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Spatial exploration behaviour in an extended labyrinth in patients with panic disorder and agoraphobia

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Abstract

Finding one's way through a labyrinth is both stressful and panicogenic for individuals suffering from panic disorder with agoraphobia (PDA), whilst normal subjects experience no stress. In this study the spatial exploratory behaviour of 15 subjects suffering from PDA, together with 15 patients with generalised anxiety disorder (GAD) and a further 15 normal control subjects — all female — was analysed during a walk through a labyrinth-like basement in an attempt to find the exit. The study covered behavioural variables, i.e., anxiety levels whilst route-searching and exploration-related movements (the frequency and intensity of trunk and head rotation, touching oneself and folding one's arms across the chest) and also physiological variables (blood pressure, heart rate) before and after the labyrinth walk. Data obtained in the PDA subjects were compared with those of the GAD and control subjects, and it was found that the PDA subjects' high blood pressure was associated with disturbed exploratory activity, which restricted their contact to the environment. As a consequence, they did not detect navigation signals to find the right route to the labyrinth exit. The interpretation focused on the analysis of the structure of human extraterritorial fear.

Keywords: Extraterritorial fear; Spatial disturbance; Blood pressure; Route finding

1. Introduction

From the aetiological point of view, panic disorder with agoraphobia (PDA) qualitatively differs from generalized anxiety disorder (GAD) (Marks and Nesse, 1994; Barlow, 1988). PDA has been postulated as a neuro-psychological defect (Klein, 1981) that involves several specific response sets, such as separation anxiety, shyness and high behavioural inhibition capacity (Kagan et al., 1990; Gray and McNaughton, 2000). The co-morbidity of panic with other anxiety disorders and with depression has been repeatedly documented (Andrews et al., 1990; Bouton et al., 2001). The behavioural and physiological components of panic–agoraphobic symptoms (see American Psychiatric Association, 1994) as elements of the defensive behaviour pattern of humans play an adaptive role but are frequently mobilised in situations of inadequacy, creating and maintaining psychopathological states (Nesse, 1987). Based on data

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from examinations concerning human anxious attachment and the neuropsychological background, a panic with agoraphobic syndrome is considered to be a typical 'new object reaction' or neo-phobia (Marks, 1987), which is characterised by a slow habituation rate in orientation reaction, by intensive arousal changes, and by intensive, general physiological reactions to open-field and unaccustomed situations (Roth and Telch, 1986; Kagan et al., 1990). In typical agoraphobic situations (e.g., public places, a crowd), both open and enclosed spaces may be considered as a biologically based precondition, and it might be suggested that agoraphobia is a pathological form of the extraterritorial fear that many species show outside their home range and manifest in body, head and trunk movements, in walking speed, in gait and in forms of exploration in new situations (Marks, 1987; Schmitt and Atzwanger, 1995; Atzwanger and Schmitt, 1997). The symptoms of PDA are built upon a prepare, "hard-wired alarm system" that responds to an immediate perceived threat to the individual's well-being (Hugdahl and Öst, 1985; Nesse, 1987; Fanselow, 1994; Jacob et al., 1996; Öhman and Mineka, 2001). The low fear threshold significantly decreases the individual's survival potential, causing a high level of physiological impairment and long-term morbidity (Markowitz et al., 1989). From the point of view of survival function, we are focusing on the clinical fact that agoraphobic patients are inclined to reduce attention to the perceptual field when their level of phobic and panic anxiety is high (Watts et al., 1986), to pay too much attention to safety signals (Thorpe and Salkovskis, 1998), to exhibit cognitive (Foa and Kozak, 1986) and behavioural avoidance (Eysenck, 1976; Rachman, 1976), and to experience distress in the processing of the contextual or spatial signals of their current environment (Kallai et al., 1995; Nadel and Jacobs, 1996). This anxiety-triggered, biologically founded spatial orientation disorder (Jacobs and Nadel, 1985; Watts, 1989) plays a significant role in the genesis of the maladaptive cognitive and behavioural defence patterns that characterize PDA. In phobia, several defensive reactions are observable, such as gaze aversion, rejection of that part of the environment that is related to the fear-inducing object (Watts et al., 1986), and defensive gestures (Masterson and Crawford, 1982), visuo-spatial attention disorder (Dupont et al., 2000), perceptual avoidance (Viaud-Delmont et al., 2000), and behavioural avoidance vector deviation during goal-directed locomotion (Kallai et al., 1996). As noted above, the components of anxiety differ in subjects suffering from GAD versus those with PDA. These groups of patients respond to unfamiliar situations with different defensive patterns.

