Understanding Freezing Of Gait (UnFOG) : A scale for measuring and subtyping FOG

Amey Desai[1], Ria Rajput[2], Shivali Verma[3], and Samit Chakrabarty[4]

[1-3]Lifespark Technologies
[4]School Of Biomedical Sciences, University of Leeds

September 2023

Abstract

Freezing of gait (FOG) is a common and debilitating symptom in individuals with Parkinson's disease (PD), often leading to falls. Its incidence and severity vary significantly, even among people with identical disease profiles. This variation in the presentation of FOG highlights the existence of numerous underlying processes and pathologic variables. Furthermore, the pharmaceutical response varies significantly among patients, emphasising the importance of differentiating the FOG subtypes for optimised therapeutic strategies. However, due to the lack of specialised motor and cognitive testing, current FOG assessment methods are unable to categorise subtypes. To address this essential gap, we developed the Understanding FOG (UnFOG) scale. This new technique is designed for clinical and research use, providing a complete method for documenting the clinical manifestations of FOG while incorporating cognitive tests. UnFOG has the potential to revolutionise our understanding of FOG subtypes by combining these discoveries, paving the path for more personalised and successful treatment techniques. This study has the potential to improve the lives of Parkinson's disease sufferers while also expanding our understanding of this complex disease.

Acronyms

BDT Block Design Test. 5

BG Basal Ganglia. 3

BQSS Boston Qualitative Scoring System. 6, 11

CDT Clock Drawing Test. 5

DA Dopamine Agonist. 2

FES-I Fall Efficacy Scale - International. 9

FOG Freezing of Gait. 2

FOGQ Freezing of Gait Questionnaire. 2

JLO Benton Judgement of Line Orientation Test. 5

MLR Mesencephalic Locomotor Region. 3

NFOGQ New Freezing of Gait Questionnaire. 2

PD Parkinson's Disease. 2

PPN Pedunculopontine Nucleus. 4

RF Brainstem Reticular Formation. 3

ROCF Ray-Osterrieth Complex Figure Test. 5

SMA Supplementary Motor Area. 4

SNc Substantia Nigra Pars Compacta. 4

TMT Trail Making Test. 5, 6, 11

UPDRS Unified Parkinson's Disease Rating Scale. 2

1 Introduction

A significant proportion of Parkinson's disease(PD) patients suffer from freezing of gait (FOG), ranging from 50% in moderate stages to as high as 80% in advanced stages. Freezing of gait is a highly debilitating symptom. FOG is recognised as the leading cause of falls among individuals with PD[1, 2]. The cause and pathophysiology of FOG is not definitively known. Clinical observations have indicated that certain situations or environmental factors, such as anxiety, cluttered spaces, or turns, can trigger FOG in different patients[3]. But these symptoms do not appear uniformly in all individuals. Individuals at the same disease stage do not necessarily have similar incidences of FOG. Even among individuals who have FOG, the same triggers do not necessarily elicit FOG. The response to drugs is also heterogeneous. There exists a dopamine-unresponsive type of FOG[4], which is different in terms of cognitive changes compared to dopamine-responsive FOG. Long-term treatment with Levodopa and Dopamine agonists (DAs), especially in pulsatile regimens, are positively correlated with the development of FOG[5]. Some drugs have been reported to worsen or even cause FOG in some cases[6, 5]. This diverse presentation of FOG suggests varying underlying mechanisms and the presence of distinct subtypes[7, 1]. FOG manifests in various forms, each linked to specific triggers, with multiple proposed mechanisms and pathophysiologies to explain these variations.

The subtyping of FOG will allow a clear distinction between different types of FOG in different groups of patients, thus acting as the first step towards the development of evidence-based personalised strategies to tailor the treatment of the disease. Drugs, exercise regimes, different preventive strategies, etc., could be used according to subtypes to provide better FOG management for patients. Understanding the underlying mechanism can help develop a more targeted and individualised intervention that increases the likelihood of reducing freezing episodes[7, 8].

Current scales for measuring FOG are insufficient for such classification into subtypes. Methods such as Unified Parkinson's Disease Rating Scale(UPDRS) part III, Freezing of Gait Questionnaire(FOGQ), New Freezing of Gait Questionnaire(NFOGQ) are used commonly for screening the presence of FOG but do not record details of its presentation. Newer scales, such as Freezing of Gait Severity Tool[9] do record activities and situations that triggers FOG. However, to identify the subtypes, it is necessary to include measures that assist in narrowing down the potential mechanisms and regions of the central nervous system that may be involved. This would require a scale that includes the cognitive and psychometric evaluations along with the current FOG scales. This has led us to develop the "Understanding Freezing Of Gait" scale (UnFOG), a scale that includes both motor and non-motor assessments to accurately assess FOG such that it allows for therapeutic decisions being made in practical clinical settings in an economical and patient-friendly manner.

2 Review of Existing Measures of FOG

Multiple scales have been reported in the literature for the assessment of FOG. They range from older scales such as UPDRS (Part II, item 14) or the Movement Disorder Society-UPDRS (Part II, item 2.13: Activities of Daily Living)[10], Dynamic Parkinson Gait[11], FOGQ[12] and NFOGQ[13], to recent additions such as Freezing of Gait Score[14], Freezing of Gait Severity Tool[9] and its revised version[15].

Among these scales, FOGQ and NFOGQ are most extensively reported and used in clinical settings as they assist clinicians in identifying the presence of FOG. FOGQ is a subjective measurement of the severity of FOG, whereas NFOGQ is accompanied

by a video to demonstrate severity of FOG in terms of frequency of occurrence, intensity, and duration of the longest FOG episodes, self-reported subjective impact on quality of life and activities of daily living. However, these questionnaires measure FOG only during gait initiation and when turning. Other situations that trigger FOG, such as dual tasking and narrow spaces[16, 17], are not assessed.

