Eyeblink Startle Responses in Spider Phobics
Before and After Treatment: A Pilot Study

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Accepted: August 8, 1991

Before and after treatment, acoustic probes eliciting eyeblink startles were presented to 41 female spider phobics during a behavioral approach test (BAT). During this test, subjects pulled a glass jar containing a live spider as nearby as they normally would tolerate. In order to obtain baseline startles, the subjects also carried out a BAT with a basket containing attractive food items. Startle responses were found to be relatively larger during the “spider” BAT than during the “food” BAT. This difference in relative magnitude decreased as a result of one-session treatment. The startle response appeared to be relatively independent of other outcome measures (i.e., Spider Questionnaire, BAT, and heart rate). Taken together, the results sustain findings previously reported by Lang and co-workers.

KEY WORDS: startle; phobia; exposure.

INTRODUCTION

Recent studies by Lang and colleagues (Bradley, Cuthbert, & Lang, 1990; Vrana, Spence, & Lang, 1988) show that the eyeblink component of the startle probe response is modulated by the emotional valence of the foreground stimuli used. In their experiments, normal subjects were confronted with a series of slides depicting pleasant (e.g., nudes of the opposite sex), neutral (e.g., household objects), or unpleasant (e.g., mutilated bodies) stimuli. Acoustic startle probes were delivered during and between slide

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presentation. Lang and associates repeatedly documented that the startle reflex magnitude increases linearly from pleasant to unpleasant foreground stimuli. This increase in magnitude was found to be independent of arousal and attention attracting properties of the foreground stimuli used. These results led Vrana et al. (1988) to the suggestion that "the startle probe would be useful in evaluating treatment methods and in the prognostic assessment of patients with pathological anxiety" (p. 491; see also review by Lang, Bradley, & Cuthbert, 1990).

The present study was designed in order to investigate (1) whether acoustic probes, indeed, elicit stronger startle responses in phobic subjects during a fear-relevant foreground stimulus than during a pleasant foreground stimulus; (2) whether startles elicited in the presence of a fear-relevant foreground stimulus are modulated by behavior therapy; and (3) whether the eyeblink startle can be used in predicting and evaluating treatment outcome.

In the current study, startle probes were presented to spider phobics during a behavioral approach test (BAT). During this test, subjects had to pull a glass jar containing a live spider as nearby as they normally would tolerate. In order to obtain baseline values of the startle responses, patients also performed the BAT with a basket containing attractive food items. The food items can be considered as a pleasant foreground stimulus for startle probes. After a one-session exposure in vivo treatment (Öst, 1989) which lasted approximately 2.5 hr, the subjects underwent the same assessment procedure.

On the basis of Vrana and co-workers' (1988) results, it was predicted that startle responses would be stronger with an unpleasant (i.e., a live spider) than with a pleasant foreground stimulus (i.e., attractive food items). Furthermore, it was anticipated that the ratio of the "spider" and the "food" startles would decrease as a result of one-session treatment.

METHOD

Subjects

Subjects were 41 female spider phobics. They applied for therapy after reading articles about spider phobia treatment in regional newspapers and/or after watching a program on satellite television. In return for "free" treatment (see below) subjects were invited to participate in research. The mean age was 30.6 years (range, 18–55 years). Mean duration of complaints was 25 years (range, 9–48 years). The mean score on the Spider Questionnaire (SPQ; Klorman, Weerts, Hastings, Melamed, & Lang, 1974) was 23.4
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(range, 20–28), which is comparable to the mean scores that Fredrikson (1983) reported for this phobic sample. All phobics considered their phobia to be a serious handicap. Two subjects were excluded from the final analyses because no measurable startle responses were obtained.

