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Psychological factors influencing recovery from balance disorders

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Abstract

This article reviews evidence for three mechanisms whereby psychological factors may aggravate dizziness and retard recovery from balance disorders. Firstly, a common behavioral response to dizziness is to avoid activities and environments that provoke symptoms, yet such avoidance deprives the individual of the exposure necessary to promote psychological and neurophysiological adaptation. Secondly, anxiety arousal and hyperventilation may add to, amplify, and disinhibit the somatic symptoms induced by balance disorder. Thirdly, attention and cognitive load may influence the central processing of information required for the perception and control of orientation. The need to combine physiotherapy for dizziness with psychotherapy is discussed. © 2001 Elsevier Science Inc. All rights reserved.

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1. Introduction

There has been extensive research showing that balance disorders and complaints of dizziness are associated with elevated levels of anxiety. The prevalence of diagnoses of anxiety disorders (particularly panic disorder and agoraphobia) among patients attending specialist clinics for balance disorders is substantially higher than in the general population (Clark, Hirsch, Smith, Furman, & Jacob, 1994; Eagger, Luxon, Davies, Coelho, & Ron, 1992; Frommberger,

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Tettenborn, Buller, & Benkert, 1994; Kroenke, Lucas, Rosenberg, & Scherokaman, 1993; Stein, Asmundson, Ireland, & Walker, 1994). Conversely, evidence of balance system dysfunction has been found in people with panic disorder and agoraphobia (Jacob, Furman, Durrant, & Turner, 1996; Jacob, Lilienfeld, Furman, Durrant, & Turner, 1989; Yardley, Britton, Lear, Bird, & Luxon, 1995). It seems likely that this association is not confined to clinical samples, as reports of dizziness are also correlated with reports of anxiety in community surveys of people of working age (Yardley, Owen, Nazareth, & Luxon, 1998) and those aged over 60 years (Sloane, Blazer, & George, 1989).

The association between anxiety and balance disorders can be partly explained by somatopsychic processes, as dizziness is a frightening experience which can lead to panic and avoidance of situations in which dizziness could cause danger or embarrassment (Mendel, Lützén, Bergenius, & Björvell, 1997; Pratt & McKenzie, 1958; Yardley, Todd, Lacoudraye-Harter, & Ingam, 1992). In some cases, the reported dizziness may simply be a somatic manifestation of anxiety, although most people with a primary complaint of dizziness exhibit signs of balance system dysfunction on medical examination and neuro-otological testing (Clark et al., 1994; Kroenke et al., 1993; Sloane, Hartman, & Mitchell, 1994; Sullivan et al., 1993; Yardley, Burgneay, Nazareth, & Luxon, 1998). Another possibility is that psychosomatic processes may contribute to the development, maintenance, or severity of balance system dysfunction. This article reviews evidence for the influence of psychological factors on orientation and balance, and especially, their impact on recovery from balance disorders. The following three sections consider different mechanisms, which might mediate psychosomatic links between dizziness and anxiety. The first section focuses on cognitive–behavioral processes which may promote or retard recovery from balance disorder, drawing attention to the remarkably close parallels between psychological habituation to anxiety and neurological adaptation to perceptual disorientation. The second section considers psychophysiological links between dizziness and anxiety, and in particular, the possibility that arousal and hyperventilation may aggravate dizziness and imbalance. Finally, preliminary evidence is presented which suggests that cognitive activity may play a significant role in basic orientation perception and balance control.