Ziegler and colleagues introduced the "FOG Score," a metric designed to assess occurrences of freezing of gait during tasks known to induce FOG. These tasks encompass start hesitation, both clockwise and anticlockwise turns, and navigating through confined spaces, such as doorways. The FOG Score is calculated in conjunction with either a motor dual task, a cognitive dual task, or in isolation without any additional task. The "FOG score" is a simple test that involves freeze provoking activities and can be completed reasonably quickly. While it addresses a majority of the types of freezing, it does not collect cognitive data, which we believe is critical for subtyping.

Similarly, Scully et al.[9] recently developed a clinician-rated tool to determine the severity of FOG. This tool, termed as Freezing of Gait Severity Tool, was developed based on a consensus study of healthcare professionals (Delphi process). The Delphi experts collectively determined the 'triggering circumstances' to be evaluated which include 'turning hesitation', 'narrow space hesitation', 'start hesitation', 'cognitive dual task', and 'open space hesitation'; and agreed upon the 'aspects of gait freezing' such as 'medication state', 'type of freezing', 'number of freezing episodes' and 'average duration of freezing episodes' should be measured. The FOG Severity Tool is the most comprehensive scale to date. The need to include various psychometric measures along with the scale is discussed, but no suggestions are made about which measures might be helpful to aid the understanding of FOG.

FOG takes on various forms, triggered by multiple factors, and has numerous mechanisms and pathophysiologies to account for these variations. Identifying the specific combination of these pathologies in an individual is crucial for tailoring more precise and personalized treatment strategies. UnFOG utilizes cognitive assessments alongside the standard sensory and motor tests, to offer insights into the associated pathophysiology of distinct FOG subtypes. Furthermore, by gathering longitudinal data through the UnFOG framework, we can continuously refine therapeutic guidance, leading to more cohesive and effective management of FOG and related symptoms.

3 Manifestations of FOG

Based on different FOG-provoking situations, FOG can be classified as follows[1, 8, 18, 19]:

- Start Hesitation: Occurs when individuals freeze upon initiating walking
- Turn Hesitation: Manifests as feet appearing stuck while turning.
- Hesitation in Tight Quarters: FOG occurs when passing through narrow spaces such as doorways.
- Destination-Hesitation: Freezing occurs when approaching a target, typically within the final 2 meters of a task.
- Open Space Hesitation: Spontaneous freezing while walking in open spaces without apparent triggers such as doorways.
- Sudden Demands/Time Pressure: FOG arises due to unexpected stimuli such as a ringing telephone or doorbell.
- Dual Task: Simultaneous execution of two tasks (either motor or cognitive) leads to FOG.

Multiple hypothesized mechanisms and specific brain regions are implicated in FOG. Broadly, it involves the malfunction of supraspinal regions, including the brainstem reticular formation (RF), Mesencephalic locomotor regions (MLR), Basal Ganglia (BG), cerebral cortex, and cerebellum, all of which have crucial roles in locomotion[20, 21]. These regions are engaged in different locomotor activities such as gait initiation, turning, obstacle negotiation, dual tasking, and other complex motor tasks, all capable of triggering FOG. One of the most widely

accepted pathophysiological factor in FOG is dysfunction within the basal ganglia[22, 23, 24], particularly due to the loss of dopamine-producing neurons in the substantia nigra pars compacta (SNc). This dopamine loss disrupts the functioning of intrinsic networks within the basal ganglia, leading to impairments in gait initiation[25], increased reliance on goal-directed systems[26], and difficulties in executing dual tasks. However, it's important to note that striatal dopamine loss is not the sole cause of FOG[27]. The Pedunculopontine nucleus (PPN), a part of the brainstem, is another critical player in FOG[28, 29, 30]. Dysfunction or cholinergic neuron loss within the time (PPN) has been linked to FOG , especially in cases of start hesitation[27, 31, 32, 33, 34]. The PPN is instrumental in gait initiation and control.

Frontostriatal circuits, which connect the frontal cortex and basal ganglia, have also been implicated. Impairments in these circuits affect cognitive processes such as attention, working memory and executive control, contributing to the challenges faced by individuals with FOG, particularly in dual-task scenarios[27, 31, 32, 35]. Over-activation of the prefrontal cortex (PFC) has been observed during unsuccessful turns in PD, possibly serving as compensation for impaired basal ganglia output[36, 37]. The cerebellar pathway, specifically the cortico-pontine-cerebello-thalamo-cortical pathway, is involved in preparing and executing the first step in locomotion. Although increased cerebellar activation is noted in FOG, it is still unclear whether this activation is pathological or compensatory[27]. Additionally, FOG can be triggered by perceptual judgement deficits, such as damage to frontoparietal circuits, and difficulties in integrating visual and proprioceptive inputs with motor output. These issues can cause individuals to struggle when navigating confined spaces[38, 39].

We outline the cognitive scales that can narrow down these mechanisms and thus the brain areas in the following section.