Assessment and Apparatus

As a behavioral measure of phobic anxiety, a Behavioral Approach Test (BAT) was used. During this test subjects were seated in a chair located behind a large table (0.4 x 3.0 m). At the far end of the table, a live spider (Tegenaria atrica) was kept in a closed glass jar. A guided string was fastened to the jar. Subjects were instructed to pull the spider as nearby as they normally would tolerate and to keep the spider in that position for 90 sec. It was stressed that by no means should they force themselves. The BAT was scored on a 13-point scale ranging from 0 (“distance between subject and spider 3 m”) to 12 (“spider on hand”). On completion of the BAT, subjects were asked to indicate on 100-mm Visual Analogue Scales (VASs) their fear during the test (0 = no fear at all; 100 = panic).

When subjects indicated that they had reached their (BAT) limit, startle reflexes were induced by means of 50-msec, 90-dB white-noise probes with instantaneous rise time delivered by headphones (binaurally). In total, three probes were given, with the first interstimulus interval (ISI) being 20 sec and the second ISI being 35 sec. In order to obtain baseline values, subjects carried out a BAT with both a spider and a basket containing attractive food items (e.g., bananas, chocolate, candies, Coca-Cola, orange juice). Half of the subjects started with the “food BAT,” while the other half started with the “spider BAT.” Subjects were randomly assigned to one of the two groups. In the food BAT condition, subjects were instructed to pull the string until the basket was in reach. Next they had to select the most attractive item and to keep it in their hands for approximately 90 sec in order to prevent distraction from the food item. The ingredients of the basket were explicitly shown to the subjects before the food BAT started. Subjects also were reassured that nothing unexpected would happen and that the basket did not contain spiders. During the last 90 sec of the BAT, probes were delivered.

Eyeblink startle responses were measured by recording EMG activity from the m. orbicularis oculi beneath the left eye, using Beckman miniature Ag–AgCl surface electrodes filled with Hewlett Packard Redux creme. The

2 More detailed information about the BAT and the 13-point scale are available on request from the first author.
EMG signal was fed to a Beckman EMG coupler (9852A). Frequencies below 60 Hz were filtered (48 dB/octave), using a Krohn Hite filter (Type 3341 with a Butterworth characteristic). The EMG signal was then rectified and integrated by a contour following integrator of the type recommended by Fridlund (1979). In order to optimize the sensitivity for momentary fluctuations of EMG activity, a short integration time constant was chosen (1/32 sec). The transformed signals were fed to a Beckman polygraph using five different channels. To maintain optimal sensitivity for both incubating and habituating responses, each channel used a different amplification factor (0.5, 1, 2, 5, and 10, respectively). For each subject, the magnitude of pre-BAT endogenous eyeblinks were used to adjust the preamplifier of the EMG coupler to the strength of the signal (in order to be sure that the full range of the polygraph would be used). Magnitudes were scored by hand in arbitrary EMG units. Trials with an unstable baseline were eliminated. Scoring was done by a research assistant who was blind as to the conditions under which startle responses were obtained.

During the food and spider BAT, heart rate (HR) was measured by recording pulse volume from the left ear, using a Beckman transilluminated plethysmograph connected to a Beckman voltage/pressure/pulse coupler (9853A). Mean HR during the last 90 sec of the BATs was obtained by dividing the sum of pulse waves by 1.5.

Physiological signals were fed to a Beckman R 611 polygraph. A PDP Minc II microcomputer controlled response registration and probe administration.

Procedure

Upon arrival, subjects were shown around the laboratory. After the procedure had been explained, subjects signed an informed consent form. Next they completed the SPQ. The SPQ is a 31-item self-report instrument that measures fear of spiders. It has been recommended as an outcome measure (Fredrikson, 1983). Next EMG electrodes and the plethysmograph were attached. Following this, subjects carried out the BATs. After these behavioral tests, electrodes and plethysmograph were removed and subjects were treated with the one-session therapy recently described by Öst (1989). This treatment consists of exposure in vivo and, if necessary, modeling, and has been found to yield good immediate and long-term results. The one-session treatment lasted about 2.5 hr. Finally, EMG electrodes and plethys-
mograph were reattached and the subjects went through the BATs again and completed another SPQ.

**Data Reduction and Analysis**

Change scores of the BAT (0–12; BAT score after minus BAT score before treatment) were used as the main outcome measure for therapy success.