We hypothesise that the cognitive and behavioural elements of PDA subjects' defensive behaviour are rooted in an evolving history of avoidance behaviour patterns that serve as normal defensive mechanisms to specific forms of stress. However, in PDA sufferers, there is a pathologically low threshold for inborn defensive response. This defensive response pattern is elicited by unfamiliar and strange surroundings, that is, when away from the home or personal territory — very specifically, as observed in the different components of exploratory behaviour and physiological reactions whilst searching for the exit from an unfamiliar and potentially fear-inducing labyrinth. The present study is designed to analyse patterns of cardiovascular reactions and exploration behaviour in PDA, GAD and control subjects. Finding one's way through a labyrinth has been a challenge ever since humans began dwelling in cities. Labyrinth navigation is both stressful and panicogenic for individuals diagnosed as having PDA, and indeed "in vivo" systematic desensitisation or "flooding therapy" often takes place in labyrinth-like supermarkets or in subways. In light of this, we made use of a labyrinth that is, firstly, similar to situations that individuals might ordinarily encounter and, secondly, structured in a way that might test a person's spatial orientation abilities. Using a real-world labyrinth, we compared three groups of subjects (PDA, GAD and control) in respect of their spatial learning performance, and their physiological and behavioural features. Our subjects were first instructed to orient themselves within a real-world labyrinth — i.e., in a Labyrinth Walk (LW), in which they were asked to find a direct route to a designated target: the exit from the labyrinth. We expected individuals with PDA to find such a walk stressful, whilst those with GAD and the normal control subjects were expected to experience no real stress during the walk. Based on our own findings (Kallai et al., 1995, 1999) and on previous studies (Jacobs and Nadel, 1985), we predicted that individuals in the PDA group would show defects in their ability to orient themselves in the current space and would simultaneously show specific exploration movements and defensive cardiovascular reactions.

2. Methods

2.1. Subjects

The male:female ratio of the PDA clinical population is approximately 1:3. It is a widely accepted fact that human males and females can differ significantly in the completion of a spatial navigation task (Sandstrom et al., 1998). With this knowledge in mind, we chose to examine female subjects only. Each patient was recruited from a waiting list and was diagnosed as PDA or GAD by structured interviews (DSM-IV). Control volunteers were interviewed, and only those without psychiatric or significant medical histories were recruited. Subjects comprised 15 individuals with panic with agoraphobia (PDA: mean age = 32.93, S.D. = 9.7), 15 with generalized anxiety disorder (GAD: mean age = 31.47, S.D. = 4.9), and 15 controls (mean age = 34.13, S.D. = 7.6). There were no significant age differences among the groups ($F = 0.39$, $P = 0.67$). The subjects were drug-free for at least 3 weeks. The study was approved by the appropriate review board for human research. Informed consent was obtained from all participants.

2.2. Procedure

2.2.1. Labyrinth walk (LW)

We selected a 142-m-long labyrinth, located in the basement of a hospital, where it was possible for the subjects to explore the labyrinth and to find the way out through the exit, as in a natural, real-life situation (see Fig. 1).

2.2.2. Stage I. Spatial orientation in real space, in a labyrinth-like basement

Whilst standing at the entrance of the labyrinth, each subject was addressed as follows: "We must now go through this basement to the examination room." The subject was then guided slowly from the entrance to the labyrinth to the examination room without further comment.