4 FOG and associated cognitive disparities

Several studies have investigated the cognitive disparities between people with and without FOG. They consistently show that those experiencing FOG tend to perform less effectively in cognitive assessments. Specifically, they exhibit weaker performance in domains associated with the frontal lobe, including executive function, attention, and visuospatial abilities, when compared to their counterparts who do not experience FOG [4, 40, 35, 41, 42, 43]. A summary of associated tests can be found in **Table 1**

4.1 Basal Ganglia-Thalamocortical Circuits and FOG

Dysfunction of basal ganglia-thalamocortical circuits[22, 23, 24] can cause FOG. Disruption of the neural output from basal ganglia to thalamus can reduce the cortical drive through the Supplementary Motor Area (SMA) drive, thus contributing to FOG. The grasp test[44] can be used to detect SMA dysfunction, which affects motor planning and execution. It is also reported that cognitive factors such as conflict resolution, i.e inhibition and/or selection of responses, can also play a role in the incidence of FOG. It has been suggested that FOG is associated with impairment in executive control networks for conflict resolution in freezers compared to non-freezers and healthy control[45, 46]. Individuals with FOG exhibit deficits in these tasks[41], suggesting a link between FOG and executive control network dysfunction. Cognitive tests such as Go No Go test and tasks involving conflicting instructions can potentially help identify impairments in conflict resolution.

4.2 Frontostriatal Pathway Dysfunction and FOG

Dysfunction of the frontostriatal pathway is associated with freezing linked to start hesitation or gait initiation[25]. This dysfunction can lead to impairments in executive function and motor planning, leading to difficulties in initiating and maintaining

gait patterns. Executive dysfunction and specifically set shifting, the ability to switch attention during a task (e.g., Standing to walking) during gait initiation, may be compromised in PD individuals. It has been demonstrated that FOG during gait initiation in PD is correlated with poorer performance on set-shifting tasks[47]. In addition, it is also reported that the visuospatial ability plays a significant role in gait initiation for generating motor plan and controlling locomotion in individuals with PD who experience FOG[47]. Cognitive assessments that focus on executive function and visuospatial skills such as The Trail Making Test(TMT) and tests for evaluating the visuospatial ability such as Benton Judgement of Line orientation test[48](JLO) or the Clock Drawing Test[49](CDT) can be used to explore these deficits in individuals with freezing.

4.3 Narrow Space Hesitation and Perceptual Judgment

Narrow space hesitation is thought to be due to perceptual judgement deficits, due to damage to frontoparietal circuits[38, 39] in addition to PPN dysfunction and poor communication between BG and frontal lobe[50]. Visuospatial ability also appears to be involved in doorway walking, and PD individuals with FOG tend to perform poorly in visuospatial processing tests[51, 38]. Since visuospatial ability is also related to frontal and parietal lobes[52], the impairment in this region may result in freezing in narrow spaces. Cognitive tests related to frontoparietal network and visuospatial ability[42] include the JLO, the Rey-Osterrieth Complex Figure Test[53](ROCF), the Block Design Task[54](BDT), and the CDT. Hence a lower score or inability to perform these tests can be linked with factors related to occurrence of FOG in narrow spaces. Anxiety is an additional factor that may influence narrow space FOG. Increased levels of anxiety can impede motor planning and execution[55].

4.4 Sudden Obstacle-Related FOG and Executive Dysfunction

Sudden obstacle related FOG has also been linked with difficulties in switching tasks or set shifting, which can result from frontal executive dysfunction in addition to basal ganglia dysfunction[56]. Performance on the (TMT) Part B[57] can be used for assessing this dysfunction. A strong correlation between TMT part B and self-reported freezing symptoms has been reported[40, 58]. Additionally, anxiety in PD is associated with attentional set shifting[59] and it is reported that increased anxiety levels can also contribute to sudden obstacle FOG[56, 55]. Combining the results of TMT Part B and an anxiety scale can help in evaluation of switching difficulties and anxiety levels in individuals with FOG. This combined assessment can potentially predict the likelihood of freezing during sudden obstacle encounters or situations with time pressure.

4.5 Dual Task FOG and Frontostriatal Circuits

Dual task FOG may involve the disruption in frontostriatal circuits[27, 31]. Frontostriatal dysfunction can result in executive dysfunction[60], including difficulties in planning, organizing, shifting attention and multitasking. In PD, dual tasking can overload cognitive resources, leading to FOG. Cognitive tests that assess different aspects of executive and frontostriatal functions[61] include TMT, CDT, Stroop Test, Digit Span Test, Serial Subtraction 7, and Verbal Fluency. Lower scores or failure to complete these tests may indicate executive dysfunction, which contributes to difficulties in dual tasking.

These cognitive tests, followed by motor assessments and other clinical observations, can provide valuable insights into different subtypes and the severity of FOG in PD. It can help identify specific cognitive and motor deficits that may contribute to FOG episodes, allowing a more comprehensive understanding of the condition, which can aid in the management of treatment strategies.

Table 1: FoG and associated cognitive disparities

TEST	INTERPRETATION	TYPE OF FOG
Trail Making Test(TMT) part B	In part B of TMT, participants are instructed to switch between connecting the numbers and letters (eg. 1-A-2-B-C-3. . . . .) [62].When the time required to complete the task is greater than 273 seconds, it indicates that individual have difficulty in shifting tasks. Higher scores reveal greater impairment	Sudden obstacle FOG, Narrow space hesitation, Start hesitation
Judgement of line orientation task	The Benton Judgment of Line Orientation assessment instructs participants to match/align two angled line portions on the top page to an array of eleven target lines. The total number of correct matches is recorded, and both lines need to be correctly matched to be counted as correct[63]. The total possible score is 30 points. Score lower than 20 might indicate impairment of visuospatial ability	Narrow space hesitation, Start hesitation
Rey-Osterrieth Complex Figure Test	Participants are instructed to copy or replicate the ROCF. In ROCF test, the figure is divided in 3 parts : a) Configural elements: scored as present or accurate b) Clusters: scored as present, accurate and placed correctly c) Details: scored as present and placed correctly [64]. A Boston Qualitative Scoring System (BQSS) copy total score of 16 or lower suggests a global cognitive impairment. This score reflects difficulties in executive function such as planning and neatness, rather than visuoconstructional impairments. These planning difficulties are believed to be associated with a dysfunctional frontal basal ganglia network responsible for coordinating goal directed and voluntary actions[64]	Sudden obstacle, Start hesitation
Clock drawing test	In CDT, participants are instructed to draw a clock face that includes all numbers and set time to 10 past 11. A 10 point scoring system is used. Cut off score of 6 out of 10 indicates a normal cognitive functioning. Lower score indicate prominent impairment[65, 66]	Sudden obstacle FOG, Narrow space hesitation, Start hesitation
Serial 7 Test	In this test, individual are instructed to subtract 7 from 100, then subtract 7 from the result, and so on till 2.High score indicates higher number of errors indicating potential frontal lobe dysfunction. This dysfunction impairs the ability to dual task leading to FOG	Dual task FOG, Start hesitation

