Waning of panic sensations during prolonged hyperventilation

MARCEL A. VAN DEN HOUT,† PETER DE JONG,† JAN ZANDBERGEN‡ and HARALD MERCKELBACH†

†Department of Mental Health Sciences/Experimental Psychopathology and
‡Department of Clinical Psychiatry/Experimental Psychopathology, Limburg University,
P.O. Box 616, 6200 MD Maastricht, The Netherlands

(Received 19 January 1990)

Summary—Recent theories about panic emphasize that a hyperventilatory positive feedback loop is involved in panic: catastrophic misinterpretation of bodily sensations may trigger anxiety, anxiety may stimulate hyperventilation, hyperventilation may promote the salience of feared sensations etc. Such models leave unexplained how and when panics come to an end.

It was hypothesised that panic with hyperventilation may end because pronounced hyperventilation becomes, in the course of time, less powerful in generating perceivable bodily sensations. Twenty healthy subjects hyperventilated forcefully and experienced clear panic symptoms as defined by DSM III*. When pCO2 was kept 55% below base line for 90 min, panic symptoms waned. The mean intensity of the symptoms declined as did the number of symptoms occurring. No panic symptoms were observed in the control group (n = 20) who ventilated normally.

In so far as hyperventilation is involved in the positive feedback loops that characterize panic, panic attacks may be time-limited because sensations induced by hyperventilation become less salient even if massive hyperventilation continues.

As to the explanation of the reported phenomenon, it is suggested that, apart from habituation, local physiological changes due to prolonged hyperventilation may produce a decrease in interoceptive input.

INTRODUCTION

Panic patients are frightened by bodily sensations that happen to accompany extreme anxiety and panic attacks have been conceptualised as clinical manifestations of positive feedback loops. Bodily sensations are catastrophically misinterpreted, producing fear which intensifies the very feared sensations etc. While this model has received considerable empirical support (Rachman & Maser, 1988; Clark, Salkovskis, Gelder, Koehler, Martin, Anastasiades, Haakman, Middleton & Jeavons, 1988; McNally, 1990) it is incomplete. The model implies that panics, once started, continue forever. Happily, they do not. Why? What factors determine the termination of panics?

Sensations feared by panic patients are highly similar to the ones produced by hyperventilation. When asked to voluntarily hyperventilate for 2 or 3 min, approx. 2/3 of panic patients report that the ensuring symptoms are the very sensations occurring during panic (Garsen, Veenendaal & Bloemien, 1983). This suggests that in at least some patients anxiety intensifies feared sensations via hyperventilation. While piloting a different study we made an unexpected observation. Healthy Ss who profoundly hyperventilated initially reported DSM III* defined panic sensations. If hyperventilation continued, however, sensations tended to decline within 45 min, despite the pCO2 remaining constantly extremely low.

If prolonged hypocapnia becomes increasingly less effective in producing sensations this may be a mechanism involved in the termination of panics that are initially maintained by hyperventilation.

As a first step to elucidate the time limitedness of panic attacks we tested the hypothesis that hyperventilation induced panic sensations wane over the course of persisting hypocapnia.

METHOD

Subjects

Forty healthy students (36 male; 4 female; mean age 23 yr) volunteered to participate.

Assessment

pCO2 was assessed by means of a Could Godart Mark III capnograph. Occurrence of panic symptoms was indicated on a check-list containing 14 items. For each item, responses were given on a 100 mm VAS scale ranging from 0 (absent) to 100 (very strong).

Items 1–11 were physical panic sensations derived from DSM III*. Items 12, 13 and 14 were also derived from DSM III* and asked for fear of dying (item 12), of going crazy (item 13) or doing something uncontrolled (item 14).

Procedure

Ss were randomly assigned to an experimental condition (hyperventilation group) or to a control condition (normoventilation group). During the week before the actual experiment, the Ss in the hyperventilation group visited the laboratory once, when they were trained in hyperventilating.

Throughout the actual experiment, Ss were breathing through the capnograph mask. After a 15 min pCO2 base line had been obtained, Ss scored the VAS scales. The experimental intervention started with a 2 min extreme hyperventilation. The

†To whom all correspondence should be addressed.
rationale was that from earlier studies it is known that restoration of hypocapnia is slow (see for this 'fly wheel' effect Eldridge, 1973). The 2 min extreme hyperventilation was interspersed to facilitate subsequent hyperventilation. After this period of 2 min, the Ss again filled in VAS scales and were instructed to reduce hyperventilation somewhat; pCO₂ had to remain at 50% of its base level. The continuous capnographic display provided the necessary bio-feedback. VAS scores were obtained at 30, 60 and 90 min after hyperventilation had started.

The 20 Ss in the control condition breathed through the capnograph but did not receive breathing instructions. VAS scales were scored at the same intervals as in the experimental condition.

