ILLUSORY CORRELATION, ON-LINE PROBABILITY ESTIMATES, 
AND ELECTRODERMAL RESPONDING 
IN A (QUASI)-CONDITIONING PARADIGM

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Twenty normal subjects were exposed to two series of two different slides randomly paired with the occurrence or non-occurrence of shock. The first series started with a greater number of pairings of one slide with shock ("target slide") than the other to induce an illusory correlation (IC). Meanwhile, across all trials shock/slide contingency was equal for both slides. During the second series, a truly random sequence of slide–shock trials was used in order to examine whether IC was resistant to disconfirmational information. Subjects' contingency estimates were recorded a posteriori as well as on-line. In addition, electrodermal responding was recorded on a trial-by-trial basis. Data show that it is possible to induce an IC between a neutral stimulus and an aversive outcome by means of a conditioning-like procedure. Moreover, data strongly suggest that an IC can act in such a way as to maintain or enhance covariation bias as indexed by on-line probability estimates. Finally, data sustain the hypothesis that a covariation bias is associated with differential autonomic responding.

Keywords: Classical conditioning, skin conductance, illusory correlation, phobia

1. Introduction

The concept of illusory correlation (IC) refers to the report by subjects of a covariation between two categories of events which, in reality, are correlated to a lesser extent or even correlated in the opposite direction (Chapman, 1967). ICs have been described in psychodiagnostic observations (Chapman & Chapman, 1967, 1969), interpersonal perception (Hamilton & Gifford, 1976), and statistical inferences (Nisbett & Ross, 1980).

Recently, the phenomenon of IC has been related to phobic anxiety (Mineka & Tomarken, 1989; Tomarken, & Cook, 1989; experiments 1–3). In

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the studies of Tomarken et al. (1989), phobic and control subjects were confronted with a sequence of 72 slides. Three different categories (one phobic and two neutral) were used. Slide offset was followed by one of three possible outcomes: a tone, an aversive shock, or nothing at all. The base-rate probabilities of all slides and outcomes were equal and so were the conditional probabilities (i.e., 33%). Consequently, stimuli and outcomes were equally correlated. At the end of the experiment, subjects were asked to estimate the covariation between all stimulus/outcome combinations. In contrast to low-fear subjects, phobic subjects dramatically overestimated the covariation between phobic stimuli (i.e., slides of snakes or spiders) and shock outcome. Thus, phobic subjects reported an illusory correlation between phobic stimuli and aversive outcomes. The authors suggested that the IC phenomenon might be an important factor in the etiology and maintenance of phobic anxiety. Acknowledging the potential strength of Tomarken et al.'s laboratory model, the present study sought to further elaborate the model.

First, a question not empirically addressed by Tomarken et al. (1989) concerns the origin of the observed IC. The authors suggest that the IC reflects biased processing of information during the experiment. An alternative explanation might be that phobic subjects entered the laboratory with a habitual tendency to overassociate phobic cues with negative outcomes. The IC may have reflected an enduring phobic memory network and not necessarily biased on-line processing. A first aim was to see whether a paradigm comparable to that of Tomarken et al. (1989) allows for the detection of on-line covariation bias. More specifically, we examined whether an a posteriori covariation bias (IC) would occur after presenting a “suggestive” sequence of slide/shock trials (see below) to non-phobic subjects and, if so, whether this a posteriori IC is related to on-line probability ratings. Second, the model may gain in strength if it could be demonstrated that covariation bias has effects on autonomic “conditioned” responding. Note that a number of studies suggest that human covariation judgement is sensitive to the same factors as conditioned responding (e.g., Alloy & Tabachnik, 1984; Dickinson & Shanks, 1985; Lovibond, 1988). Furthermore, recent human conditioning studies underline that awareness of conditioned stimulus (CS)/unconditioned stimulus (UCS) covariation is a necessary prerequisite for conditioned autonomic responding (e.g., Dawson, Schell, & Banis, 1986). It was predicted, therefore, that illusory belief in close CS/UCS association is sufficient to produce heightened autonomic responding and that the latter is associated with high a posteriori covariation bias. Third, Tomarken et al. (1989) argue that IC serves to maintain phobias; this implies that ICs, once established, are resistant to “extinction”, that is, do not disappear during exposure to disconfirmational information.