Continued on next page

Table 1: FoG and associated cognitive disparities (Continued)

TEST	INTERPRETATION	TYPE OF FOG
Digit Span Test	In digit span test, examiner reads a sequence of digits and the participant has to repeat the sequence. There are 2 parts in this test: Forward span (recall in the same order) and backward span (recall in the reverse order). Assign one point for each correctly repeated sequence.[67]. A cutoff score of $\leq$6 is associated with high global specificity rates of 96% and 97% and it is also reported that most of the healthy participant perform well within a span of apprehension range of seven plus/minus two.[68, 69]	Dual task FOG, Start hesitation
Stroop Test	In this test, participants are given instructions to read 3 different tables as quickly as possible. Two of these tables are in congruous condition(read words and color sections accordingly). The third table, known as the color-word table, is in incongruent condition, for example, red may be printed in blue ink. In this condition,the participants have to name the ink of the color rather than reading the word	Dual task FOG, Start hesitation
VFT	Verbal fluency test includes two common types: Letter fluency : Participants are asked to name all the possible words that start with that specific letter. The most common letters chosen are F, A, and S. Some clinicians may set 60 second time limit for each letter, while others may select only one letter for assessment. Category fluency: Person is asked to create a list of as many words as possible within a given semantic category (e.g., Animals) within a specific time frame, typically 60 seconds). A low score ($<$14) can indicate dysfunction in specific areas of brain including the dorsolateral prefrontal cortex, anterior cingulate cortex, SMA and the cerebellum. [70]	Dual task FOG, Start hesitation
Plantar Grasp Reflex	The grasp reflex can be elicited by stroking the plantar surface of foot with an object such as reflex hammer. In adults, there should typically be no response. If there is a response such as flexion or adduction of toes, it may indicate underlying pathology (marked flexion of the toes on standing or when stroking the sole)[71, 44, 72, 73]. The presence of flexion or adduction of toes in this test indicates dysfunction of the supplementary motor area and cingulate motor cortex, as the etiology of the palmar or plantar grasp[71, 74, 73, 75]	General FOG

Continued on next page

Table 1: FoG and associated cognitive disparities (Continued)

TEST	INTERPRETATION	TYPE OF FOG
Go/ No-Go Test	During the Go/No-Go Test, participants are instructed to press the button in response to specific Go stimuli as fast as possible and withhold their response in presence of letter X (No-Go stimuli). Failing to respond on go trials indicate difficulty in response initiation and failing to inhibit responses on No-go trials may indicate difficulty in inhibitory control in the Go/No-go task[41]. Longer reaction times or delayed response may indicate a deficit in motor preprograming [76].This test is correlated with the involvement of preSMA, which is critical for selection of appropriate behaviour[77].	General FOG

5 The UnFOG scale

The UnFOG scale is designed to differentiate between various subtypes of FOG and to objectively assess the presence and severity of FOG in individuals with PD. The order of activities in UnFOG is listed in **Table 2**.

UnFOG begins with a comprehensive assessment that encompasses psychometric and cognitive tests, as well as specialized gait testing specifically tailored for Freezing of Gait (FOG) evaluation. To gauge anxiety levels, we employ two established scales: the Geriatric Anxiety Scale [78] and Part C of Parkinson Anxiety Scale[79]. These instruments enable us to assess general anxiety as well as anxiety related to specific activities or environments, a crucial consideration as FOG and falls are often interrelated in individuals with PD [3]. in addition, we employ the Fall Efficacy Scale - International [80](FES-I) to assess self reported fear of falling, with a particular focus on daily activities, especially among older adults and individuals with disabilities. Following this anxiety assessment, we proceed with the cognitive evaluation. The cognitive assessment portion includes a battery of tests, detailed in **Table 3** along with scoring and interpretation. These cognitive assessments may provide insights into potential correlations with specific subtypes of FOG.

In UnFOG, six distinct FOG provoking situations are used to assess FOG, as seen in **Table 5**. These activities, such as small radius turns, passing through doorways, sit-stand-gait initiation, have been shown to reliably elicit freezing in most individuals [14, 7].

Our scoring system for the FOG scale ranges from 0 to 36. A score of 0 signifies an absence of freezing across all tasks, while a score of 36 indicates severe FOG, necessitating task abandonment or external assistance.

A score of

< 12 indicates minor freezing

12-24 moderate levels of freezing

> 24 indicate severe freezing

UnFOG Gait tasks can also be video recorded for post-hoc analysis of frequency and duration of Freezing of Gait. This design allows for both in-person and remote administration, offering flexibility for clinical settings. The relationship between cognitive dysfunction and FOG subtype is established by identifying the brain areas involved in both the cognitive task and the specific FOG subtype. Consequently, cognitive performance on these tests can be analyzed in relation to the corresponding FOG subtype.