2.2.3. Stage II. Labyrinth walk task

Upon arriving at the end of the labyrinth — at the examination room — the subjects were given the following instruction: "We have just come through a labyrinth. Please use the same route to return to the entrance-unaided." An assistant with a camcorder then followed the subject, recording her behaviour. Although no subject required help at this stage of the study, an assistant was constantly available to help in case a subject should experience a serious attack of panic or agoraphobic avoidance.

2.3. Data collection

2.3.1. Route finding

The research assistant assigned to observe the subject's behaviour was given a scale plan of the labyrinth copied on 8.5 × 11 in. coordinate paper in which each unit on the paper represented 1 m. The assessor recorded the actual route taken by the subject on this sheet by referring to the videotape shot during the LW.

Comparison of the 'correct' route with the route actually taken by the subject produced a route-finding score. If a subject had correctly negotiated the labyrinth, she would have travelled 142 m. However, if a subject had made an error (e.g., by entering an incorrect passageway), the distance covered before correcting the error was subtracted from the total length of the correct route (142 m). By way of example, if a subject had made a single error, travelling 3 m down an incorrect passageway, the metric of inaccuracy of route finding would be: $3/142 \times 100 = 2.1\%$. The calculated route finding score = inaccuracy score − 100%.

2.3.2. Exploratory movements

The recorded video material showing the subjects' labyrinth walk was replayed in slow motion and analysed by two independent psychologists who acted as "blind scorers"; this yielded an assessment of the subjects' exploratory behaviour. Inter-scorer reliability for the exploratory parameters for the 45 subjects ranged between $\alpha = 0.85$ and $\alpha = 0.91$.

2.3.2.1. Trunk rotation frequency. This score indicates the total number of a subject's trunk rotational movements from the medial axis in a lateral direction (both to the left and to the right) whilst walking. Such a movement was defined as completed at the point when the subject's trunk returned to the medial axis.

2.3.2.2. Trunk rotation intensity (in degrees). This score shows the actual intensity of trunk rotation, but it is totally independent of the actual frequency of such movements. Using a 360° (circular) model, a scorer estimated the degree of rotation. A full circle, i.e., a complete turn, was rated at 360 points (=360°), a half-turn at 180, a quarter-turn at 90 and so on. The number of degrees actually turned was estimated separately by two independent scorers, and the mean figure was used as the final result.

2.3.2.3. Calculation of total head rotation frequency. The calculation relating to the total head rotation frequency was based on the head's horizontal movements precisely as with the trunk rotation frequency.

2.3.2.4. Head rotation intensity total. This score was based upon the subject's turning her head from the medial axis towards either side within the range of 0° to 90° (right or left). When the head was turned rotated at the same time as the trunk, the head rotation intensity was shown in relation to the current medial axis of the trunk.

2.3.2.5. Folding arms across the chest. The total duration (in seconds) of the periods when arms were held folded across the chest during the LW task was noted.

2.3.2.6. Self-touching. This measure involved hand movements toward the medial axis of the body involving several adjunctive hand movements (e.g.,