The present study examined whether on-line covariation bias is, indeed, resistant to extinction. It aimed at inducing an IC by presenting a “suggestive” series of CS/UCS pairings. Animal studies have shown that truly random
control procedures result in excitatory conditioning when CS–UCS pairings occur before non-pairings (Benedict & Ayres, 1972). A similar primacy effect was observed in social–psychological experiments: early successes in a purely chance task (e.g., coin tossing) leads to overestimation of past success and increased expectation of future success (Langer & Roth, 1975). Adopting an analogous strategy, the present study attempted to induce an IC between a neutral stimulus and an aversive outcome (shock). Subjects were exposed to two series of slides randomly paired with the occurrence or non-occurrence of shock. For both series, base-rate probabilities of the two slides were equal, as were the conditional probabilities (50%). The first series (IC induction phase) started, however, with a number of pairings of one slide category (the “target” slide) with shock. Across all trials, shock/slide contingency was equal for both slides. During the second phase, subjects were exposed to a random series of slide/shock pairings (IC extinction phase). Again shock/slide contingency was equal for both slides. The extinction phase was used in order to examine whether IC was resistant to disconfirmational information (no “suggestive” order of slide–shock trials). On-line probability estimates and electrodermal responding were recorded concurrently on a trial-by-trial basis. At the end of the experiment, subjects were asked to make judgements concerning the degree of covariation between slides and outcomes.

It was predicted that subjects would report an (a posteriori) IC between the the “target” slide and the aversive outcome. Furthermore, we examined whether subjects reporting an a posteriori IC react with conditioning-like SCR components and biased on-line probability estimates to the target slide as compared to the control slide.

2. Method

2.1. Subjects

Twenty healthy undergraduate volunteers (12 females) were paid for participating in this experiment. Mean age was 21 years (range 18–25 years).

2.2. Stimulus materials and apparatus

Two stimuli were used throughout the experiment: a slide depicting an “X” and a slide depicting an “O”. Slides were projected by a Kodak Carousel onto a screen (80 cm × 120 cm), approx. 2 m in front of the subject.

Shocks were delivered from a Siemens Neuroton 623 apparatus and administered to the subject’s lateral side of the lower (right) leg just above the ankle through two electrodes (8-mm diameter Ag–AgCl). During the experiment, electrodermal activity was recorded from two Beckman Ag–AgCl electrodes
(8-mm diameter), placed on the medial phalanges of the second and third finger of the non-dominant hand. The electrodes were filled with an isotonic paste and connected to a Beckman skin conductance coupler (type 9844). Frequency and depth of ventilation was recorded by means of a Beckman respiratory belt connected to a Beckman voltage/pressure coupler.

For measuring on-line probability estimates (PE), a rotary lever mounted on a scale was used (range 180°) positioned in front of the seated subject (e.g., Furedy & Schiiffmann, 1973). Subjects were informed that the scale represented a continuum. The horizontal left (0), vertical, and horizontal right (100) positions represented absolute certainty that the shock would not occur, complete uncertainty, and absolute certainty that the shock would occur, respectively. The output from the "PE device" was recorded on a Beckman polygraph. Stimulus presentation, shocks and intertrial intervals were controlled by a PDP Minc-II computer.

2.3. Procedure

After introduction to the laboratory, electrodes and respiratory belt were attached to the subject. Following this, a shock work-up procedure was carried out in order to set the intensity level of the shock. Shock level was increased in steps of 0.2 mA until the subject indicated that the intensity was uncomfortable but not painful. After the completion of this procedure, the subject was informed about the experimental task. It was explained that he or she had to determine whether or not there was a relationship between a particular slide and a particular outcome following the slide. Furthermore, subjects were instructed to use the "PE device" during each slide presentation. PE output was used as an index of subject’s on-line beliefs about the likelihood of shock occurrence (in some studies referred to as "subjective contingency"; e.g., Shiffmann & Furedy, 1977).

The experiment consisted of 52 trials: 26 X slides and 26 O slides. Both slide categories were followed half of the time (13 trials) by a 2-s shock. Slide duration was always 8 s. The intertrial interval varied from 10 s to 30 s with a mean of 20 s. The 52 trials were grouped into two phases. The first ("induction") phase (32 trials) was analogous to the "primacy series" used by Langer and Roth (1975). This phase aimed at inducing an illusory correlation between the target slide and shock. In half of the subjects the X was used as target slide, in the other half the O. For the sake of convenience, the target and the control stimulus will hereafter be referred to as the T and C slide, respectively. The first phase began with a random series of 3 C slides, of which 1 was followed by shock, and 7 T slides, of which 5 were followed by shock. During the remaining 22 trials slide–shock contingencies were such that the positive T–shock correlation was down-scaled to a momentary deviation in what might be a perfectly random sequence of slides and shocks.
The second ("extinction") phase consisted of 20 trials. During this phase, slides and shocks were presented randomly, with the restriction that a given slide was never followed by a shock on two or more consecutive trials. The interval between the first and the second phase was 30 s. It should be stressed that for both phases base-rate probabilities of the C and T slides were equal and so were the conditional probabilities (50%).