We anticipate that the subtypes derived from data collected using UnFOG will be more robust and offer valuable insights into the potential progression of FOG. For instance, if multiple cognitive functions exhibit impairment, one can expect a higher level of progression and severity in FOG. This knowledge empowers clinicians to make more informed decisions regarding rehabilitation and physical therapy regimens based on cognitive scores.

6 Discussion

The heterogenous presentation of FOG across the PD population, combined with variable response to medication indicate the presence of FOG subtypes. Current scales focus on the clinical manifestation of FOG, but lack details to understand the underlying subtypes. UnFOG aims to differentiate FOG subtypes, provide comprehensive characterization, and assist in better FOG management. Subtyping allows for a finer level of characterization, essential for tailored interventions. Additionally, UnFOG can identify patient groups susceptible to medication-induced FOG, aiding in medication choices.

Subtyping would significantly enhance the functional characterization of this debilitating symptom. It allows clinicians to categorize patients based on specific triggers and the severity of their FOG episodes. For instance, individuals who primarily experience FOG in open spaces can be distinguished from those who exhibit FOG during motor dual tasks or gait initiation. This level of characterization is vital for tailoring interventions to individual patient needs.

Moreover, considering the widespread usage of various drug classes, such as levodopa and dopamine agonists (DAs), in PD treatment, UnFOG holds sig-

Table 2: UnFOG schedule of activities

	Activity	Estimated time
1	Geriatric Anxiety Scale, Parkinson Anxiety Scale Part C) and Falls Efficacy Scale International	12 minutes
2	Cognitive assessment tests	70 minutes
3	FOG tests	15 minutes

nificant potential in identifying patient groups at higher risk of adverse effects, including medication-induced FOG. By linking specific FOG subtypes to medication-induced FOG, clinicians can enhance their ability to make well-informed decisions concerning medication selection. This becomes particularly valuable in cases where patients may experience exacerbation or even the onset of FOG as a side effect of specific medications[6, 5]. UnFOG's ability to pinpoint patient groups prone to these adverse effects empowers clinicians to tailor treatment strategies more effectively. For example, if a particular FOG subtype is associated with drug-induced FOG, clinicians can make more precise and patient-centered choices regarding medication options. To evaluate the effectiveness of therapeutic interventions accurately, a sensitive and specific scale is essential. UnFOG is precisely tuned to gauge FOG changes brought on by therapy. Researchers and clinicians can track advancements or relapses with greater precision over time. This objective measurement has the potential to improve treatment selection, potentially leading to more efficacious therapies. For instance, consider the clinical evaluation of Rasagiline and its impact on FOG. While a positive change of 1.11 points was recorded on the FOGQ scale [81] its significance remained unclear due to the lack of differentiability in the FOGQ scale. The UnFOG scale is specifically designed for such purposes.

The scale is designed such that it can be administered digitally in its entirety, making it practical for use in busy clinical settings. For added clinical utility, we recommend using the Mini-BESTest[82], a reliable scale for detecting fall risk[83] to find the risk of falls associated with each distinct subtype. Demographic and medication data including age, gender, disease duration, and medical history will also be recorded for more robust data analysis. (Draft proforma in A.1)

7 Conclusion

To advance our understanding of FOG, we introduce an objective, quantifiable assessment method to characterise FOG comprehensively, including the underlying mechanisms. The UNFOG scale encompasses psychometric, cognitive and gait assessments systemically exploring FOG . Together, these measures provide a holistic view of FOG. The necessity for personalised care and treatment in Parkinson's disease has become extremely evident. This need can only be achieved by precisely targeted interventions, based on identified subtypes. The UnFOG scale will empower researchers and clinicians to better gauge the condition of FOG in patients, facilitating identification and development of better personalised therapies. The scale presents a significant step towards a better comprehension of FOG and a more effective approach to management of individuals with Parkinson's disease.

Table 3: UnFOG Part B (Cognitive)

TEST	DESCRIPTION	SCORE / TIME
Trail Making Test TMT part B	Average time to complete the task is 75 secs, Time more than 273 seconds indicates a deficient score The test is discontinued if an individual cannot complete the task in 5 minutes.[84].	
Judgement of line orientation task	The total possible score is 30 points. A raw score of 0 is assigned for an item when either one or neither of the stimulus lines in that item is correctly identified by the subject.[85]. Scoring criteria: A score below 17 indicates severe defect in JLO Score between 17 to 20 represent mild to moderate defects in JLO Score of 21 and above indicates no defect or unimpaired state. [63].	
Rey-Osterrieth Complex Figure Test	A Boston Qualitative Scoring System (BQSS) copy total score of 16 or lower suggests a global cognitive impairment.	
Clock drawing test	A 10 point scoring system is used, where the lowest score is 1 (worst representation) and highest is 10 (best representation). 5 points for correctly drawing the clock face and accurate placement of numbers. 6-10 points for correctly depicting the time	
Stroop Test	3 scores are noted according to the correctly named items in 45 seconds: a) Word (W) score, b) Color (C) score, c) Color-Word (C-W) score and d) Interference score is calculated using $(W \times C)/(W + C)$ [86]	
Serial Subtraction 7	Any subtraction other than 7 is considered as error and total number of errors are calculated. [87, 88] Formula: (no. of incorrect responses/total no. of responses)*14 Cutoff score: >7 indicates moderate to severe impairment	
Digit Span Test	RDS is calculated by adding together the last set of forward and backward sequences in which participant correctly repeated the in both trials without any errors.	
Verbal fluency Test	One point is awarded for each unique correct response [89, 90]. A low score (<14) can indicate dysfunction. [70]	
Plantar Grasp reflexes	If there is a response such as flexion or adduction of toes, it may indicate underlying pathology (marked flexion of the toes on standing or when stroking the sole) [71, 44, 72, 73]	

