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Peripheral Psychophysiological Reactivity to Mental Tasks in Children with Psychiatric Disorders

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Summary. Peripheral psychophysiological reactivity (skin conductance and heart rate changes) to mental activity tasks (imagery and listening to music) was examined in child psychiatric day or in-patients with conduct and emotional disorders. Children with predominant antisocial symptomatology showed higher electrodermal than cardiovascular reactivity to the experimental tasks, whilst children with predominant neurotic symptoms showed more marked cardiovascular reactivity. No statistical differences between the groups emerged in response to listening to music, but antisocials were more responsive (with higher skin conductance level increases) to imagining pleasant situations, whereas neurotics were more reactive (increased heart rate levels and decreases in skin conductance) to imagining unpleasant situations. The results are compatible with an enhanced biological responsiveness by antisocials to reward and with neurotics experiencing an unusually marked sense of threat and withdrawal to aversive stimuli.

Key words: Psychophysiology – Children – Conduct disorders – Emotional disorder – Mental activity tasks

Introduction

Psychophysiological research in psychopathology aims to further our understanding of the biological and psychological mechanisms involved in behaviour disorders. Work in adults has used psychophysiological measures as biological indicators of psychological states or symptoms, as markers for different types of psychiatric disorders and to assess the differential effects of environmental events on patients and controls (Zahn 1986). In the area of child development, individual physiological reactivity to various standards and common events has been well documented and is regarded as a particularly useful method for testing reactivity before speech has developed (Venables 1980).

The potential of the method to further our understanding of psychopathological states in childhood has barely been explored (Taylor 1980). This is surprising since children's limited ability to verbalize subjective experiences and feelings should make a more indirect and "objective" biological exploration particularly promising. Jones (1935, 1960) studied electrodermal and behavioural responses in normal children and adolescents to a variety of different stimuli and showed the capacity of those which were unexpected and of high intensity, involving mental activity or having emotional significance, to elicit particularly marked electrodermal changes.

We set out to test whether this strategy could be used to discriminate children with different types of psychiatric disturbance (emotional and conduct disorders) as a way of exploring associated biological mechanisms which may predispose children towards the expression of different types of psychopathology. Because fantasy is a prominent mental activity in childhood, we devised tasks where children were asked to imagine emotionally charged situations and contrasted these reactions with those to emotionally neutral and relatively passive mental activity tasks (listening to music). Studies in adults have demonstrated the value of measuring arousal changes during imagery tasks as a means of studying anxiety and stress in clinical samples (Pitman et al. 1987).

The specific questions addressed in this preliminary report are:

1. Are measures of psychophysiological reactivity (skin conductance and heart rate) to mental activity tasks able to discriminate children with conduct disorders from children with emotional disorders? Are imagery tasks with different emotional components better discriminators than passive and neutral tasks (listening to music)?
2. Since work in adults suggests that there is a closer relationship of physiological measures with symptoms than with syndromes (Zahn 1986), does this also apply to children?

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Subjects and Methods

Fifteen day or in-patients (8 girls and 7 boys) attending Booth Hall Hospital Child Psychiatry Unit with clinical conduct ($n = 9$) or emotional ($n = 6$) disorder ICD-9 diagnoses (International Classification of Diseases 9th Edition, WHO 1978) were included in the study. We scrutinized the psychiatric case notes to confirm the clinical diagnoses. The children had severe or protracted problems, and associated clinical features such as hyperkinesis, depression, school refusal and encopresis were common. Four had low average or borderline intellectual function and five had learning problems. Associated physical problems were also commonly noted, including obesity, visual disorder or epilepsy. Most children came from broken families and/or were in stressful psychosocial circumstances. Three were on medication (antidepressants, anticonvulsants). None of the subjects had hearing difficulties or exhibited any difficulties in understanding the experimental procedures.

Assessment of Psychological Symptomatology

All children were attending the Hospital school and teachers were asked to complete the Rutter B Teacher Questionnaire (Rutter et al. 1970). This consists of 26 statements describing the child's behaviour and emotions, which are rated on a 3-point scale. As well as individual and total behavioural scores, neurotic, antisocial, hyperactive and peer relationship sub-scores are derived by adding up the relevant individual items.