2. Cognitive–behavioral mechanisms influencing recovery from vestibular disorder

Damage to the vestibular organ initially provokes disorientation, postural instability, and autonomic symptoms similar to motion sickness. During the following weeks and months, these symptoms gradually abate, and near normal function is restored by a process known as 'compensation.' The mechanisms involved in compensation are probably multifarious and are not yet fully understood. Central recalibration of the balance system occurs as input from the undamaged portions of the vestibular system, and from the visual and somatosensory systems, comes to substitute for input from the damaged organ (Blakley, Barber, Tomlinson, Stoyanoff, & Mai, 1989; Robertson & Ireland, 1997). There are clear parallels with adaptation to environments in which information about orientation derived from the visual and/or somatosensory systems does not appear congruent with that derived from the vestibular system (Gonshor & Melville Jones, 1980; Gordon, Fletcher, Melville Jones, & Block, 1995; Guedry, 1965). At first, such environments tend to induce motion sickness, but prolonged exposure leads to changes in the automatic vestibular regulation of eye movements and postural control, and in subjective perceptions of orientation and self-motion. In the case of both vestibular damage and motion sickness, there may be an element of 'habituation' or 'desensitization' to disorientation, whereby tolerance increases and anxiety decreases despite persisting symptoms (Cowings & Toscano, 1982; Dobie, May, Fisher, & Bologna, 1989; Shepard, Telian, & Smith-Wheelock, 1990).

Changes in perceptual–motor strategies also play a part, as individuals unconsciously learn to adopt altered modes of postural control or make different use of the perceptual information for orientation, for example relying to a greater extent on the visual than the vestibular system for orientation (Black, Shupert, Peterka, & Nashner, 1989; Farber, 1989; Lacour et al., 1997; Yardley, 1992). There may also be deliberate alterations in behavior, such as avoidance of head movements (which stimulate the vestibular system) or disorienting environments (Yardley, Todd, et al., 1992). Paradoxically, some of these latter adaptations are likely to retard central recalibration of the balance system, since recalibration occurs as a result of active exposure to the motions that provoke disorientation (Yardley, 1992). The result can be a vicious cycle of self-imposed inactivity caused by fear of movements and environments that might provoke dizziness, which in turn deprives the individual of the opportunity to adapt to these provocative movements and environments. Similarly, an inflexible reliance on the visual system for orientation can lead to recurring disorientation and imbalance in situations where visual information regarding orientation is absent, ambiguous or misleading (see Redfern, Yardley, & Bronstein, this issue).

Most rehabilitation programs for people with vestibular damage have been developed and delivered by physiotherapists to treat physical disorder, and therefore naturally emphasise physical processes and objectives. However, it is clear that compensation is a form of (re)learning, and must therefore be influenced by psychological factors such as anxiety, arousal, attention, and motivation. Moreover, there are many intriguing parallels between 'vestibular rehabilitation' and cognitive–behavioral therapy for panic disorder and agoraphobia, and these suggest a currently underexploited potential for explicitly combining physical and psychological therapy for the many people suffering from both anxiety and balance disorder (Yardley & Luxon, 1994).

In 'vestibular habituation training' (Norré & De Weerdt, 1980), the patient is taught to perform repeated head movements that provoke dizziness in order to promote central recalibration. This deliberate, self-controlled induction of dizziness has clear parallels with the 'interoceptive exposure' to feared autonomic sensations, which is used to promote habituation to somatic symptoms in panic disorder — indeed, Barlow, Craske, Cerny, and Klosko (1989) specifically recommend spinning as a useful form of exposure. Moreover, from the perspective of cognitive therapy, self-exposure to dizziness can be considered to function as a form of 'behavioral experiment,' which allows the individual to collaboratively explore with the therapist the causes and consequences of dizziness (Salkovskis & Clark, 1991). Testing the validity of fears about dizziness may be an important component in treatment for vestibular disorder, since the vicious cycle of avoidance of activity and persistent dizziness described above is linked to negative beliefs about dizziness. These erroneous beliefs include fear that dizziness is a sign of serious untreated illness, that an episode of dizziness may have catastrophic consequences, or that dizziness provoked by movement is a warning that continued movement could damage the balance system, in the same way that a twinge of back pain can signal imminent damage to spinal nerves or muscles (Beyts, 1987; Yardley, Beech, & Weinman, 2001; Yardley, Todd, et al., 1992). Therapy provides a context in which such beliefs can be safely challenged, without the fear of physical harm or public embarrassment.