Continued on next page

Table 4: UnFOG Part B Interpretation sheet

Circuit / Mechanism	Associated Test	Impairment and Severity Score
SMA dysfunction	Plantar Grasp Reflex test (pressence of reflex response)	Yes/No
Frontoparietal network (including the prefrontal and parietal regions)	TMT test, CDT test	High/moderate/low/none
Frontostriatal/ Frontal- basal ganglia network	ROCF, Serial 7 test	High/moderate/low/none
Visuospatial ability dysfunction: Posterior parietal and occipitoparietal	JLO test	High/moderate/low/none
Frontal executive dysfunction : the left inferior frontal cortex and the left dorsolateral prefrontal cortex, the supplementary motor cortex, the anterior cingulate cortex and the cerebellum	Verbal Fluency Test	High/moderate/low/none
(Frontostriatal)Damage to DLPFC, temporoparietal and basal ganglia structures	Digit Span Test	High/moderate/low/none
Anterior cingulate cortex and DLPFC	Stroop test	High/moderate/low
preSMA	Go/No-Go task	High/moderate/low Yes/No

Table 3: UnFOG Part B (Cognitive) (Continued)

TEST	DESCRIPTION	SCORE / TIME
Go/No-Go test	The parameters observed during this test includes measuring the number of correct and incorrect responses and response time (the time interval between appearance of Go stimulus and the individual response of pressing the button) [91, 41, 92] Cutoffs : >2 errors, 1-2 errors and 0 errors. Reaction time scoring (Low to High level of impairment) [76] : <350ms, 350-450ms, >450ms	

Table 5: UnFOG Part C : Gait Assessment

TASKS	SITUATION	SCORE
WALKING	Sit to stand from chair	
	4m straight walk - Cross large carpet at 2m	
	Turn 360 in one direction	
	Turn 540 in other (direction can be along the more affected side first)	
	2 rounds in Cluttered maze - Maze made from 2 chairs	
	2 1- foot cones, 2 $\frac{1}{2}$ foot cones	
	Pass through the door	
WALKING + Arithmetic dual task	Pass through the door	
	2 rounds in Cluttered maze - Maze made from 2 chairs	
	2 1- foot cones, 2 $\frac{1}{2}$ foot cones	
	Turn 360 in one direction	
	Turn 540 in other (direction can be along the more affected side first)	
	4m straight walk - Cross large carpet at 2m	
	Stand to sit	

Table 6: UnFOG Part C Scoring system

SCORE	SEVERITY OF FOG
0	No freezing
1	Minor festination, shuffling
2	FOG (trembling in place, total akinesia) overcome by patient without external help
3	Severe FOG (Task aborted or external interference needed)

References

[1] JD Schaafsma et al. "Characterization of freezing of gait subtypes and the response of each to levodopa in Parkinson's disease". In: *European journal of neurology* 10.4 (2003), pp. 391–398.

[2] C. Gao et al. "Freezing of gait in Parkinson's disease: Pathophysiology, risk factors and treatments". en. In: *Translational Neurodegeneration* 9.1 (2020), p. 12. DOI: 10.1186/s40035-020-00191-5.

[3] Bastiaan R Bloem et al. "Falls and freezing of gait in Parkinson's disease: a review of two interconnected, episodic phenomena". In: *Movement disorders: official journal of the Movement Disorder Society* 19.8 (2004), pp. 871–884.

[4] S.A. Factor et al. "Freezing of gait subtypes have different cognitive correlates in Parkinson's disease". en. In: *Parkinsonism & Related Disorders* 20.12 (2014), pp. 1359–1364. DOI: 10.1016/j.parkreldis.2014.09.023.

[5] M. Salari et al. "Irreversible extreme freezing of gait after dopamine agonist withdrawal". en. In: *Clinical Case Reports* 9.8 (2021), p. 04712. DOI: 10.1002/ccr3.4712.

[6] R. Constantinescu. "Update on the use of pramipexole in the treatment of Parkinson's disease". en. In: *Neuropsychiatric Disease and Treatment* 4.2 (2008), pp. 337–352.

[7] K.A. Ehgoetz Martens et al. "Evidence for subtypes of freezing of gait in Parkinson's disease". en. In: *Movement Disorders* 33.7 (2018), pp. 1174–1178. DOI: 10.1002/mds.27417.

[8] S. Rahman et al. "The Factors that Induce or Overcome Freezing of Gait in Parkinson's Disease". en. In: *Behavioural Neurology* 19.3 (2008), pp. 127–136. DOI: 10.1155/2008/456298.

[9] Beatriz I.R. Oliveira et al., eds. *Developing the Freezing of Gait Severity Tool: A Delphi consensus study to determine the content of a clinician-rated assessment for freezing of gait severity—Aileen E Scully.* en. n.d. Retrieved September 26, 2023, from. Ross Clark, Elissa Burton, 2022. URL: https://journals.sagepub.com/doi/10.1177/02692155221121180.

[10] Christopher G Goetz et al. "Movement Disorder Society-sponsored revision of the Unified Parkinson's Disease Rating Scale (MDS-UPDRS): scale presentation and clinimetric testing results". In: *Movement disorders: official journal of the Movement Disorder Society* 23.15 (2008), pp. 2129–2170.