In order to test whether symptoms were better correlates of physiological patterns than syndromes, as well as subdividing the total sample according to syndromic diagnostic criteria (subjects with clinical conduct or emotional disorder diagnoses), we classified them for analysis according to predominant Rutter B questionnaire symptomatology, into those with high neurotic or high antisocial scores. High scores indicated that there was at least a 2-point difference between the neurotic and antisocial questionnaire scores of the child. Of the 15 children, 10 could so be classified.

Statistical methods were used as appropriate to compare the groups (the Mann-Whitney non-parametric test).

Apparatus and Experimental Procedure

Heart rate was recorded using a Biodata PA400 physiological signal amplifier (range 0.5 mV; low pass filter 30 Hz; high pass filter 2 ms). Heart rate signal was picked up from subjects using disposable electrodes (one on each wrist and one on left ankle) connected to the PA400 via an EEG headbox.

Skin conductance level (SCL) was monitored using an "Electronics Development" skin conductance meter. A constant voltage of 0.5 V d.c. was applied via a pair of 9.3 mm silver/silver chloride disc electrodes. Electrodes were applied to the volar surface of the medial phalynx of the first two fingers of the subject's left hand. Dragard electrode gel was used as electrolytic medium.

A digital/computer record was kept of skin conductance and heart rate during the experiment using a purpose-designed Biodata program. The program is run on a Sirius 1 computer. Conversion of the data from analogue to digital form was achieved using a Biodata Microlink with an analogue input module to receive skin conductance readings and a heart rate module for the PA400 output. Heart rate was recorded as beat to beat interval. Both input modules were sampled at a rate of 10 times per second. Collected data were recalled for later analysis by a Biodata transient capture program. Owing to technical difficulties heart rate data were recorded from only 12 of the cases.

During the first part of the experiment, the child's heart rate and SCL were recorded at rest and in response to sounds. The results of this part of the experiment have been reported elsewhere (Garralda et al. 1989). During the second part of the procedure an audiotape was played through a loudspeaker. This consisted of four mentally stimulating tasks, each lasting 1 min, as follows:

1. The subjects were asked to imagine something "nice" happening to them.
2. Next they listened to soft music.
3. They were asked to imagine something "nasty" happening to them.
4. They listened to heavy rock music.

Before the two imagining tasks the children listened to 30 s of instructions as to what they were required to picture. Some examples were given, i.e. for NICE: "imagine you are being congratulated for good work at school or playing with your friends"; for NASTY: "being told off for something you have not done or being chased by a monster". It was stressed to the children that these were only examples and that they should concentrate on what they thought of as nice or nasty. Each task was followed by 1-min silence periods.

Data Analysis

Assessment of Psychophysiological Change during Tasks. We computed mean heart rate and eletrodermal values for each of 11 experimental periods (2 instructions, 4 main tasks and 5 silence periods: see Table 1). The means were derived from readings carried out at regular intervals (8 readings during instruction periods and 14 during main tasks and silence periods).

To assess changes in arousal, we compared electrodermal and heart rate levels during each period with those during the immediately preceding one using a measure of percentage or relative change. This was to allow for the fact that comparing individuals or groups in different situations has to take into account their varying initial basal levels: the magnitude of this will effect their capacity for change (law of Initial Value; Levey 1975; Stern et al. 1980). The formula used to calculate percentage change was:

$$\left(\frac{\text{Mean level during period}}{\text{mean level during preceding period}} \times 100\right) - 100.$$

For example, for two consecutive mean SCL values of 4.57 and 4.69, the mean percentage change would be +2.6 (i.e. $[4.69/4.57 \times 100] - 100 = 2.6$). For each period both the magnitude and the direction of change were recorded.

Table 1. Mean heart rate and skin conductance levels during each period, based on predominant antisocial or neurotic traits

Period	Mean electrophysiological levels during each period			
	Skin conductance level (μΩ)		Heart rate (beats/min)	
	Antisocial ($n = 4$)	Neurotic ($n = 6$)	Antisocial ($n = 4$)	Neurotic ($n = 5$)
Silence	4.57	4.20	77.9	97.1
"Nice" instr.	4.69	4.15	76.3	101.7
Imagine "nice"	5.10	4.24	77.3	105.0
Silence	5.87	4.19	76.5	102.4
Soft music	6.39	4.22	77.0	100.3
Silence	6.04	3.99	76.8	103.3
"Nasty" instr.	6.55	4.23	76.8	101.1[a]
Imagine "nasty"	6.75	3.89	75.7	103.9[a]
Silence	7.56	3.86	74.8	102.6[a]
Heavy music	7.99	4.12	74.8	102.5[a]
Silence	7.94	4.13	75.9	104.8[a]