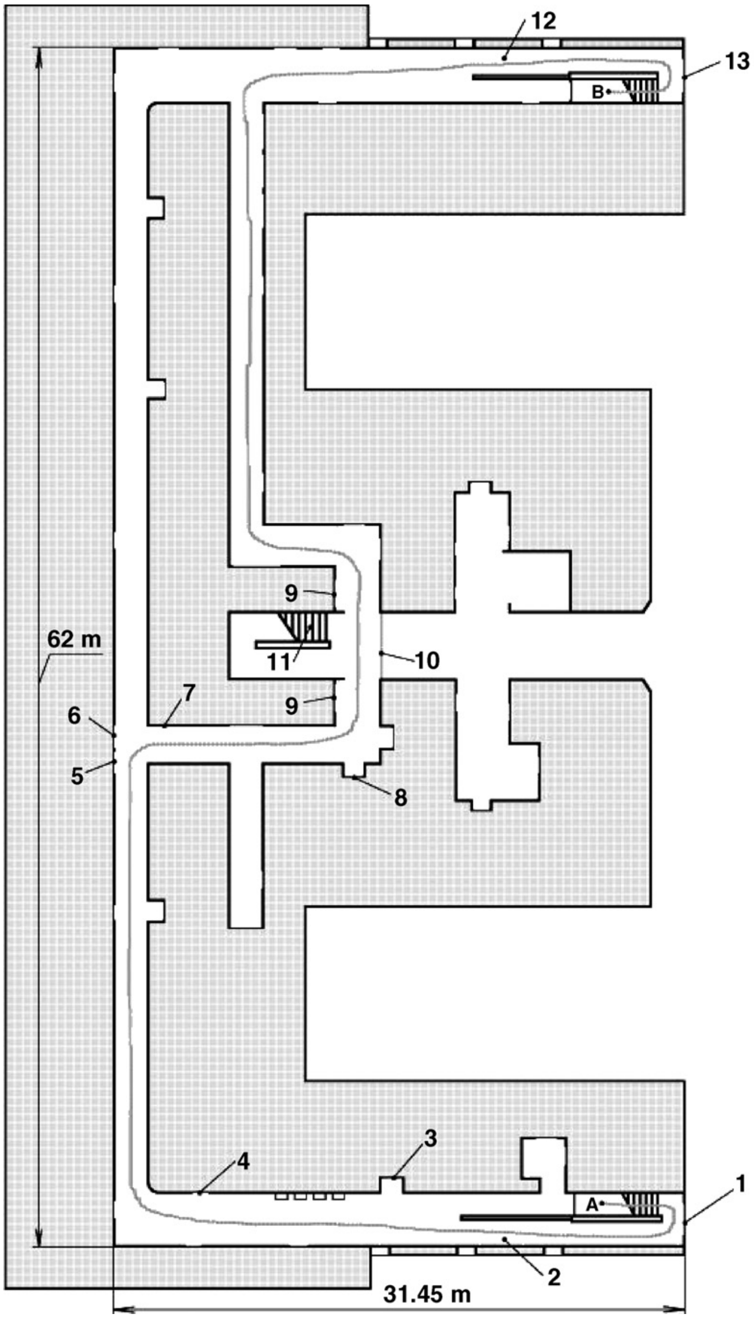

Fig. 1. Map of labyrinth and the subjects' route during the Labyrinth Walk with the landmarks: A. Starting point of the backward route, B. Exit of the labyrinth, 1. Garden gate I, 2. Windows to the garden, 3. Cafeteria, 4. Niche for cleaning tools, 5. Administration Office, 6. MRI examination room, 7. Nature painting on the wall, 8. Neuroscience classroom, 9. Elevator I–II, 10. Emergency exit, 11. Stairs, 12. Morgue, 13. Garden gate II.

touching the head, adjusting clothing, holding arms akimbo, and grasping).

2.3.3. Physiological features

Pre- and post-walk systolic and diastolic blood pressure were measured before and after the LW, with the subject in a sitting position (after 1 min of rest). Pre- and post-walk heart rate were also measured with the subject in a sitting position by a Minolta Pulsox-7 instrument via a photoplethysmographic sensor.

2.3.4. Self-reported anxiety

After completion of the LW, subjects were asked to give a self-report on the intensity of their anxiety during the completion of the LW. Self-reports were rated on a 0–4 scale.

2.4. Data analysis

The data were analysed using SPSS 10.0. Means and standard deviations were calculated to describe the variables under investigation. The differences between variables in the groups were tested by one-way analysis of variance (ANOVA) with Tukey's post hoc comparison. To test for the relationships between the variables, Pearson correlation coefficients were calculated. Association between sociodemographic variables and physiological and exploratory behaviour data were calculated by a multiple regression analysis.