[11] J. Crémers et al. "Construction and validation of the Dynamic Parkinson Gait Scale (DYPAGS". en. In: *Parkinsonism & Related Disorders* 18.6 (2012), pp. 759–764. DOI: 10.1016/j.parkreldis.2012.03.012.

[12] N. Giladi et al. "Construction of freezing of gait questionnaire for patients with Parkinsonism". en. In: *Parkinsonism & Related Disorders* 6.3 (2000), pp. 165–170. DOI: 10.1016/s1353-8020(99)00062-0. URL: https://doi.org/10.1016/s1353-8020(99)00062-0.

[13] A. Nieuwboer et al. "Reliability of the new freezing of gait questionnaire: Agreement between patients with Parkinson's disease and their carers". en. In: *Gait & Posture* 30.4 (2009), pp. 459–463. DOI: 10.1016/j.gaitpost.2009.07.108.

[14] K. Ziegler et al. "A new rating instrument to assess festination and freezing gait in Parkinsonian patients". en. In: *Movement Disorders* 25.8 (2010), pp. 1012–1018. DOI: 10.1002/mds.22993.

[15] Aileen E Scully et al. "Scoring festination and gait freezing in people with Parkinson's: The freezing of gait severity tool-revised". In: *Physiotherapy Research International* (2023), e2016.

[16] Anke H Snijders et al. "Clinimetrics of freezing of gait". In: *Movement disorders: official journal of the Movement Disorder Society* 23.S2 (2008), S468–S474.

[17] C. Barthel et al. “The Practicalities of Assessing Freezing of Gait”. en. In: *Journal of Parkinson's Disease* 6.4 (), pp. 667–674. DOI: 10.3233/JPD-160927. URL: https://doi.org/10.3233/JPD-160927.

[18] Joke Spildooren et al. “Freezing of gait in Parkinson's disease: the impact of dual-tasking and turning”. In: *Movement Disorders* 25.15 (2010), pp. 2563–2570.

[19] Yasuyuki Okuma and Nobuo Yanagisawa. “The clinical spectrum of freezing of gait in Parkinson's disease”. In: *Movement disorders: official journal of the Movement Disorder Society* 23.S2 (2008), S426–S430.

[20] J.G. Nutt et al. “Freezing of gait: Moving forward on a mysterious clinical phenomenon”. en. In: *The Lancet. Neurology* 10.8 (2011), pp. 734–744. DOI: 10.1016/S1474-4422(11)70143-0. URL: https://doi.org/10.1016/S1474-4422(11)70143-0.

[21] M.J. Ferreira-Pinto et al. “Connecting Circuits for Supraspinal Control of Locomotion”. en. In: *Neuron* 100.2 (2018), pp. 361–374. DOI: 10.1016/j.neuron.2018.09.015.

[22] K. Takakusaki, N. Tomita, and M. Yano. “Substrates for normal gait and pathophysiology of gait disturbances with respect to the basal ganglia dysfunction”. en. In: *Journal of Neurology* 255.4 (2008), pp. 19–29. DOI: 10.1007/s00415-008-4004-7.

[23] Kaoru Takakusaki. “Neurophysiology of gait: from the spinal cord to the frontal lobe”. In: *Movement Disorders* 28.11 (2013), pp. 1483–1491.

[24] S.J.G. Lewis and R.A. Barker. “A pathophysiological model of freezing of gait in Parkinson's disease”. en. In: *Parkinsonism & Related Disorders* 15.5 (2009), pp. 333–338. DOI: 10.1016/j.parkreldis.2008.08.006.

[25] A. Delval, C. Tard, and L. Defebvre. “Why we should study gait initiation in Parkinson's disease”. fr. In: *Neurophysiologie Clinique = Clinical Neurophysiology* 44.1 (2014), pp. 69–76. DOI: 10.1016/j.neucli.2013.10.127.

[26] Peter Redgrave et al. “Goal-directed and habitual control in the basal ganglia: implications for Parkinson's disease”. In: *Nature Reviews Neuroscience* 11.11 (2010), pp. 760–772.

[27] J.M. Shine, S.L. Naismith, and S.J.G. Lewis. “The pathophysiological mechanisms underlying freezing of gait in Parkinson's Disease”. en. In: *Journal of Clinical Neuroscience* 18.9 (2011), pp. 1154–1157. DOI: 10.1016/j.jocn.2011.02.007.

[28] M.-L. Welter et al. “PPNa-DBS for gait and balance disorders in Parkinson's disease: A double-blind, randomised study”. en. In: *Journal of Neurology* 262.6 (2015), pp. 1515–1525. DOI: 10.1007/s00415-015-7744-1.

[29] Cecile Gallea et al. “Pedunculopontine network dysfunction in Parkinson's disease with postural control and sleep disorders”. In: *Movement Disorders* 32.5 (2017), pp. 693–704.

[30] T.L. Tattersall et al. “Imagined gait modulates neuronal network dynamics in the human pedunculopontine nucleus”. en. In: *Nature Neuroscience* 17.3 (2014). DOI: 10.1038/nn.3642.

[31] Alice Nieuwboer and Nir Giladi. “Characterizing freezing of gait in Parkinson's disease: models of an episodic phenomenon”. In: *Movement Disorders* 28.11 (2013), pp. 1509–1519.

[32] Y. Okuma. “Practical approach to freezing of gait in Parkinson's disease”. en. In: *Practical Neurology* 14.4 (2014), pp. 222–230. DOI: 10.1136/practneurol-2013-000743.

[33] D. Grabli et al. “Normal and pathological gait: What we learn from Parkinson's disease”. en. In: *Journal of Neurology, Neurosurgery, and Psychiatry* 83.10 (2012), 10 1136 –2012–302263. DOI: 10.1136/jnnp-2012-302263.