Similar psychological benefits may accrue from another element of physiotherapy known as 'balance retraining,' which involves employing structured practice of balancing tasks (e.g. standing with eyes closed, or turning quickly) in order to help the patient relearn postural control across a wide range of activities and situations (Shepard et al., 1990; Shumway-Cook & Horak, 1989). This type of therapy not only serves to improve postural control, but also provides a source of powerful 'enactive efficacy information' (Bandura, 1982), which teaches the individual that they are able to cope, physically and psychologically, with balancing acts previously perceived as precarious.

3. Psychophysiological mechanisms linking dizziness and anxiety

Recovery from vestibular disorders might also be affected by arousal, and hence by the somatic component of anxiety. Elevated arousal may be implicated in amplification or enhanced perception of autonomic symptoms, and failure to habituate (Rief, Shaw, & Fichter, 1998). Heightened autonomic reactions due to anxiety may also contribute to conditioned aversive responses, which can include both fear and autonomic symptoms (Challis & Stam, 1992; Öhman & Soares, 1993). Therapists have found that techniques to ensure that arousal levels remain low during exposure appear to facilitate habituation to fear of disorientation and imbalance, and to the somatic symptoms induced by both anxiety and disorientation (Acierno, Hersen, & Van Hassett, 1993; Cowings & Toscano, 1982; Dobie et al., 1989; Feldman & DiScipio, 1972).

Questionnaire research has shown that dizzy patients who report higher levels of autonomic symptomatology report greater concurrent handicap (Yardley, Masson, Verschuur, Luxon, & Haacke, 1992) and recover less quickly (Yardley, 1994). In one study, health status, 7 months after patients were initially assessed, was predicted better by levels of anxiety-related somatic symptoms than by tests of balance function or measures of vestibular symptomatology (Yardley, Luxon, & Haacke, 1994). Levels of autonomic symptomatology mediated the correlation between degree of reported handicap and trait and state anxiety. This finding suggests that anxiety results in higher levels of autonomic symptoms (or increased attention to somatic symptoms), and that these symptoms in turn motivate self-handicapping restriction of activity — thus helping to maintain the vicious cycle of inactivity and failure to habituate described in the previous section. However, it is also possible that anxiety exerts direct effects on vestibular functioning via numerous central interconnections between the balance system and the autonomic nervous system (Balaban & Porter, 1997; Jacob, Furman, Clark, Durrant, & Balaban, 1993). For example, there is some preliminary evidence to suggest that heightened arousal and anxiety may enhance vestibulo−ocular reflex responses to vestibular stimulation (Swinson et al., 1993; Yardley, Watson, Britton, Lear, & Bird, 1995).

Elevated arousal is often associated with hyperventilation, and hyperventilation itself induces somatic symptoms, including disorientation. Hyperventilation is relatively common among patients with vestibular disorders, and may therefore contribute to their symptoms (Drachman & Hart, 1972; Sama, Meikle, & Jones, 1995). A recent study found that dizziness induced by head movement was accompanied by an increase in respiration rate among those patients with balance disorders who reported elevated levels of somatic symptomatology (Yardley, Gresty, Bronstein, & Beyts, 1998). There is also mounting evidence that the central changes which accompany hyperventilation may influence balance system functioning. Healthy individuals exhibit a substantial increase in sway following voluntary hyperventilation (Sakellari & Bronstein, 1997), and this postural instability may be linked to peripheral and central changes in somatosensory function (Sakellari et al., 1997). In addition, hyperventilation results in the reappearance of reflex eye movements indicative of vestibular imbalance in patients who have recovered from vestibular disorder (Sakellari et al., 1997). Since these eye movements are normally suppressed in asymptomatic individuals, their emergence following voluntary overbreathing suggests that one effect of hyperventilation may be to render central compensatory mechanisms temporarily ineffective.