3. Results

In the first step we focused on analysing the general features of the sample, independently of the diagnostic categories. Pearson product-moment correlation analyses were conducted to evaluate the relationships between sociodemographic factors and the physiological, exploratory behaviour, route finding and state anxiety data. No significant relationships with education or age were obtained. Multiple regression analyses were performed with systolic blood pressure as dependent variable in the pre-labyrinth walk condition and physiological, exploration behaviour, route finding, state anxiety and subject's weight as independent variables. The standardized beta (β) for weight was 0.41 ($R^2=0.10$, $F=4.63$, $P=0.03$).

Another regression analysis addressed whether the pre-LW cardiovascular parameters predicted the intensity of the exploratory behaviour elements during the subjects' negotiation of the labyrinth. The stepwise regression analysis on the entire sample between the physiological and exploratory behaviour data showed that pre-systolic blood pressure predicted the frequency of trunk rotation exploration movements ($\beta=0.46$, $R^2=0.20$, $F=12.14$, $P<0.001$), pre-heart rate predicted the frequency of head rotation ($\beta=0.48$, $R^2=0.21$, $F=13.09$, $P<0.001$), and pre-diastolic blood pressure predicted the time of folding arms across the chest ($\beta=0.34$, $R^2=0.08$, $F=5.72$, $P<0.002$), but the cardiovascular preconditions did not predict the intensity of trunk rotation ($F=2.48$, NS), the intensity of head rotation ($F=0.15$, NS) or the frequency of self-touching ($F=0.59$, NS) exploration movements. From another point of view, examination of the predictive power of the exploration movements to the post LW cardiovascular parameters revealed that the frequency of trunk rotation movements predicted elevation in the systolic blood pressure after the LW ($\beta=0.38$, $R^2=0.12$, $F=7.31$, $P<0.01$), the frequency of trunk rotation predicted elevation in the diastolic blood pressure after the LW ($\beta=0.31$, $R^2=0.07$, $F=4.69$, $P<0.03$), and the frequency of trunk rotation predicted the heart-rate elevation after the LW ($\beta=0.44$, $R^2=0.17$, $F=10.59$, $P<0.002$).

A separate regression analysis was conducted between the experience of anxiety during the labyrinth walk and the cardiovascular and exploratory behaviour components of the spatial orientation in LW. It was found that the experience of anxiety during the subject's negotiation of the labyrinth predicted an elevation in the post-systolic blood pressure ($\beta=0.33$, $R^2=0.09$, $F=5.35$, $P<0.026$). On the other hand, elevated pre-systolic blood pressure was a significant predictor of the intensity of anxiety during the negotiation of the labyrinth ($\beta=0.38$, $R^2=0.12$, $F=7.52$, $P<0.009$). In the next analytic step, the predictive power of the cardiovascular component and exploration movements to route-finding performance was examined in the entire sample. The frequency of trunk rotation movements ($\beta=-0.42$, $R^2=0.16$, $F=9.53$, $P<0.004$), and the frequency of head rotations ($\beta=-0.31$, $R^2=0.10$, $F=4.86$, $P<0.03$), were associated with poor route-finding performance. Therefore, subjects who frequently lost their way in the labyrinth also frequently turned their trunks and heads to the left and the right, but this exploration activity did not improve route-finding performance. The next step was to analyse the specific exploratory behaviour patterns in the different diagnostic groups. The effects demonstrated above were to some extent present in different diagnostic groups. The results show that age, level of education, body weight and body height did not play a significant role in the response formation during the LW. ANOVA statistics did not show significant differences in age, level of education, body weight or body height in the three groups of subjects (see Table 1).

A comparison between PDA and GAD subjects' physiological data indicates that PDA subjects have higher pre-systolic and diastolic blood pressure and post-diastolic blood pressure, but they do not differ from control subjects in this respect ($F(2, 43)=4.68$, $P<0.01$; $F(2, 43)=3.53$, $P<0.05$; $F(2, 43)=5.57$, $P<0.01$).