At the end of the experiment, subjects completed the probability questionnaire (PQ), on which they indicated their perceptions of the relationships between slides and outcomes. The PQ comprised two sections. Questions in the first section asked subjects to estimate the percentage of times each of the two outcomes (shock/no shock) occurred given the prior presentation of each of the two slides (T/C). The second section asked subjects to estimate the base-rates of each slide type and each outcome during the 52 trials. For all estimates visual analogue scales (VAS) were used, ranging from 0 to 100%.

2.4. Data analysis and reduction

2.4.1. Skin conductance response

For each trial, three different skin conductance response (SCR) components were scored: the first interval response (FIR; 1–4 s after CS onset), the second interval response (SIR; 4–9 s after CS onset), and the third interval omission response (TOR; 1–4 s after CS offset, on non-reinforced trials). The FIR component is said to reflect an orienting response (e.g., Stern & Walrath, 1977), the SIR component is regarded as an anticipatory response due to the preparation for the occurrence of the UCS (e.g., Grings, 1969), while the TOR component is thought to reflect "surprise" about the non-occurrence of shock (e.g., Seligman, Maier, & Solomon, 1971; see, however, Maltzman, 1987, for a different view). A conditioned-like SCR was assumed to have occurred when FIR, SIR, and TOR components occurred more frequently and the UCR component decreased more during the T slide trials than during the C slide trials. Following the criteria of Stern, Ray, and Davis (1980), responses associated with ventilatory irregularities were omitted. SCR data were analyzed as magnitudes and probabilities. Because preliminary inspection of the FIR, SIR, and TOR magnitude data showed a large number of zero responses, further analyses were performed on frequency data (Stern et al., 1980). The electrodermal data were subjected to a 2 (slide type) × 2 (phase) ANOVA with both factors being a within-subjects factor.

2.4.2. On-line probability estimates

For both slide types and for each phase of the experiment, the mean PE was computed. The mean scores were used as dependent measures. To test differences in PE between the two slides during the two parts of the experi-
ment, a 2 (slide type) × 2 (phase) ANOVA was conducted with both factors being a within-subjects factor.

2.4.3. Probability questionnaire

We tested whether the P(shock/T) and/or P(shock/C) estimates differed from 50%. It was predicted that subjects would overestimate the covariation between T slide and shock but not between C slide and shock.

As the present study was primarily concerned with concomitants of the "illusory correlation" phenomenon, only subjects reporting an IC (P(shock/T) > 0.5) were included in the final analyses of SCR (n = 16). For all subjects, Pearson’s product–moment correlations were computed between PE and SCR data on a trial-by-trial basis. After Fischer’s Z transformation these correlations were averaged. Finally, in order to explore the interrelationship between the a posteriori reported IC and the on-line reported probability estimates a multiple regression analysis (backward) was carried out. The a posteriori reported P(shock/T) was used as the dependent variable and mean PE(shock/T) “induction” phase, mean PE(shock/C) “induction” phase, mean PE(shock/T) “extinction” phase, and mean PE(shock/C) “extinction” phase were used as predictor variables.

3. Results

3.1. Covariation estimates (a posteriori)

Fig. 1 shows PQ data. Overall, subjects overestimated the probability of shock given a T slide (mean = 59.6; SD = 13.9) compared to their estimated

![Bar chart showing covariation estimates](image)

Fig. 1. Subjects' a posteriori covariation estimates.
probability of shock given a C slide (mean 46.2; SD = 14.8). Paired t tests showed that the reported P(shock/T) differed significantly from 50%, $t(19) = 3.05, p < 0.05$, whereas the reported p(shock/C) did not $t(19) = -1.16, p = 0.26$. Base-rate estimates did not differ significantly.

