

Innovations in Cueing for Parkinson's Disease:

Portable, Adaptable Cueing to Improve Gait and Freezing

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Cueing training for Parkinson's disease is well known and widely accepted for its beneficial effects on gait disturbances and as a powerful adjunct to physical therapy.^{1,2,3}

In Parkinson's disease, nerve cell degeneration in the basal ganglia is responsible for triggering a progression of dopaminergic disruptive changes that lead to impaired motor and cognitive functions, both of which are necessary for mobility and for navigating real world environments.⁴ Changes in overground mobility are characterized by gait disturbances, common features of which include shortened stride, reduced gait speed, shuffling, and freezing of gait (FOG). Gait disturbances can also result from spatial and temporal impairments, such as variability in step time and step length or asymmetry, and increased double limb support.¹

It is generally understood that external sensory cues allow the cortical, pre-motor control system to bypass the supplementary motor area (SMA) circuit that is deficient in Parkinson's disease.^{5,6} These cues invigorate and facilitate movement by shifting control from habitual to more goal-directed neural pathways.

Both visual and auditory cueing have been shown to be effective strategies for improving gait disturbances such as stride length (visual cues) and walk rhythm (auditory cues).^{7,8,9,10,11} Cues can also reduce the impact or severity of freezing of gait (FOG), both by preserving optimal gait and thereby, reducing the number of episodes and/or duration of a FOG episode once it occurs.

	Visual Cueing	Auditory Cueing
	Significant Positive Effect	
Step length	Yes	Yes
Walk speed	Yes	Yes
# of FOG episodes	Yes	Yes
Duration of FOG episodes	Yes	Yes
# of Falls	Yes	

Visual cueing: Muthukrishnan et al., 2019; Azulay et al., 2006; Dvorsky et al., 2011; Suterawattananon et al., 2004; Sidaway et al., 2006; McCandless et al., 2016; Lewis et al., 2000; Nieuwboer et al., 2008; Nieuwboer et al., 2007; Velik et al., 2012; Donovan et al., 2011. Auditory cueing: Suterawattananon et al., 2004; McCandless et al., 2016; Ghai et al., 2018; Nieuwboer et al., 2008; Nieuwboer et al., 2007; Bryant et al., 2009; Lim et al., 2010.

The body of knowledge on cueing as it relates to Parkinson’s pathology is extensive. The purpose of this paper is not to review that detail but, rather, to highlight certain recurring themes in the literature which impact the practical choice of cueing approach:

Researchers consistently cite the need for cueing which can be adapted to each person and controlled on-demand, and the importance of cueing training both in-clinic and at-home.

Importance of empowering patients with cueing options

Parkinson’s is a multi-system, neurodegenerative disease. Each person with Parkinson’s faces a unique and evolving set of complexities and variables related to: disease stage and rate of progression, presentation of motor and nonmotor symptoms, response to medications, environmental conditions, availability to rehabilitation, age of onset and lifestyle factors.

This heterogeneity of Parkinson's disease points to the importance of cueing which can be personalized to each person's circumstance. As examples:

Disease stage:

External cues are effective in different ways at different stages of Parkinson's. At early stages, cueing techniques can counteract subtle changes in gait and provide people with a tool to help sustain the automaticity of gait and preserve physical conditioning and participation. For people at severe stages of Parkinson's, external cues improve gait and reduce both the incidence and duration of FOG, as well as reduce the risk of falls, by helping to compensate for automatic control deficits.^{1,12,13}

Environment:

Cueing exercises administered by trained specialists in the clinic setting can be a vital tool in assessment and rehabilitation sessions. However, real-world conditions outside of the clinic involve environmental variables that can complicate the person with Parkinson's ability to safely negotiate different settings – like noise level, light intensity, obstacles and terrain. Different cueing types are more useful in different settings. For example, laser light cueing may not be visible in direct sunlight where a metronome beat may be more effective. Yet in a quiet public setting, the laser light approach may be preferred over an audible beat.