4. Role of attention in the perception and control of orientation

The complex orientation activities that are common in daily life (e.g. reading road signs while driving) more closely resemble perceptual−motor skills than basic reflexes, and make significant demands upon cortical spatial processing resources (Baddeley, 1986). Hence, orientation can be considered as a perceptual–motor skill, and adaptation to vestibular imbalance can be regarded as a learning process. Patients with persistent dizziness following a vestibular disorder often report an association between episodes of dizziness and periods of mental activity, stress, or fatigue (Andersson, Hagnebo, & Yardley, 1997; Yardley, Burgneay, et al., 1998). There appears to be a bidirectional relationship, whereby mental stressors can provoke dizziness, while dizziness can disrupt concentration. This association between disorientation and mental effort might be attributable to limited information-processing capacity. Capacity devoted to the accomplishment of orientation and adaptation will be unavailable for alternative mental activity, while high-priority attentional demands may draw processing resources away from the task of orientation, resulting in a resurgence of dizziness and imbalance. If this is the case, it is possible that some processing deficit could be responsible for enhanced susceptibility to disorientation under challenging conditions, and for failure to adapt following a vestibular disorder.

The extent and type of cognitive processing involved in the perception and control of orientation can be examined by dual-task studies, which assess the effects of performing various mental activities while carrying out a range of orientation tasks. Competition for processing capacity can be inferred if simultaneous performance of orientation and mental tasks results in a performance decrement on either task, relative to single-task performance. An early study of the relationship between cognitive processes and posture using a dual-task paradigm was carried out by Kerr, Condon, and McDonald (1985). They combined a balance task, consisting of standing in a Tandem Romberg position (heel/toe), with spatial and nonspatial memorisation tasks. Kerr et al. found that maintaining the Romberg posture during presentation of the items to be memorised affected recall for the spatial task but not for the nonspatial control task. Postural sway did not vary across the memory tasks. This result was interpreted as implying that cognitive processes (specifically spatial processes) rely on neural mechanisms that are also necessary for the regulation of standing posture. In other words, there was interference between the postural and cognitive task indicating a shared resource, which could be thought of as attention.

Further investigations into the influence of cognitive processes (i.e. attention) on postural control have continued to use the dual-task paradigm, but changing the postural and cognitive tasks. Teasdale, Bard, LaRue, and Fleury (1993) employed a simple reaction-time task. They found no significant differences in reaction times (RTs) to an auditory stimulus when sitting and when standing with the feet a shoulder-width apart, but there was a significant increase in RT with feet together compared with feet apart. In another study, the single-support phase of walking (when only one foot is on the ground) induced large increases in RTs to an auditory stimulus, compared with the double-support phase (Lajoie, Teasdale, Bard, & Fleury, 1993), again supporting the notion that increased postural demands require attentional resources.

A more complicated set of tasks has recently included balance tasks used in the evaluation of balance disorders, namely, ‘sway referencing’ of the standing platform and 'sway referencing' of a moving visual scene. 'Sway referencing' attempts to set up a sensory conflict by altering the movement of the floor and/or visual scene with respect to the subject. Thus, sensory information commonly used in balance control is manipulated. Andersson, Yardley, and Luxon (1998) observed a decrement in performance on a visuospatial mental task when balancing on a sway-referenced platform, compared with a stable platform. Recently, Redfern and Jennings (1998) and Redfern, Jennings, Martin, and Furman (1999) conducted an extensive study of the interaction of postural challenge and attention, using a sway-referenced platform and/or scene with young healthy adults. Postural challenge was varied by providing five levels of difficulty: (1) seated (SEAT), (2) fixed floor with a stable visual environment (FIXED), (3) sway-referenced floor with a fixed visual scene (SRF), (4) sway-referenced floor and sway-referenced visual scene (SRFV), and (5) an anteroposterior linearly translating floor with a fixed visual scene (TRANS). The information processing tasks were: (1) none, (2) a visual simple RT (SRT) task, (3) an auditory SRT, and (3) an inhibition RT (IRT) task. The results showed that increasing postural challenge increased RTs on both simple and inhibitory reaction-time tasks (Fig. 1a, b). However, postural sway was not affected by