However, PDA subjects display a higher level of self-reported anxiety than do control subjects ($F(2, 43)=3.52$, $P<0.05$). These results may suggest that PDA subjects had a higher rate of anxiety during the LW task, and had a higher blood pressure rate than did the GAD subjects. In relation to the cardiovascular findings, diastolic blood pressure was found to be more sensitive to the stress induced by the LW than was systolic blood pressure.

The principal aim of the present study was to investigate the role of exploratory movements in a LW, and a number of important differences between the various diagnostic categories were found. Each group differed in the following behavioural features: head rotation frequency ($F(2, 43)=6.60$, $P<0.01$), folding arms across the chest ($F(2, 43)=5.52$, $P<0.01$) and labyrinth route finding ($F(2, 43)=11.12$, $P<0.001$). The data shows that PDA subjects turned their heads during the LW more frequently and that they also folded their arms across their chest and lost their way whilst searching for the exit more frequently than did GAD patients or normal subjects.

Finding objects or a target in a complex spatial maze plays a central role in animal and human behaviour. We found that PDA subjects' spatial orientation during the negotiation of the labyrinth was disturbed. This disturbance was indicated by high blood pressure, frequent trunk and head rotations, and the "arms-across-the-chest" posture during the spatial orientation task. Through analysis of the related video material, we found that most subjects moved their hands and rhythmically touched some objects or the wall of the labyrinth, or they pointed in the right direction with their hands to aid themselves during the LW. This natural, free-hand movement was lacking in the behavioural repertoires of the PDA subjects.

4. Discussion

Our findings show that systolic blood pressure relates to the psychophysiological, behavioural and cognitive reaction patterns associated with the completion of the labyrinth maze task. High systolic blood pressure coincided with the reported anxiety rate and with an increased frequency of trunk rotations and, similarly, a higher heart rate was associated with an increased frequency of head rotations. From the diagnostic point of view, PDA subjects had higher blood pressure than GAD patients. PDA patients, when compared with GAD and control subjects, showed more frequent head rotations, folded their arms across the chest more

Table 1
Physiological and behavioural differences between panic disorder with agoraphobia (PDA), generalized anxiety disorder (GAD), and control groups

Variables	Means and standard deviations			F	Post hoc multiple comparisons significant Tukey HSD
	PDA (1)	GAD (2)	Control (3)		
Age	32.9 (9.7)	31.4 (4.9)	34.1 (9.3)	0.39	
Education	1.93 (0.5)	1.93 (0.5)	1.39 (0.5)	0.00	
Weight	62.5 (14.4)	59.8 (5.6)	63.2 (11.0)	0.40	
Height	163.1 (8.0)	167.2 (2.9)	166.2 (8.3)	1.42	
Pre syst. blood pressure	128 (16.8)	114 (10.2)	116 (12.7)	4.68*	1–2
Pre diast. blood pressure	85.6 (9.4)	77.0 (9.4)	79.6 (8.5)	3.53*	1–2
Pre heart rate	80.2 (1.1)	72.6 (1.2)	72.4 (3.1)	2.09	
Post syst. blood pressure	123 (18.8)	111 (9.4)	118 (14.6)	2.45	
Post diast. blood pressure	86.3 (9.9)	74.7 (9.0)	80.6 (9.6)	5.57**	1–2
Post heart rate	77.1 (9.8)	69.1 (10.1)	71.8 (9.3)	3.03	
Trunk rotation frequency	2.83 (0.6)	1.1 (0.3)	1.2 (0.2)	3.77*	1–2
Trunk rotation intensity	58.0 (14.7)	25.0 (12.3)	42.2 (15.6)	1.93	
Head rotation frequency	11.2 (5.6)	5.4 (3.1)	7.1 (4.4)	6.60**	1–2, 1–3
Head rotation intensity	72.1 (10.1)	66.9 (20.0)	72.0 (23.8)	0.38	
Folding arms across chest	57.2 (16.8)	14.5 (7.7)	9.2 (5.6)	5.51**	1–2, 1–3
Self touching time	2.1 (1.1)	1.9 (0.5)	1.8 (0.8)	0.10	
Self reported anxiety	1.5 (1.0)	0.8 (0.2)	0.6 (0.2)	3.52*	1–3
Labyrinth route finding	86.4 (7.6)	95.7 (6.3)	96.8 (7.9)	11.11**	1–2, 1–3

*$P<0.05$; **$P<0.01$; $df=42$.

frequently and also lost their way more often while finding the labyrinth exit.