In the major analyses, ratios of startle magnitude (i.e., mean magnitudes spider BAT/food BAT) rather than absolute magnitudes were used. Ratios were preferred for the following reasons: (1) minor changes in electrode position can result in changes in the magnitude of EMG signals; (2) changes in cutaneous impedance affects the magnitude of EMG signals (e.g., due to changes in blood perfusion); and (3) other uncontrollable and/or unknown factors may contaminate the absolute magnitudes of EMG signals (e.g., increased baseline muscle tension, fatigue). As in the present study electrodes were reattached about 4 hr after the pretreatment BAT in order to obtain posttreatment eyblink startle responses, all of these contaminating factors may be at work. Consequently, analyses of differences in magnitudes rather than in ratios may reduce the power of the experiment in evaluating treatment effect.

The (pre- and posttreatment) mean startle ratios were subjected to a MANOVA with a priori contrasts in order to test (a) both the pre- and the posttreatment values of the ratio against 1 (1 indicates no difference between food and spider BAT; null hypothesis, ratio \( \leq 1 \)); (b) whether the posttreatment ratio was smaller than the pretreatment ratio as a result of treatment (null hypothesis, ratios are equal); and (c) whether the order used (i.e., food–spider BAT vs. spider–food BAT) had effects for the above-stated contrasts. The SPSSX–MANOVA output yields \( t \) tests, which allow for directional interpretation.

Because there are large differences in EMG responding among individuals, ratios of startle magnitude (i.e., mean magnitude spider BAT/food BAT) were also preferred in the regression analyses. Three regression analyses were carried out: (1) in order to explore the relationship between the startle response ratio and the SPQ, BAT, VAS, and HR (as indexed by HR spider minus HR food) both before and after treatment; (2) in order to examine the prognostic properties of the pretreatment startle ratio, SPQ, VAS, and HR for treatment outcome as indexed by the change scores of the spider BAT. The pretreatment BAT score was included in this re-
gression analysis in order to control for the initial distance of the spider during the pretreatment session.

RESULTS

Pretreatment Startle Response

As expected, the ratio of the mean startle response during the spider BAT and the food BAT was significantly greater than 1 \( t(38) = 4.53, p < .05; \) one tailed, indicating that the magnitude of the startle response was smaller when the food item basket was used as foreground stimulus than when the spider was used as a foreground stimulus. No interaction with order appeared (food BAT-spider BAT vs. spider BAT-food BAT), indicating that there was no carryover effect of anxiety \( t(38) = 1.62, p > .10 \). Additional analysis confirmed that the mean magnitude of the spider startle was larger than the magnitude of the food startle, the means being 26.3 and 18.0, respectively \( t(38) = 3.53, p < .05; \) one tailed (see also Fig. 1).

![Bar chart showing mean magnitudes of the eyeblink startle responses during the "spider" BAT and during the "food" BAT, both before and after treatment.](image-url)
Treatment Effects and Startle Response

As can be seen in Table I, the one-session treatment yielded good results. More specifically, mean BAT scores increased, mean SPQ scores decreased, and mean VAS scores decreased. A notable exception was HR; the cardiac acceleration during the spider BAT was maintained during the posttreatment test. In contrast, the startle response during the spider BAT relative to the startle response during the food BAT declined after therapy. Although the ratio spider/food still differed significantly from 1 after therapy [t(38) = 5.63, p < .05], the MANOVA showed that the posttreatment ratio was significantly smaller than the pretreatment ratio (see Table I). Neither the decrease in the startle ratio nor the posttreatment difference between the food and the spider stimulus was modulated by the order used \[ r(38) = -0.97, p > .10, \text{ and } t(38) = 1.22, p > .10, \text{ respectively} \]. Additional analysis confirmed that the decrease of the ratio was, indeed, caused by a reduction of the spider startle magnitude [t(38) = 2.00, p < .05] rather than an increase in the food startle magnitude [t(38) < 1] (see Fig. 1). The pre- to posttreatment changes in startle magnitudes differed for the two types of foreground stimuli: \( t(38) = 1.90, p < .05 \).