Fig. 2. (a) Mean on-line estimates of probability of shock (PE) during both phases ($n = 20$). PE during the "induction" phase is depicted in blocks of four presentations; PE during the "extinction" phase is depicted in blocks of two presentations. (b) Mean on-line estimates of probability of shock (PE) during both phases for those subjects reporting an a posteriori IC ($n = 16$). PE during the "induction" phase is depicted in blocks of four presentations; PE during the "extinction" phase is depicted in blocks of two presentations.
3.2. Probability estimates (on-line)

Fig. 2(a) reflects the mean on-line probability estimates. A 2 (T vs. C) × 2 (induction vs. extinction) ANOVA performed on the PE data yielded no significant effects; for all effects, $F(1,19) < 1$. However, when the ANOVA was performed on the data of those subjects ($n = 16$) showing an a posteriori IC, $P(\text{shock}/T) > 0.5$ (see fig. 2b), a main effect of slide category, $(F1,15) = 7.57, p < 0.05$, was found. This result implies that during the experiment $P(\text{shock}/T)$ was consistently judged greater by the subjects than $P(\text{shock}/C)$. In addition, an interaction effect between slide category with phase, $(F1,15) = 10.70, p < 0.05$, appeared. This result suggests that in spite of the disconfirmational sequence of random shock–slide combinations during the “extinction” phase, the estimated $P(\text{shock}/T)$ relatively increased, whereas the estimated $P(\text{shock}/C)$ declined. Post hoc $t$-test confirmed that $P(\text{shock}/T)$ increased during the “extinction” phase, $t(15) = -2.19, p < 0.05$ (two-tailed), while the on-line reported $P(\text{shock}/C)$ tended to decrease, $t(15) = 1.42, p = 0.18$ (two-tailed).

3.3. Skin conductance responses

Mean SCR data are summarized in table 1. A 2 (slide) × 2 (phase) ANOVA on the UCR magnitude data showed a main effect of slide type, $F(1,15) = 5.72, p < 0.05$, indicating that the UCR was smaller on reinforced T trials than on reinforced C trials. An ANOVA performed on the FIR frequency data yielded only a significant main effect of phase, $F(1,15) = 5.78, p < 0.05$, indicating a decrease in SCR from first to second phase. The SIR frequency data showed a main effect of slide type, $F(1,15) = 4.84, p < 0.05$. This effect was due to the fact that more SIRs occurred during the C slide in comparison to the T slide. Finally, an ANOVA of the TOR data showed a marginally significant main

Table 1
Mean FIR, SIR, TOR, and UCR during control (C) and target (T) trials. Response frequencies (%) are shown in parentheses

<table>
<thead>
<tr>
<th></th>
<th>Induction phase</th>
<th>Extinction phase</th>
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<tbody>
<tr>
<td></td>
<td>C magna. FR%</td>
<td>T magna. FR%</td>
</tr>
<tr>
<td>FIR</td>
<td>0.21 (60)</td>
<td>0.22 (63)</td>
</tr>
<tr>
<td>SIR</td>
<td>0.19 (46)</td>
<td>0.17 (40)</td>
</tr>
<tr>
<td>TOR</td>
<td>0.27 (72)</td>
<td>0.28 (77)</td>
</tr>
<tr>
<td>UCR</td>
<td>0.62</td>
<td>0.58</td>
</tr>
</tbody>
</table>

UCR, unconditioned response; FIR, first-interval response; SIR, second-interval response; TOR, third-interval omission response; magna., magnitude.
Table 2
Pearson $r$ correlations of subjects' ($n = 20$) on-line probability estimates (PE) with first interval response (FIR), third omission response (TOR), and unconditioned response (UCR)

<table>
<thead>
<tr>
<th></th>
<th>FIR</th>
<th>TOR</th>
<th>UCR</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE</td>
<td>0.13</td>
<td>-0.17</td>
<td>-0.12</td>
</tr>
</tbody>
</table>

effect of slide type in the predicted direction for the TOR probability data (more omission responses after the T slide), $F(1,15) = 3.43$ p = 0.09.

Pearson product–moment correlations of PE with SCR data (based on all subjects) are depicted in table 2. All correlations were low and non-significant.

The multiple (backward) regression analysis (based on all subjects) showed that only the on-line PE data during the “extinction” phase had significant predicting properties for the a posteriori reported P(shock/T). PE(shock/T) during the “extinction” phase (beta = 0.53, $p = 0.0035$) and PE(shock/C) during the “extinction” phase (beta = -0.46, $p = 0.009$) explained 61% of the variance in a posteriori reported covariation between shock and target slide. The PE(shock/T) and PE(shock/C) during the “induction” phase had non-significant contributions ($p > 0.20$).

4. Discussion

Three conclusions can be drawn from the data presented above. First, the results of the present study show that it is possible to induce an IC between a neutral stimulus and an aversive outcome. Subjects overestimated the covariation between one of the signalling stimuli and the aversive outcome though the probability of shock was equal for both stimuli. Thus, these data indicate that exposure to conditioning-like experiences (e.g., incidental slide–shock pairings) is a possible pathway to robust covariation bias.