Symptom Presentation:

Different types of sensory cues are thought to engage different mechanisms, which in turn, may be effective in improving different symptoms such as speed/amplitude vs. incoordination. Visual cues – such as laser-projected lines on the floor – may focus attention and invoke conscious motor control pathways, thereby circumventing automatic pathways.^{5,6} Auditory cues – such as audible metronome beats – provide rhythmic stimuli which may substitute for internal timing cues, thereby overriding the internal rhythm deficit that is associated with Parkinson's.^{3,5,13,14}

Although no single cueing type has been found uniformly effective for every gait symptom in every patient, the most studied cueing types are **visual** and **auditory**, and nearly every study of these two modalities has shown significant positive effects on gait.¹³

The table below shows examples of common Parkinson's motor symptoms with the positive effect of visual and auditory cueing approaches in different settings (in-clinic and at-home):

Symptom/Problem	Cueing Type	Effect
Step length	Visual Auditory	Both visual cueing and auditory cueing significantly improved step length in both in-clinic and at-home settings. ^{1,3,7,8,10,11,15,16}
Walking speed	Visual Auditory	Both visual cueing and auditory cueing significantly improved walking speed in both in-clinic and at-home settings.
Physical activity	Auditory	Cueing using beep sound increased amount of time spent walking at home. ¹⁷
Freezing of gait	Visual Auditory	Laser light cueing improved movement patterns between freezing episodes and reduced duration of freezing. ¹⁰ Both Laser light cueing (continuous and on-demand) and auditory cueing reduced duration of freezing. ^{9,12,13}
Fall frequency	Visual	Laser light visual cues provided substantial reduction in frequency of falls. ¹²
Turning	Auditory	Auditory tone reduced variability of step time during turning and elicited largest effect in increasing turning speed among cueing types. ^{6,18}
Dual Tasking	Auditory	Rhythmic tone found useful in reducing interference and maintaining gait performance during complex functional activities. ¹⁹

Importance of portable cueing solutions

Research shows that the benefits of cueing training are immediate and significant, but fade within 6-12 weeks without regular performance outside of the rehab setting.¹⁶ These

benefits include specific positive effects on gait, freezing, and balance, and general improvement in quality of life.³

There is strong evidence that the improvements are extended when cueing is continued at home, in a patient's daily routine.¹ In fact, these studies show that retaining the benefits of cueing training depends on how much a person continues cueing practice at home. The evidence shows that cueing technologies that can be used outside of the clinic encourage physical activity and increase movement practice.

Therefore, cueing devices intentionally designed to be suitable in any setting – portable, lightweight, easy to attach/detach, adaptable – are essential tools to optimize gait training and improve clinical outcomes.

Importance of on-demand controls

Sensory cues have been historically delivered in continuous-on mode, whether needed in the moment or not. Researchers note that continuous-on cueing can be intrusive for people and may also be habit-forming, thereby impacting effectiveness, and that flexibility is essential to help match cueing to the cognitive profile of patients.^{13,20} Further, studies show a significant reduction in duration of freezing using on-demand cueing when FOG is imminent or has already occurred compared to continuous-on cueing.²¹

With auditory cueing, providing self-control over tempo and volume have been found to be particularly effective for improving gait speed and stride length. Varying beat tempo during training is associated with increased neuronal activation and has been shown to promote healthy gait pattern.^{3,17}

The ability to personalize and control cueing delivery and content (e.g. turn on/off, adjust volume, adjust tempo, adjust the position of the laser light) offers significant advantages such as reducing intrusiveness, reducing potential for habituation, improving motor symptoms, and increasing personal empowerment.

Summary

Cueing training for persons with Parkinson's disease is well known and widely accepted for its beneficial effects on gait disturbances. Many studies report that both visual and auditory cueing are effective strategies to help improve a variety of mobility issues including, but not limited to, optimizing spatial/temporal gait features (like stride length and gait speed) , and reducing the frequency and duration of FOG episodes.

Given the many complexities and variables facing each individual with Parkinson's, the ideal is to deliver cueing in a form that is both portable and adaptable:

- Offer a choice of cueing type and method to accommodate the heterogeneity of Parkinson's disease and to complement individual preference and settings,
- Available to patients in any environment to promote daily use and assist mobility outside the rehabilitation setting, in public settings and especially at home, and
- Provide on-demand control such as on/off and volume.

Portable devices that offer both visual and auditory cueing options, with on-demand controls, can extend the positive effects of physical therapy treatment outside the clinic and help improve quality of life.

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