ELSEVIER

Journal of Anxiety Disorders 21 (2007) 704–716

Journal of Anxiety Disorders

# Visually induced postural sway in anxiety disorders

Mark S. Redfern [a,b,*], Joseph M. Furman [a,b], Rolf G. Jacob [c,b]

[a] Department of Bioengineering, University of Pittsburgh, Pittsburgh, PA, United States
[b] Department of Otolaryngology, University of Pittsburgh, Pittsburgh, PA, United States
[c] Department of Psychiatry, University of Pittsburgh, Pittsburgh, PA, United States

Received 8 June 2006; received in revised form 1 September 2006; accepted 6 September 2006

**Abstract**

Postural sensitivity to moving visual environments in patients with anxiety disorders was studied. We hypothesized that patients with anxiety disorders would have greater sway in response to a moving visual environment compared to healthy adults, especially if they have space and motion discomfort (SMD). Twenty-one patients with generalized anxiety without panic (NPA) and 38 patients with panic and agoraphobia (PAG) were compared to 22 healthy controls. SMD was evaluated in all subjects via questionnaire. Subjects stood on a force platform that was either fixed or rotating with the subject (i.e., sway referenced) during exposure to a sinusoidally moving visual surround. Center of pressure (COP) data were computed from force transducers in the platform as a measure of sway. Results showed that patients swayed significantly more in response to the moving visual scene compared to control subjects, with no differences between the NPA and PAG groups. SMD was a predictor of sway response in the patients: patients with high SMD swayed significantly more than both Controls and anxiety patients with low SMD. These results indicate that patients with anxiety disorders, particularly those with SMD, are more visually dependent for balance. This subgroup of patients may be amenable to treatment used for patients with balance disorders (i.e., vestibular rehabilitation) that focuses on sensory re-integration processes that address visual sensitivity.


*Keywords:* Anxiety; Panic; Optic flow; Posture; Sway; Sensory integration; Balance

## 1. Introduction

Anxiety is highly prevalent in patients with balance disorders. About 30% of patients with vestibular disorders report persistent panic and agoraphobic symptoms or generalized anxiety

* Corresponding author at: Department of Bioengineering, University of Pittsburgh, Eye & Ear Institute Room 110, 203 Lothrop Street, Pittsburgh, PA 15213, United States.
*E-mail address:* mredfern@pitt.edu (M.S. Redfern).

0887-6185/$ – see front matter 
doi:10.1016/j.janxdis.2006.09.002

(Clark, Hirsch, Smith, Furman, & Jacob, 1994; Clark, Sullivan et al., 1994b; Eagger, Luxon, Davies, Coelho, & Ron, 1992; Stein, Asmundson, Ireland, & Walker, 1994; Sullivan, 1993). Conversely, vestibular dysfunction is common among patients with anxiety disorders (Hoffman, Oleary, & Munjack, 1994; Jacob, Furman, Durrant, & Turner, 1996; Jacob, Moller, Turner, & Wall, 1985; Perna et al., 2001; Sklare, Stein, Pikus, & Uhde, 1990; Yardley, Britton, Lear, Bird, & Luxon, 1995; Yardley, Luxon, Lear, Britton, & Bird, 1994).

While many anxious patients have symptoms of imbalance and/or dizziness, few have a syndromal vestibular disorder (Furman & Jacob, 2001). For example, balance symptoms in agoraphobics only rarely include rotational vertigo (Jacob, Lilienfeld, Furman, Durrant, & Turner, 1989). However, many patients with anxiety complain of discomfort in situations that are challenging for patients with balance disorders. These situationally specific symptoms include ''supermarket syndrome'' (Rudge & Chambers, 1982) ''space phobia'' (Marks, 1981), ''visual vertigo'' (Bronstein, 1995) and ''height vertigo'' (Brandt, Arnold, Bles, & Kapteyn, 1980). We have labeled this patterns of situationally specific symptom elicitation ''space and motion discomfort'' (SMD) and developed a questionnaire to detect this condition (Jacob et al., 1993). SMD is commonly seen in patients with balance disorders, suggesting that it may be possible to identify a select group of patients with anxiety that has vestibular dysfunction.

Vestibular dysfunction can give rise to situational discomfort, i.e., SMD because three sensory channels (vision, proprioception and vestibular) are involved in balance control. When sensory conflict arises, the postural control system normally adjusts the sensory integration process toward an appropriate sensory channel or away from the channel providing misleading information. Thus, normal healthy adults, when exposed to misleading balance information, downweight information from the misleading sensory channel and upweight information from channels that provide correct information. Patients with vestibular disorders are prone to develop SMD because they become unusually dependent on information from non-vestibular channels and thus become sensitive to misleading information in these channels (Redfern, Yardley & Bronstein, 2001). For example, a person who is visually dependent due to vestibular dysfunction would be expected to experience particularly high levels of ''height vertigo.'' Visual information is degraded due to the absence of motion parallax and reduction of retinal slip resulting from the long visual distances characteristic of height and a lack of a reliable vestibular channel.

SMD is observed not only in patients with balance disorders, but also in individuals unable to flexibly adjust the above-mentioned inter-sensory integration process, e.g., those who are visually dependent or surface dependent. Some patients with anxiety disorders, particularly those with panic disorder and agoraphobia (Jacob et al., 1989, 1993) seem especially prone to developing SMD. In a previous study, we found that anxious patients with SMD swayed more in response to moving visual environments than did healthy adults. That is, they seemed to be visually dependent (Jacob, Redfern, & Furman, 1995). That study however, did not include a non-SMD control group. Since it has been found that anxious patients in general are sensitive to visuo-vestibular sensory conflict (Viaud-Delmon, Ivanenko, Berthoz, & Jouvent, 2000; Viaud-Delmon, Siegler, Israel, Jouvent, & Berthoz, 2000; Viaud-Delmon, Berthoz, & Jouvent, 2002), we wanted to directly compare anxious patients with SMD to anxious patients without SMD. The motivation for this study was: (1) to investigate the central integration of visual information for balance (visual dependence) in an anxious population to determine if this mechanism was different in patients with anxiety as compared with healthy adults; (2) to investigate if this mechanism was linked to phenomenological variables, such as the presence or absence of panic attacks, height phobia and SMD. In a previous study, we had shown that patients with panic disorder with agoraphobia were surface dependent, i.e., unusually sensitive to a sway referenced support surface (Jacob, Furman,