Second, the present findings indicate a close relationship between the a posteriori reported IC and subject’s on-line probability estimates. Thus, it appears that IC is not restricted to biased memories of covariation, but can also emerge during processing of information concerning CS–UCS contingencies. Admittedly, these data do not indicate if or to what extent ICs as reported by phobic subjects (cf. Tomarken et al., 1989) are due to memory rather than on-line information-processing phenomena.

Third, the data demonstrate that an IC, once induced, can become “self-supporting”: the subjects’ on-line probability estimates of shock given “T” [P(shock/“T”)] increased during the second (“extinction”) phase, whereas the P(shock/“C”) declined. Obviously, an acquired IC can act in such a way as to promote the assessment of selective associations. This finding together with
the revealed close relationship between the on-line and a posteriori covariation estimates provides additional support for the suggestion that covariation bias may be a prominent factor in the etiology and maintenance of phobic anxiety (Tomarken et al., 1989).

Approximately, the electrodermal data parallel the subjective indices of covariation estimation. A number of studies have shown that signalled shock elicits a smaller UCR than unsignalled shock (e.g., Morrow, 1966), a phenomenon which has been termed "UCR diminution". Although there is discussion about the theoretical meaning of this phenomenon (see, for example, Lykken, Macindoe, & Tellegen, 1972, vs. Furedy, 1975), UCR diminution has been found in electrodermal (Kimmel, 1966; Merckelbach & de Jong, 1988), cardiovascular (Lykken et al., 1972), and evoked potential (Roth, 1973) studies. Of particular interest to the present context is a study of Grings and Sukoneck (1971), who demonstrated that UCR magnitude decreases as (objective) probability of UCS increases. These authors also suggest that the ability to predict with confidence the occurrence of shock (within a given physical probability category) is inversely related to the magnitude of response elicited by the shock. The present data fit nicely with the results of Grings and Sukoneck (1971). After successful IC induction, the pertinent slide had greater "predictive validity" (Lovibond, 1988) for shock occurrence than the control slide. In line with this, shocks preceded by the pertinent slide elicited smaller UCRs than shocks preceded by the control slide.

The TOR component is thought to reflect the arousal of an orienting response precipitated by breaking the expected CS–UCS pairing (e.g., Seligman, Maier, & Solomon, 1971). Therefore, if autonomic responding parallels the reported IC, a greater incidence of TOR components is expected after the pertinent slide in comparison to the control slide. Indeed, the pertinent slide was followed by a (marginally significant) greater number of TORs than the control slide.

No difference could be detected between the FIR C slide and the FIR T slide. The absence of a differential "conditioned" responding in relation to the on-line expectancies of shock occurrence may be attributed to the small magnitude of the FIR and rapid habituation.

In contrast to the other SCR components, the SIR probability data conflict with the hypothesis that electrodermal responding is congruent with subjects' contingency estimates. The SIR is thought to reflect an anticipatory response to UCS occurrence (see for example, Prokasy & Kumpfer, 1973). However, in contrast to our prediction, the SIR component occurred more frequently during the C slide than during the T slide. As for the interpretation of this phenomenon it could be speculated – in line with Ohman's theory (1979) – that the SIR component in the present study reflects (uncertainty-induced) effort "invested" by the central channel in processing CS–UCS contingency information (PE data showed that subjects were more uncertain about shock
occurrence after the C slide than after the T slide). Of course, the present study is far from conclusive in this respect.

Although the present study provides some evidence for conditioning-like autonomic responding associated with on-line and a posteriori covariation estimates, the absence of relevant correlations indicates that there is no simple, linear relationship between the two sets of phenomena. In this respect, present data are consistent with earlier studies which failed to find high positive cognitive–autonomic correlations (e.g., Schiffmann & Furedy, 1977; see also Merckelbach, van den Hout, & de Jong, 1989). This led Schiffmann and Furedy to conclude that "there is no clear support for any position which holds that the extent of autonomic conditioning is directly related to the extent of CS–UCS awareness" (p. 276).

In summary, the present experiment showed: (1) that it is possible to induce an IC between a neutral stimulus and an aversive outcome by means of a conditioning-like procedure; (2) that covariation bias can emerge during processing of information concerning CS–UCS contingencies; (3) that an IC can serve to maintain or enhance covariation bias as indexed by on-line probability estimates. Furthermore, the present study provides some support for the hypothesis that a covariation bias is associated with differential autonomic responding.

References


