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# Auditory instructional cues benefit unimanual and bimanual drawing in Parkinson's disease patients

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### ARTICLE INFO

#### Article history:

Available online 18 December 2010

#### PsychINFO Classification:

2330

3297

#### Keywords:

Timing

Motor control

Drawing

Cues

Movement disorders

### ABSTRACT

The present study investigated performance of unimanual and bimanual anti-phase and in-phase upper limb line drawing using three different types of cues. Fifteen Parkinson's disease (PD) patients, 15 elderly, and 15 young adults drew lines away from and towards their body on a tabletop every 1000 ms for 30 s under three different cueing conditions: (1) verbal ('up', 'down'); (2) auditory (high tone, low tone); (3) visual (target line switched from top to bottom). PD patients had larger and more variable amplitudes which may be related to the finding that they also produced more curvilinear movements than young and elderly adults. Consistent with previous research, when compared to the elderly and young adult group PD patients produced a mean relative phase which deviated more from the instructed coordination modes and they showed larger variability of relative phase in bimanual coordination, especially in anti-phase conditions. For all groups, auditory and verbal cues resulted in lower coefficient of variance of cycle time, lower variability of amplitude and lower variability of relative phase than visual cues. The benefit of auditory cues may be related to the timing nature of the task or factors related to the auditory cues (e.g., reduced attentional demands, more kinesthetic focus).

Published by Elsevier B.V.

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## 1. Introduction

Parkinson's disease (PD) results in sensorimotor deficits (see [Abbruzzese & Berardelli, 2003](#)). This is likely because PD is associated with basal ganglia dysfunction, which is part of the network associated with the generation of sensory related potentials ([Ikeda et al., 1994](#)), which have been shown to be reduced in PD patients ([Cunnington et al., 2001](#); [Thobois et al., 2000](#)). This alteration in sensorimotor function has resulted in testing different cueing strategies that could be used to enhance motor function. It has been proposed that rhythmic cueing may circumvent the difficulties experienced by PD patients when performing voluntary initiated and continued rhythmic tasks (see for example [Rubinstein, Giladi, & Hausdorff, 2002](#)). Early research suggested that PD patients rely on vision ([Cooke, Brown, & Brooks, 1978](#)), however, a review examining several studies on the effects of external rhythmical cueing on gait in PD patients concluded that there was “strong evidence for improving walking speed with the help of auditory cues” but that there was “insufficient evidence for the effectiveness of visual and somatosensory cueing” ([Lim et al., 2005 p. 695](#)). However, the majority of research investigating the effects of external cues on motor tasks in PD patients has been focused on locomotion, rather than rhythmic timing and coordination of upper extremity tasks. Improvements in upper extremity motor function have the potential to greatly enhance PD patients quality of life as the vast majority of PD patients report having ‘clumsy hands’ ([Jankovic, 1987](#)). Successful performance of manual tasks, such as writing, dressing, eating, etc. are important activities of daily living which require complex coordination between upper limb segments. Despite the importance of upper extremity motor function, the impact of providing cues to improve upper extremity performance of PD patients has not been examined systematically.

Neuroanatomical ([Kraft et al., 2007](#); [Wu, Wang, Hallet, Li, & Chan, 2010](#)) and animal ([Kermadi, Liu, Tempini, Calciati, & Rouiller, 1998](#)) studies have indicated that the basal ganglia contribute to supplementary motor area (SMA) function and bimanual coordination. Only a few studies have examined the influence of auditory cues on bimanual timing and coordination of the upper limbs. For example, [Almeida, Wishart, and Lee \(2002\)](#) examined PD patients' bimanual in-phase and anti-phase rhythmic movements with and without an auditory cue and they concluded that coordination did not benefit significantly from an auditory cue. However, [Johnson et al. \(1998\)](#) reported that PD patients performing in-phase and anti-phase cranking movements, executed the in-phase movements with smaller differences between the hands (e.g., relative phase) and lower variability of relative phase using external auditory information, although no improvement in coordination occurred during the anti-phase movements. Thus, the benefits of auditory cues in rhythmical bimanual tasks are found to be inconsistent.

Other studies have investigated visual cues in bimanual movements in PD patients. Recently, [Nieuwboer et al. \(2009\)](#) examined repetitive anti-phase drawing with and without visual cues and found that visual cues decreased coordination variability in PD and controls. [Byblow, Lewis, and Stinear \(2003\)](#) examined continuous bimanual wrist flexion–extension movements in which one hand was passively driven by a motor and one hand was actively moved. They examined attention focus by manipulating vision. The vision conditions included vision of both hands, vision of the passive hand, vision of the active hand and no vision. They found decreases in amplitude variability with vision of the passive hand. [Verheul and Geuze \(2004\)](#) examined in-phase and anti-phase leading with left hand, and anti-phase leading with the right hand bimanual tapping movements and also manipulated visual feedback. Their results showed that PD patients had lower mean and variability of relative phase than a healthy comparison group when eliminating vision of both hands and when one hand was occluded it decreased coordination stability.

Research on rhythmic unimanual movements in PD is even sparser. [Stegemoller, Simuni, and MacKinnon \(2009\)](#) examined unimanual tapping in which repetitive taps were performed opposite to an auditory cue. While this created a complex task, the cue was not used with the intention of improving performance. [Ponsen et al. \(2006\)](#) examined unimanual writing of sentences among other unimanual tasks and found decreased letter height as writing progressed in PD patients but not in the control group. This finding is consistent with symptoms of micrographia ([Lewitt, 1983](#); [van Gemmert, Teulings, & Stelmach, 2001](#)) and hypometria ([van Gemmert, Adler, & Stelmach, 2003](#)). One study examined the influence of visual and verbal cues in rhythmic unimanual drawing of cursive l's and

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