RESULTS

All Ss proved well able to follow the breathing instructions. In the experimental group, CO₂ dropped to 34% during the 2 min phase, and it remained at approx. 45% during the rest of the experiment. CO₂ changes did not occur in the control condition (see Fig. 1). One-way ANOVA with repeated measures in the experimental group was highly significant \[ F(4,76) = 110.4, P < 0.0001 \]. Two-way ANOVAs with repeated measures involving Condition (hyperventilation vs normal ventilation) as a between group factor and Time (base line, and 2, 30, 60 and 90 min after hyperventilation in the experimental group) as a within group factor, were carried out for each of the bodily panic symptoms defined by DSM III R. Mean scores and \( F \) ratios are given in Table 1.

Except for symptom 7 (nausea; see Table 1), there were significant condition effects on all symptoms. For all 11 symptoms, ANOVA showed significant Condition × Time interactions, reflecting the fact that symptom occurrence was due to hyperventilation.

The same pattern [Condition Main Effect \( F(1,36) = 34.7; P < 0.001 \). Time Main Effect: \( F(4,144) = 14; P < 0.001 \); Condition × Time: \( F(4,144) = 19.9; P < 0.001 \)] emerged when all 11 symptoms were averaged at the 5 measurement points. Values of average scores are given in Fig. 1.

Not only symptom intensity but also the mean number of symptoms present at all (VAS score > 10 mm) declined in the experimental group there were on the average 5.1/11 symptoms during base line and 9.5/11; 8.2/11; 8.1/11 and 6.3/11 during later measurements [\( F(4,76) = 16.21; P < 0.001 \)].
Table 1

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Base line</th>
<th>2 min</th>
<th>30 min</th>
<th>60 min</th>
<th>90 min</th>
<th>Condition (d.f. = 1,38)</th>
<th>Time (d.f. = 4,152)</th>
<th>C × T (d.f. = 4,152)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Dyspnea</td>
<td>Experimental</td>
<td>4.9</td>
<td>22.9</td>
<td>11.6</td>
<td>5.7</td>
<td>7.2*</td>
<td>4.8*</td>
<td>3.5*</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>3.6</td>
<td>4.3</td>
<td>4.1</td>
<td>3.1</td>
<td>3.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Dizziness</td>
<td>Experimental</td>
<td>2.4</td>
<td>31.8</td>
<td>17.4</td>
<td>17.8</td>
<td>11.5</td>
<td>5.0†</td>
<td>11.3†</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>11.7</td>
<td>4.2</td>
<td>2.5</td>
<td>3.0</td>
<td>2.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Palpitations</td>
<td>Experimental</td>
<td>0.9</td>
<td>20.9</td>
<td>11.5</td>
<td>11.9</td>
<td>9.1</td>
<td>2.7*</td>
<td>4.2*</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>5.2</td>
<td>2.0</td>
<td>1.2</td>
<td>1.5</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Trembling</td>
<td>Experimental</td>
<td>3.6</td>
<td>39.8</td>
<td>27.4</td>
<td>15.8</td>
<td>9.7</td>
<td>7.4†</td>
<td>10.0†</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>7.6</td>
<td>2.6</td>
<td>2.0</td>
<td>0.9</td>
<td>1.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Sweating</td>
<td>Experimental</td>
<td>7.8</td>
<td>33.1</td>
<td>16.2</td>
<td>13.7</td>
<td>4.5</td>
<td>5.3†</td>
<td>8.0†</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>10.2</td>
<td>1.8</td>
<td>1.6</td>
<td>1.1</td>
<td>1.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 Choking</td>
<td>Experimental</td>
<td>0.8</td>
<td>18.5</td>
<td>4.4</td>
<td>2.6</td>
<td>1.1</td>
<td>5.5*</td>
<td>7.6†</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>0.8</td>
<td>2.1</td>
<td>1.8</td>
<td>1.6</td>
<td>1.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 Nausea</td>
<td>Experimental</td>
<td>1.3</td>
<td>16.8</td>
<td>3.8</td>
<td>5.8</td>
<td>1.8</td>
<td>NS</td>
<td>3.7*</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>7.4</td>
<td>2.1</td>
<td>1.2</td>
<td>0.8</td>
<td>1.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 Derealisation</td>
<td>Experimental</td>
<td>3.3</td>
<td>35.6</td>
<td>18.0</td>
<td>16.8</td>
<td>16.3</td>
<td>4.6*</td>
<td>7.1†</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>6.0</td>
<td>1.9</td>
<td>1.7</td>
<td>1.6</td>
<td>1.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 Paresthesia</td>
<td>Experimental</td>
<td>3.5</td>
<td>56.0</td>
<td>43.5</td>
<td>35.2</td>
<td>11.9</td>
<td>16.7†</td>
<td>20.9†</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>6.9</td>
<td>3.6</td>
<td>0.9</td>
<td>1.7</td>
<td>2.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 Flashes/chills</td>
<td>Experimental</td>
<td>1.2</td>
<td>25.5</td>
<td>15.5</td>
<td>16.5</td>
<td>3.6</td>
<td>3.9†</td>
<td>6.6†</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>7.7</td>
<td>2.6</td>
<td>2.0</td>
<td>3.5</td>
<td>2.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11 Chest pain</td>
<td>Experimental</td>
<td>0.7</td>
<td>16.3</td>
<td>3.9</td>
<td>2.2</td>
<td>2.0</td>
<td>8.5†</td>
<td>9.1†</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>2.1</td>
<td>1.3</td>
<td>0.9</td>
<td>1.4</td>
<td>1.1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* F ratio significant: P < 0.01.
† F ratio significant: P < 0.001.

