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Visual and cognitive predictors of driving safety in Parkinson's disease patients

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Abstract

This study assessed the clinical utility of contrast sensitivity (CS) relative to attention, executive function, and visuospatial abilities for predicting driving safety in participants with Parkinson's disease (PD). Twenty-five, non-demented PD patients completed measures of contrast sensitivity, visuospatial skills, executive functions, and attention. All PD participants also underwent a formal on-road driving evaluation. Of the 25 participants, 11 received a marginal or unsafe rating on the road test. Poorer driving performance was associated with worse performance on measures of CS, visuospatial constructions, set shifting, and attention. While impaired driving was associated with a range of cognitive and visual abilities, only a composite measure of executive functioning and visuospatial abilities, and not CS or attentional skills, predicted driving performance. These findings suggest that neuropsychological tests, which are multifactorial in nature and require visual perception and visual spatial judgments are the most useful screening measures for hazardous driving in PD patients.

Keywords: Contrast sensitivity; Executive function; Visuospatial; Activities of daily living

1. Introduction

There is converging evidence that individuals with Parkinson's disease (PD) are at increased risk for hazardous driving. Drivers over the age of 65 experience a higher annual fatality rate per mile driven than all age groups except individuals aged 25 and younger (NHTSA, 2000). Impaired driving may be more pervasive in PD, a neurodegenerative illness with onset typically in later life. In fact, in some countries, a physician's note is required for PD patients to renew their drivers' licenses (reviewed in Worringham, Wood, Kerr, & Silburn, 2006). A recent survey of over 6000 individuals with PD found that 15% of respondents reported involvement in a motor vehicle accident and 11% reported causing an accident in the past 5 years (Meindorfner et al., 2005). Compared to control participants PD patients commit more driving errors (Stolwyk, Charlton, Triggs, Iansek, & Bradshaw, 2006) and have more collisions (Zesiewicz et al., 2002) on simulated driving tasks. On-road driving assessments also indicate that PD patients perform more poorly compared to their age-matched counterparts. Grace et al. (2005) observed that during an on-road driving evaluation PD

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patients, compared to a control group, less frequently checked their blind spots when merging with traffic, changing lanes, or backing out of a space. Heikkilä, Turkka, Korpelainen, Kallanranta, and Summala (1998) also reported that during an on-road evaluation, PD participants committed more faults (errors that could lead to danger) and offences (serious infringements of traffic regulations) compared to the control group. Since some PD patients appear to have poorer driving skills compared to the general population, it is important to identify predictors of driving safety in this group.

The cardinal features of Parkinson's disease involve motor dysfunction, however, severity of motor impairment does not consistently relate to driving safety. The findings from previous studies have been mixed with some reporting an association between severity of the disease and driving safety (Wood, Worringham, Kerr, Mallon, & Silburn, 2005; Radford, Lincoln, & Lennox, 2004; Zesiewicz et al., 2002) while others report no association (Stolwyk et al., 2006; Heikkilä et al., 1998). In studies that have found a relation between the degree of motor impairment and driving performance, the measure of severity has varied (Hoehn and Yahr and Motor Scale of the UPDRS: Grace et al. and Zesiewicz et al., Webster's Rating Scale: Madeley, Hulley, Wildgust, & Mindham, 1990 and Radford et al., Disease duration: Wood et al. and Worringham et al.). In summary, no reliable measure of motor symptom severity consistently relates to driving skills in these studies.

Non-motor symptoms of Parkinson's disease also may be predictors of driving safety. For example, excessive daytime sleepiness (EDS) is commonly reported by PD patients and between 3.8% and 22.6% of PD respondents indicated falling asleep while behind the wheel of a car (Ondo et al., 2001; Hobson et al., 2002). An association between EDS and performance on a standardized road test was not supported (Amick, D'Abreu, Moro-de-Casillas, Chou, & Ott, 2007), although the presence of the driving instructor may have functioned to keep PD drivers more alert, as participants were aware that falling asleep could cause them to fail the road test.

By contrast, performance on neuropsychological tasks has been found to be associated with driving skills measured with a standardized road test. Previous studies indicate that performance on tasks that are multifactorial and require visually mediated executive functions and visual spatial skills are related to driving performance (Stolwyk et al., 2006; Worringham et al., 2006; Grace et al., 2005; Radford et al., 2004; Zesiewicz et al., 2002; Heikkilä et al., 1998). These findings are similar to the results of other studies conducted with healthy aging subjects. Specifically, the useful field of view (UFOV), a multifactorial measure of visual attention has been found to be a strong predictor of driving skills in the healthy elderly (Owsley, 1994). The UFOV, however, may be limited when used with neurological populations, as many patients are unable to complete this lengthy and difficult attentional task (Whelihan, DiCarlo, & Paul, 2005Duchek, Hunt, Ball, Buckles, & Morris, 1998) and no difference in road test performance was found between patients with Alzheimer's disease (AD) who failed portions of the UFOV compared to AD patients who completed all the sections (Whelihan et al.).

It is possible that the previously observed association between visually mediated neuropsychological tasks and driving safety is due to an underlying deficit in basic visual functioning. Changes in basic visual functioning occur frequently in patients with PD. A common change in basic visual functioning among PD patients is decreased contrast sensitivity (CS) (Bodis-Wollner et al., 1987). CS is a measure of how faded a figure can be before it is indistinguishable from the background. CS deficits are due to the neuropathology of PD and do not reflect a normal aging process. Reduced availability of dopamine, which characterizes PD, likely accounts for changes in CS because medication state (on versus off) alters CS (Bodis-Wollner et al.). It has been proposed that CS deficits are due to the disruption of retinal functioning because there are cells within the retina which use dopamine for transmission (Parkinson, 1989) and a dopamine reducing agent applied to the retina produces CS impairments typical of PD patients (Bodis-Wollner & Tzelepi, 1998). Furthermore, autopsy of PD patients reveals reduced dopamine levels within the retina (Nguyen-Legros, Harnois, DiPaolo, & Simon, 1993).

CS is a fundamental aspect of visual processing necessary for performing multifactorial visual tasks including driving. CS deficits in PD patients are severe enough to influence performance on a task of visual cognition (Amick, Cronin-Golomb, & Gilmore, 2003). In other populations (Alzheimer's disease and healthy older adults) CS has been found to be an important predictor of driving errors during an actual road test (Uc, Rizzo, Anderson, Shi, & Dawson, 2004). PD related changes in CS could account for the previous findings that visually mediated neuropsychological tasks are the best predictors of driving safety. In sum, visual abilities are affected by PD and visual dysfunction may account for compromised performance on visually mediated tasks such as driving.

The purpose of this study was to identify visual and neuropsychological predictors of driving safety in individuals with Parkinson's disease. It was hypothesized that measuring CS would increase the amount of variance accounted