[a] $n = 4$

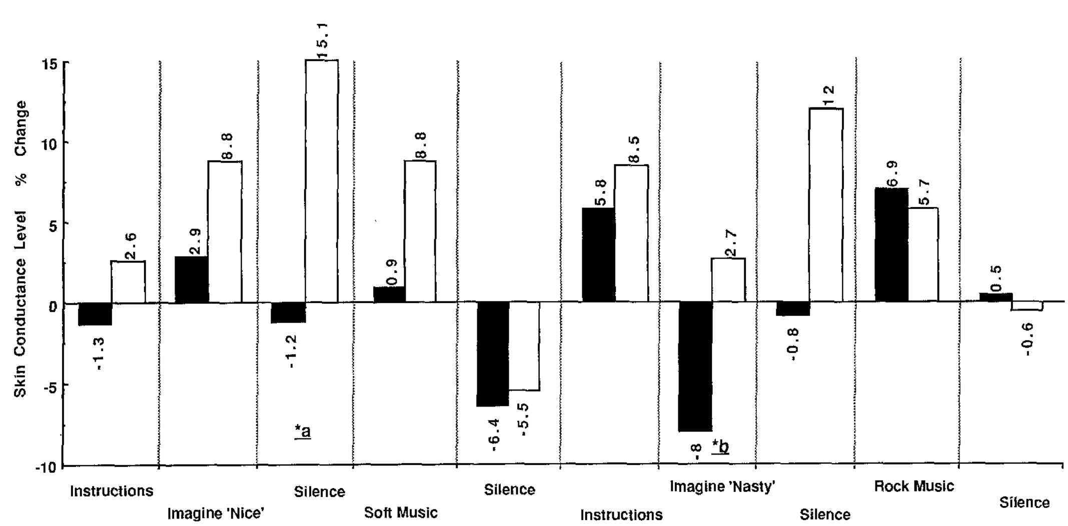

Fig. 1. Changes in skin conductance levels in subjects with predominant neurotic and antisocial symptomatology. ■ Neurotics ($n = 6$); □ antisocials ($n = 4$). Statistically significant differences (Mann-Whitney): * a $P = 0.01$; * b $P = 0.016$

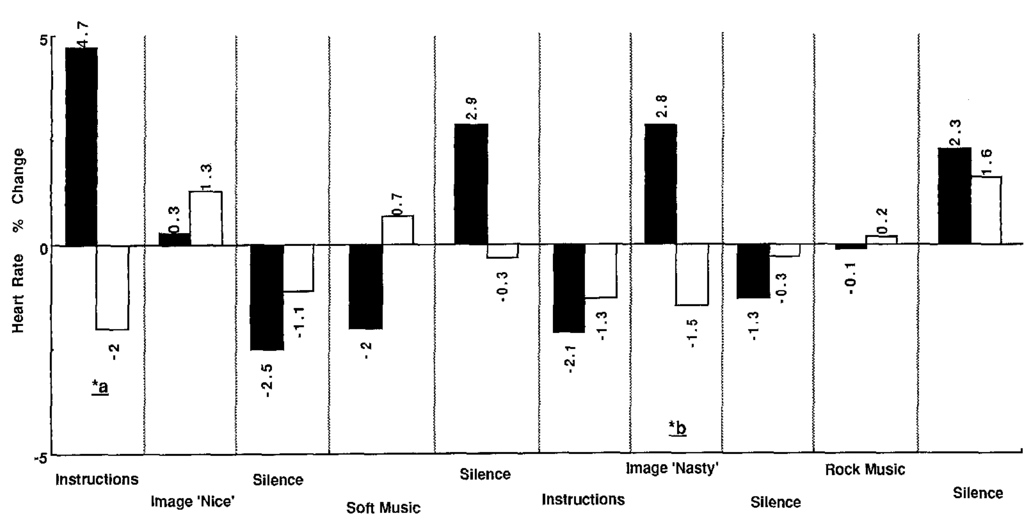

Fig. 2. Changes in heart rate levels in subjects with predominant neurotic and antisocial symptomatology. ■ Neurotics ($n = 5$ for first five periods; $n = 4$ for last five); □ antisocials ($n = 4$). Statistically significant differences (Mann-Whitney): * a $P = 0.01$; * b $P = 0.041$

Results

The discrimination power of the psychophysiological measures proved to be superior when the children were classified in terms of predominant symptomatology (antisocial or neurotic) on the Rutter B questionnaires than in relation to clinical diagnoses. We therefore present here detailed results on the psychophysiological values and changes (computed for each period as raw values and as percentage change, relative to the preceding period) across the four different main tasks, for subjects grouped for main symptomatology.