On all three anxiety items there was a slight mean increase after 2 min due to 3/20 Ss scoring higher than 10 mm on the 100 mm VAS scales. At the other measurement points, no scores exceeding 10 mm were obtained.

DISCUSSION

What determines the termination of panic attacks? Assuming that a positive sensation–anxiety–hyperventilation–sensation loop is (often) involved, the present data suggest an answer. Panic sensations occur during hyperventilation but they become gradually less salient during, and despite, persisting extreme hypocapnia.

What mechanisms are involved? Perhaps the observation is a special case of habituation. Symptoms may have declined because they lost their novelty in the course of time and attendance may have been inhibited. Apart from a decline in symptom severity there was also a gradual disappearance of noticeable sensations. Thus, in so far as habituation was responsible for the disappearance of symptoms, one should assume that interoceptive cues had habituated below an interoceptive threshold of perception.

Whereas pCO2 was constantly low, the interoceptive input itself may have declined and the concept of habituation may not form an exhaustive description of the observed phenomenon. Three DSM III symptoms may illustrate the point.

Concerning paresthesia there was a dramatic increase after hyperventilation started, but also a drastic decline during prolonged hyperventilation. Alkalosis induced by hyperventilation lowers the concentration of ionized calcium in the extracellular fluids and this decrease of Ca2+ concentration lowers the threshold for excitation of muscle and nerve cells (Schmidt & Thews, 1983). It follows that when the free calcium concentration decreases, the nerve and muscle cells become more excitable and this explains the paresthesia after the onset of hyperventilation. The lowered concentration of ionized calcium in the extracellular fluids induced by hyperventilation also causes the parathyroid glands to increase their rate of secretion (within minutes), which results in a rapid rise of the Ca2+ concentration in the blood (Guyton, 1981) and this counteracts the hypocapnia induced by alkalosis. Likewise, forced hyperventilation produces decreases in K+ within an hour, which potentially affects the lowered neuronal excitability (Schmidt & Thews, 1983; Garson, 1986; Garcia, Lai, Atterby & Brown, 1971). Such homeostatic electrolytic mechanisms could explain why the symptoms of paresthesia in the experimental group decreased during the stable hypocapnic phase. As for decreases in dizziness and depersonalisation, it is plausible that compensation mechanisms in the brain were responsible. After prolonged hyperventilation, there is a pH compensation in the Cerebro Spinal Fluid by an active exchange in HCO3−, resulting in approximately normal CNS pH (Severinghaus & Mitchell, 1963).

In sum, though habituation may have played a role in reduction of symptoms, it should not be ruled out that interoceptive input declined through a negative feedback mechanism of electrolytes (paresthesia) or of blood gases (dizziness and depersonalisation). Experimentation may settle this issue.

The data were obtained from normal volunteers and some comment should be made on the generalizability to clinical panics. First, although hyperventilation seems common in clinical panics, not all panics are attended by overbreathing (Margraf, Ehlers & Roth, 1987). The termination of non-hyperventilatory panics obviously requires other explanations from the one given here; some thought-provoking suggestions were recently made by Ehlers and Margraf (1990).

Would high anxiety accompanying clinical panic, interfere with the symptom diminution as observed? If high anxiety would counteract symptom diminution one would, in the present data set, expect a negative correlation between initial anxiety and subsequent reduction of bodily symptoms. In fact (in line with Solomon’s opponent process theory) we found that subjective anxiety during the 2 min intense hyperventilation correlated 0.84 with symptom-reduction from 30 to 90 min;
when the initial correlation between anxiety and sensations \((r = 0.66)\) was partialled out, initial anxiety still correlated positively with symptom diminution \((r = 0.38; P = 0.054)\). The absence of a negative correlation (and the presence of a Solomonian positive one) suggests that there is at least no a priori reason to believe that high anxiety during clinical, hyperventilatory panics interferes with decline in hyperventilation produced symptoms over time.

Psychological theories of panic should incorporate mechanisms involved in panic termination. Sensation diminution during hypocapnia is a possible candidate.

REFERENCES