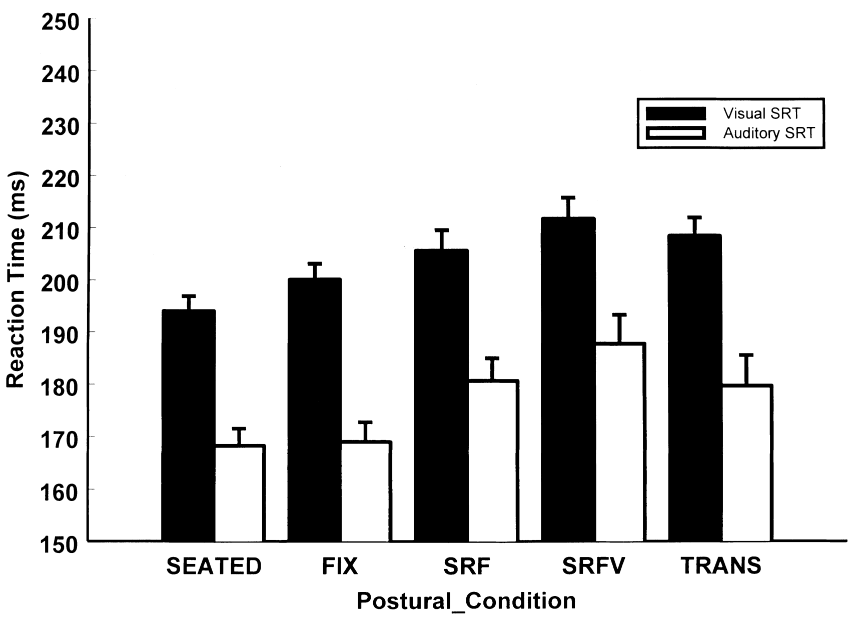

Fig. 1. Reaction-time results of dual-task study of the interaction between cognitive processing and standing postural control. Panel (a) shows RTs for auditory and visual stimuli during the five different postural conditions, and Panel (b) shows RTs for the "go" signal of the inhibitory reaction-time tasks during the five different postural conditions. The postural conditions are FIXED, SRF, SRFV, and TRANS. Error bars are standard errors. (from Redfern, Jennings, et al., 1999).

performing the concurrent reaction-time tasks. Fastest RTs occurred when seated, while the slowest occurred in the most challenging postural condition, with sway-referenced floor and scene or SRFV. This study suggests that for young, healthy adults, maintenance of standing balance is unaffected by cognitive load, but cognitive performance is affected by balancing. Another interpretation could be that balance takes priority over the processing of the cognitive task in the utilization of shared attention.

The dual-task paradigm has been used to explore the role of attention in postural control in specific populations beyond healthy young adults. Studies of older adults have found increased interference between the cognitive task and the postural task, suggesting that more attention is required for balance in older adults (Redfern, Furman, & Jennings 1999; Shumway-Cook, Woollacott, Kerns, & Baldwin, 1997; Stelmach, Zelaznik, & Lowe, 1990). Older adults with a history of falls and imbalance exhibit even greater interference (Shumway-Cook et al., 1997). Redfern, Furman, et al. (1999) employed the same sway-referencing protocol described above with healthy older subjects and found that not only did RTs increase as the postural task difficulty increased, but also sway increased as a function of the difficulty of the cognitive task. Since the sway of younger adults was unaffected by the cognitive task, it appears that attentional allocation for older adults may be different from in younger adults. Patients with vertigo and dizziness have also been investigated using the dual-task approach (Andersson et al., 1998). Although these patients exhibited a decrement in mental performance with increased postural challenge, this decrement was no greater than that of healthy controls. Surprisingly, patients with severe balance problems actually had improved balance when performing the mental task. These findings confirm that mental performance deteriorates when performing a demanding balance task, although the impact of a mental task on balance appears more variable.