Several authors mention different psychological and biological pre-dispositions for panic and agoraphobia, including dependent, unassertive, ambivalent traits (Goldstein and Chambles, 1978), hypersensitivity to arousing external situation (Hallam, 1985), narrowed exploratory capacity related to the external environment (Guidano, 1987), and spatial orientation disorder (Jacobs and Nadel, 1985), which are associated with cognitive avoiding (Foa and Kozak, 1986), cardiovascular over-reaction (Roth and Telch, 1986), specific gestures and spatial memory disturbances-namely, a high capacity to decontextualise environmental signals under intensive stress, and a loss of spatial allocentric references in stressful situations (Jacobs and Nadel, 1985; Kallai et al., 1999). Further results support that notion that these disturbances significantly diminish the subjects' response to treatment and their biological survival potential (Cyrulnik, 1998).

The present data indicate that PDA subjects' high blood pressure and related route finding disorder suggest a close association with disturbed cognitive and exploratory activity. PDA subjects restrict themselves in making exploratory contact with the actual environment, avoid paying attention to spatial reality and more frequently fail to locate the correct route towards the exit from the labyrinth.

The "arms folded across the chest" posture is part of "barrier behaviour." It may indicate distancing within the framework of interaction, so indicating disagreement with the viewpoints of others. This disapproval or disagreement generally accompanies deep self-centredness and indicates withdrawal and distancing of the self from the environment (Calvin, 1991; Cyrulnik, 1998). This defensive self-restricting posture, as an immature defence reaction, does not promote effective exploration directed towards maintaining a self-confident adult psychological constitution. Our findings suggest that folding arms across the chest as a part of phobic avoidance seems to be an essential aspect of the PDA defence. Our results demonstrated that the behaviour of PDA patients searching for the correct route towards the labyrinth exit is basically motivated by extraterritorial fears resulting in a dysfunctional defensive posture (folding arms across the chest), an ineffective exploration pattern and a high blood pressure level. These results supports the claim of Marks (1987) that PDA has marked socio-biological significance, connected with extraterritorial fear, which generally activates such symptoms as a fear of loneliness, a fear of both open and enclosed spaces, and a fear of crowds. PDA patients' maladaptive exploration in the labyrinth is associated with high blood pressure, which shows an essential physiological vulnerability to illness. Furthermore, subjects maintain a maladaptive behavioural exploratory pattern in which they restrict themselves to touching and finding a connection with environmental elements in a malfunctioning manner. They ignore information-gathering clues offered by the external environment. Instead, their attention is occupied by their inner feelings and they lose the capacity to turn their attention towards allocentric signals. As a consequence, PDA subjects are unable to acquire new and unfamiliar places and surroundings and they maintain anxious, strange feelings in the unfamiliar extraterritorial environment.

5. Conclusion

Our data support previous research data (Marks, 1987) indicating that extraterritorial defensive behaviour is a significant aspect of PDA disorder. As our study shows, this tendency can be observed in dysfunctional exploratory patterns, in the decontextualisation of external cues, and in high systolic blood pressure combined with restlessness, anxiety and frequent trunk and head rotations. The PDA subjects may be characterised by a pathologically low threshold for inborn fear responses that are eliminated by extraterritorial and idiosyncratic situational cues. The revealed sociobiologically founded dysfunctional exploration pattern and spatial disorientation disorder also play a role in maintaining PDA.

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