruled out. Moreover, these were the tremors which developed into higher, recordable magnitudes with the continuation of the session. Above all, the transient nature of CRs as brought to light, during preliminary investigations, made it justifiably exigent to set the criterion of acquisition as the first recordable appearance of knee-jerk in re-

sponse to buzzer.

The precaution strictly adhered to was, that no subject be revealed the objective of the experiment so that it could now safely be assumed that they were not aware of what was expected of them. Furthermore, the exclusion of students from psychology and other disciplines imparting the knowledge of 'Conditioning' also ruled out the chances that any of the subjects could gather any clue from the experimental situation (As a precaution, Spence (1966) also excluded those students who had a knowledge of the concept of 'Conditioning' from his masked experiments on eye-lid conditioning). The resultant advantage was the nullification of any possibility of voluntary kicking as a substitute for the conditioned reflex on the part of the subject.

Absence of knee-jerk in four subjects does not come as a surprise since Schlosberg (1928) also reports such an occurrence. Miller and Leavell (1972) have ascribed this to the sole reason of having injured the spinal connections so that no reflex is formed. Yet another minor factor, as claimed by physicians, is the deeper imbedding of nerves in the patellar region so that the intensity of the hammer blow falls short of arousing a reflex. However, this probability was guarded against by trying out the maximum intensity of 90° fall (reportedly painful to bear along) without any success.

Having tapped a much-neglected area in the field of psychology, it is believed that the experiment would stimulate new avenues for further research which, in turn, would hopefully result in the alignment of intricate network of the nature of this reflex.

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