Studies of postural control do not directly address the question of whether attention is required for the perception of orientation, since the interference with mental tasks could be due to competition between mental activity and motor control. However, a series of recent investigations has demonstrated interference between various mental tasks and the ability to accurately monitor passive whole body rotation in the dark (Yardley, Gardner, Lavie, & Gresty, 1999; Yardley & Higgins, 1998).

In one previously unpublished experiment, 12 healthy subjects were subjected to brief angular rotations in a motorised chair, and then used a joystick to return themselves to their initial position (the method is fully described in Yardley et al., 1999). In the dual-task condition, the subjects also carried out auditory RT tasks during the passive rotations. For the ‘simple’ task, subjects heard a series of digits presented by headphones, and pressed the upper button on a handset button if the number presented was a nine, and the lower button if it was not. A more demanding ‘conditional’ task was also employed in which a random sequence of seven numbers ranging from one to eight was presented, and subjects had to press the upper button if the number presented corresponded to the preceding number

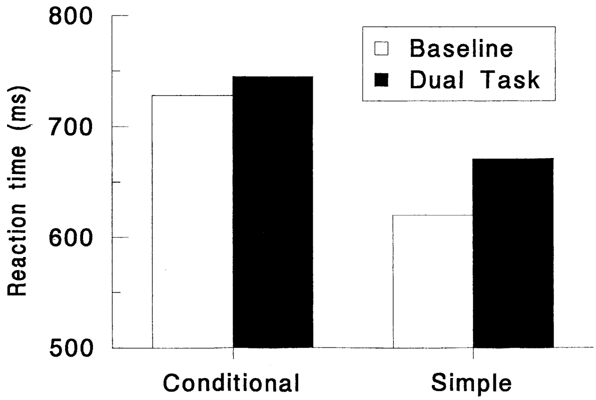

Fig. 2. Dual-task study of interference between performance on a RT task and accuracy in monitoring passive rotation in the dark; mean RTs on the simple and conditional mental tasks, in the baseline and dual-task conditions.

minus one (e.g. seven followed by six), and the lower button if it did not (e.g. seven followed by five or eight).

RTs in the dual-task condition were compared with RTs in a baseline condition, when subjects were not subjected to passive rotations. If perceived orientation is updated automatically during self-motion (as has been suggested), making no demands on attention, then subjects' performance on the concurrent mental tasks should not have been affected by the need to monitor the passive turn in the dual-task condition (in order to subsequently reposition themselves accurately). However, the data shown in Fig. 2 reveal that the dual-task condition resulted in prolonged RTs even on the 'simple' task, and ANOVA confirmed a main effect of the dual-task condition [$F(1,11) = 5.73$, $P=.036$], as well as an effect of task demands [$F(1,11) = 12.73$, $P=.004$], with no interaction [$F(1,11) = 1.39$, $P=.263$]. These findings are consistent with the results of the other studies in this series (Yardley et al., 1999; Yardley & Higgins, 1998), which have shown bidirectional interference between monitoring orientation and a variety of other mental activities (e.g. spatially locating tones, counting backwards).

5. Summary and conclusions

It is clear that recovery from balance disorder is a process of habituation and relearning that involves many different structures, mechanisms, and activities. These may include central neurophysiological adaptation, desensitization to dizziness sensations, the recovery of automaticity in the perception and control of orientation, and the development of conscious strategies and coping skills. Consequently, it is apparent that the course of recovery from balance disorder can be profoundly influenced by psychological factors, such as cognitive, emotional, and behavioral responses to dizziness. While programs of rehabilitation for balance disorder already contain implicit psychotherapeutic ingredients, it may prove beneficial to explicitly maximize the psychological benefits of rehabilitation. Research is needed to determine the optimal combination of physiotherapy and psychotherapy required to minimize handicap and to speed-up physical and psychological adaptation.

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