A closer inspection of the individual data revealed that 14 subjects showed an increase in BAT score (due to treatment) that was not accompanied by a corresponding decrease in the startle response ratio. Post hoc t tests showed that this subgroup was characterized by significantly smaller pretreatment ratios than the remaining subjects [t(22.43) = 3.40, p < .05; separate variance estimate]. In fact, the pretreatment ratio of the above-mentioned subgroup came close to 1 (0.94). Still the pre- and posttreatment BAT, HR, VAS, and SPQ data were comparable for both groups (subgroup vs. remaining subjects; all \( t's < 1.5, \text{ all } p's > .15 \)). The absence of a difference between the food and the spider startle response in this subgroup

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<tr>
<td>BAT (0–12)</td>
<td>3.2</td>
<td>8.8</td>
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<tr>
<td>SPQ (0–31)</td>
<td>23.4</td>
<td>11.4</td>
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<td>38</td>
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<tr>
<td>VAS (0–100)</td>
<td>51.3</td>
<td>23.7</td>
<td>5.6</td>
<td>38</td>
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<td>dHR</td>
<td>10.7</td>
<td>9.6</td>
<td>0.5</td>
<td>34</td>
<td>.32</td>
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<tr>
<td>Startle ratio</td>
<td>3.1</td>
<td>1.9</td>
<td>1.8</td>
<td>38</td>
<td>.04</td>
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can probably be attributed to an overall effect of anxiety induced by the anticipation of the exposure treatment in these subjects.

In order to explore the association between the startle response, on the one hand, and the SPQ, BAT, VAS, and HR, on the other hand, two (backward) multiple regression analyses were carried out ($n = 35$).\(^3\) Dependent variables were the pretreatment startle ratio and the posttreatment startle ratio, respectively. The proportion of variance ($R^2$) in startle ratios explained by SPQ, BAT, VAS, and HR operating jointly was only 0.05 for the pretreatment phase and 0.07 for the posttreatment phase. In the backward analyses, none of the above-mentioned predictor variables remained in the final equations. Consequently, the startle response can be considered as independent of the other variables. More detailed information concerning the startle ratio in relation to other common used outcome measures is provided in the correlation matrix (see Table II).

Finally, a regression analysis was carried out with the BAT change score being the dependent variable and the pretreatment startle response ratio, VAS, HR, SPQ, and spider BAT score being the predictor variables ($n = 35$).\(^3\) The results of the regression analysis are summarized in Table III. As can be seen in this table, the startle response ratio explained 16\% of the variance of the treatment effect (beta = .40, $p = .01$). The positive beta value indicates that larger startle ratios are related to larger BAT change scores. Only the pretreatment spider BAT score was a better predictor for therapy success. Yet this finding may simply reflect lower initial

\(^3\) Due to technical problems, HR data for four subjects were not available. In the regression analysis listwise delete was preferred.
BAT scores being associated with more room to move in a upward direction.

DISCUSSION

Three major conclusions can be drawn from the results presented above. First, acoustic probes elicit stronger startle responses in spider phobics during a fear-relevant (i.e., a live spider) than during a pleasant foreground stimulus (i.e., attractive food items). Thus, the present data are in accordance with the results of recent studies (Vrina et al., 1988; Bradley et al., 1990) which show that the magnitude of the startle response in normal subjects is potentiated when unpleasant foreground stimuli are used. In line with the theoretical framework of Lang et al. (1990), one could argue that the obvious negative emotional valence of a live spider for a spider phobic potentiates the startle response and/or that the positive emotional valence of attractive food items inhibits the startle response. As no neutral foreground stimulus was employed in the present study, the results are not decisive in this respect. However, it seems reasonable to assume that the differential responding during the food BAT and spider BAT is carried mainly by the negative affective response to the spider. This suggestion is sustained by the decrease in the ratio of the spider and the food startles after treatment (see below). It should be stressed that in the present study, a considerable difference in relative magnitude could be detected between the startle response during the spider BAT and that during food BAT, despite the fact that patients in general were quite stressed in an-