All children co-operated with the experimental procedure and actively attempted the imagination tasks; approximately half in each symptomatic group reported success in this. We observed that some children appeared to find it difficult or were reluctant to "let the image go" and remained involved with the imagined task during the ensuing silence period.

Table 1 lists mean SCL and heart rate values during each experimental period. It can be seen that as the experiment proceeded, there was a gradual and steady increase in SCL in the antisocial but not in the neurotic group. The mean heart rate values and variability were, however, higher in the neurotic than in the antisocial group.

Figure 1 shows the SCL changes in the neurotic and antisocial groups throughout the different experimental periods computed as percentage change. This analysis confirms that antisocial subjects had a clear overall tendency, particularly marked during the imagining periods, to respond more vigorously and positively, increasing their arousal levels. It was noticeable that the silence periods following the imagining tasks led to marked arousal changes in them. They showed significantly higher SCL increases than neurotics in the silence period following the pleasant imagining task, whilst neurotics had significantly more pronounced decreases during the aversive imagining task.

The analysis of heart rate changes (Fig. 2) revealed a degree of similarity with the electrodermal results in that neurotics showed significantly more reactivity or heart rate acceleration than antisocials to the aversive imagining task. They also showed significantly more acceleration to the first experimental activity (instructions to pleasant imagining).

When the children were classified according to clinical diagnoses (conduct or emotional disorders) no differences were found in heart rate changes. However, the groups could be discriminated on SCL measures during the imagining tasks in a pattern quite consistent with the previous analysis of neurotic and antisocial children (pleasant imagining task: 9.9% increase in conduct disorders and 2.7% decrease in emotional disorders; $P = 0.05$) (aversive imagining task: 2.5 increase in conduct disorders and 5.5 decrease in emotional disorders; $P = 0.04$).

Discussion

This preliminary investigation proved effective in differentiating the modulation of arousal of severely affected children with conduct and emotional disorders during mental activity tasks. The discrimination power of the psychophysiological measures was better when the children were classified according to predominant symptomatology than in relation to clinical diagnoses and, as hypothesized, the imagining tasks demanding an active emotional involvement from the child proved generally to be more efficient discriminators than the passive listening-to-music emotionally neutral tasks.

Antisocials were generally more reactive electrodermally whereas neurotics showed more heart rate reactivity. These findings are in line with the results of the first part of the experiment showing more electrodermal responses to sound in antisocials but higher basal heart rate levels in neurotics (Garralda et al. 1989).

In this experiment antisocials when contrasted with neurotics were particularly responsive to tasks with a positive emotional component. This is consistent with the notion that these children are unusually sensitive to reward. Previous work on hyperactive children, a group very likely to have similarities to our antisocials, has reported unusually high impulsive and arousal responses accompanying the administration of rewards in these children (Douglas 1984). Excessively high biological responsivity to pleasant events and insufficient response to aversive ones might be one of the mechanisms involved in the psychopathology of childhood antisocial behaviour.

The pattern of responses in neurotics seemed indicative of better focused attention to the first instructional task (as shown by the higher heart acceleration response) and of a special reactivity or sensitivity – a tendency to withdraw, more sense of threat – when confronted with aversive stimuli, as shown by decreases in SCL and heart rate acceleration during the aversive imagining task. This pattern might underlie a behavioural style of excessive biological responsivity and avoidance of aversive situations and a consequent failure in learning to cope with unpleasant subjective experiences.

In conclusion, the use of psychophysiological responses to tasks with varying emotional and alerting connotations appears promising in helping us to understand the biological mechanisms associated with childhood psychopathology. The findings, however, are tentative and need confirming and replicating in larger more homogeneous samples of less severely disturbed children. Future work may profitably test our hypotheses further: (1) by comparing disturbed children with psychologically healthy controls, (2) by re-examining subjects after recovery to ascertain whether the findings represent a state or a trait phenomenon, and (3) by exploring the therapeutic potential of any insights arising into psychobiological anomalies in disturbed children.

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