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<th>Table III. Results of the Regression Analysis</th>
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<td>(n = 35) Revealing the Prognostic Properties</td>
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<td>of the Pretreatment Values of HR, SPQ,</td>
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<td>Startle Response Ratio, BAT, and VAS</td>
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<td>Change Scores of the BAT)</td>
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*The beta value refers to standardized data. Results presented were obtained from the equation in which all variables were included.
ticipation of the exposure treatment. Furthermore, it is worth noting that
this effect was equally potent whether the food BAT—spider BAT or the
spider BAT—food BAT order was used.

Second, as a result of the one-session exposure in vivo, the relative
(as well as the absolute) magnitude of the startle probe response during
the spider BAT was reduced. Although a test–retest effect cannot be ruled
out (as a no-treatment control group was lacking), it seems reasonable to
suggest that this decrease was brought about largely by the treatment. This
suggestion is sustained by the finding that the magnitude of the spider startles
was lower after treatment, while the food startles remained unaffected.
The reduction occurred notwithstanding the fact that, in general, subjects
were closer to the spider after treatment than before treatment. In case
the posttreatment probes would have been presented with the spider at
the same distance as during the pretreatment BAT rather than at the point
of maximal tolerance, an even greater reduction of the startle response
during the spider BAT might have occurred. As the BAT prevailed for
clinical reasons, the former option was impossible to realize. Nevertheless,
the present results demonstrate that even under suboptimal (i.e., clinical)
conditions, a treatment effect on startle responses can be documented.
This, of course, stresses the robustness of phenomenon under considera-
tion. Third, the eyelid startle of spider phobics appears to be relatively
independent of other outcome measures such as the SPQ, BAT, and HR.

Taken together, the results of the present study sustain the suggestion
made by Vrana et al. (1988) that the startle response might be a fruitful
outcome measure. However, not all subjects who benefited from the treat-
ment (as indexed by the dBAT scores) showed a decrease in the startle
probe response during the spider BAT. As a matter of fact, 36% of the
subjects showed an increase in BAT scores which was not paralleled by a
responding decrease in the startle probe response. However, this sub-
group is characterized by the absence of the expected difference between
the pretreatment food BAT and the pretreatment spider BAT startle
responses. Possibly, these subjects' responses to the food were influenced by
a negative affect induced by the mere knowledge that they would be ex-
posed to spiders in the near future.

The present data do suggest that the startle response technique can
be used as an instrument for evaluating treatment effect in groups. The
above-mentioned suboptimal conditions under which this study had to be
performed do not allow any statements about the utility of the startle probe
methodology as a tool for evaluating treatment effects in individuals. In
addition, it is worthy of note that the pretreatment startle response ratio
(spider/food) has prognostic qualities. More specifically, the proportion of
explained treatment effect is about 16%. On the one hand, this might seem
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impressive, particularly given the numerous potential sources of error in the startle response methodology used here. On the other hand, from a clinical perspective this 16% is, at best, very modest, especially if one considers that it is difficult to create more favorable conditions in clinical practice. Thus, the present result may be seen as promising for the future use of the startle probe methodology as a prognostic tool. Meanwhile, it would be premature to recommend such methodology as a prognostic tool on basis of the present study. In addition, it should be noted that our subjects suffered from a simple phobia. Further research is needed in order to investigate whether similar effects can be demonstrated in other more complex anxiety disorders.

In sum, the current data demonstrate that spider phobics show relatively greater eyblikl startles in the presence of a spider than in the presence of attractive food items. Furthermore, the present study suggests that this differential responding is affected by treatment. In addition, the results suggest that the startle probe response is a fruitful outcome measure that is independent from commonly used outcome measures. Finally, although this study is far from conclusive regarding the prognostic properties of the startle response, the present findings can be taken as promising.

ACKNOWLEDGMENTS

The authors wish to thank the therapists Germie van den Berg and Idith Lavy for treating the patients and Dorien Wolfs for scoring the data.

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