[34] Peter A Pahapill and Andres M Lozano. “The pedunculopontine nucleus and Parkinson's disease”. In: *Brain* 123.9 (2000), pp. 1767–1783.

[35] M. Amboni et al. "Freezing of gait and executive functions in patients with Parkinson's disease". en. In: *Movement Disorders: Official Journal of the Movement Disorder Society* 23.3 (2008), pp. 395–400. DOI: 10.1002/mds.21850.

[36] S. Stuart et al. "Pre-frontal Cortical Activity During Walking and Turning Is Reliable and Differentiates Across Young, Older Adults and People With Parkinson's Disease". en. In: *Frontiers in Neurology* 10 (2019). DOI: 10.3389/fneur.2019.00536.

[37] V. Belluscio et al. "The Association between Prefrontal Cortex Activity and Turning Behavior in People with and without Freezing of Gait". en. In: *Neuroscience* 416 (2019), pp. 168–176. DOI: 10.1016/j.neuroscience.2019.07.024.

[38] Quincy J Almeida and Chad A Lebold. "Freezing of gait in Parkinson's disease: a perceptual cause for a motor impairment?" In: *Journal of Neurology, Neurosurgery & Psychiatry* 81.5 (2010), pp. 513–518.

[39] D. Cowie et al. "Insights into the neural control of locomotion from walking through doorways in Parkinson's disease". en. In: *Neuropsychologia* 48.9 (2010), pp. 2750–2757. DOI: 10.1016/j.neuropsychologia.2010.05.022.

[40] S.L. Naismith, J.M. Shine, and S.J.G. Lewis. "The specific contributions of set-shifting to freezing of gait in Parkinson's disease". en. In: *Movement Disorders: Official Journal of the Movement Disorder Society* 25.8 (2010), pp. 1000–1004. DOI: 10.1002/mds.23005.

[41] R.G. Cohen et al. "Inhibition, Executive Function, and Freezing of Gait". en. In: *Journal of Parkinson's Disease* 4.1 (2014), pp. 111–122. DOI: 10.3233/JPD-130221. URL: https://doi.org/10.3233/JPD-130221.

[42] D.S. Peterson et al. "Cognitive Contributions to Freezing of Gait in Parkinson Disease: Implications for Physical Rehabilitation". en. In: *Physical Therapy* 96.5 (2016), pp. 659–670. DOI: 10.2522/ptj.20140603. URL: https://doi.org/10.2522/ptj.20140603.

[43] Sarah Vercruysse et al. "Explaining freezing of gait in Parkinson's disease: motor and cognitive determinants". In: *Movement Disorders* 27.13 (2012), pp. 1644–1651.

[44] H Kenneth Walker, W Dallas Hall, and J Willis Hurst. "Clinical methods: the history, physical, and laboratory examinations". In: (1990).

[45] Jochen Vandenbossche et al. "Freezing of gait in Parkinson disease is associated with impaired conflict resolution". In: *Neurorehabilitation and neural repair* 25.8 (2011), pp. 765–773.

[46] E. Matar et al. "Using virtual reality to explore the role of conflict resolution and environmental salience in Freezing of Gait in Parkinson's disease". en. In: *Parkinsonism & Related Disorders* 19.11 (2013), pp. 937–942. DOI: 10.1016/j.parkreldis.2013.06.002.

[47] Sirinun Boripuntakul and Somporn Sungkarat. "Specific but not global cognitive functions are associated with gait initiation in older adults". In: *Journal of aging and physical activity* 25.1 (2017), pp. 128–133.

[48] A. Montse et al. "Visuospatial Deficits in Parkinsons Disease Assessed by Judgment of Line Orientation Test: Error Analyses and Practice Effects". en. In: *Journal of Clinical and Experimental Neuropsychology* 23.5 (2001), pp. 592–598. DOI: 10.1076/jcen.23.5.592.1248.

[49] Donald Eknoyan, Robin A Hurley, and Katherine H Taber. "The clock drawing task: common errors and functional neuroanatomy". In: *The Journal of Neuropsychiatry and Clinical Neurosciences* 24.3 (2012), pp. 260–265.

[50] D. How, H. Wagner, and M. Brach. "Using Motor Imagery to Access Alternative Attentional Strategies When Navigating Environmental Boundaries to Prevent Freezing of Gait – A Perspective". en. In: *Frontiers in Human Neuroscience* 16 (2022), p. 750612. DOI: 10.3389/fnhum.2022.750612.

[51] C.R.A. Silveira et al. "Disentangling perceptual judgment and online feedback deficits in Parkinson's freezing of gait". en. In: *Journal of Neurology* 262.7 (2015), pp. 1629–1636. DOI: 10.1007/s00415-015-7759-7.

[52] Paolo Bartolomeo, Michel Thiebaut de Schotten, and Ana B Chica. "Brain networks of visuospatial attention and their disruption in visual neglect". In: *Frontiers in human neuroscience* 6 (2012), p. 110.

[53] M. Grossman et al. "Visual construction impairments in Parkinson's disease". en. In: *Neuropsychology* 7.4 (1993), pp. 536–547. DOI: 10.1037/0894-4105.7.4.536.

[54] J. Nantel et al. "Deficits in visuospatial processing contribute to quantitative measures of freezing of gait in Parkinson's disease". en. In: *Neuroscience* 221 (2012), pp. 151–156. DOI: 10.1016/j.neuroscience.2012.07.007.

[55] Kaylena A Ehgoetz Martens, Colin G Ellard, and Quincy J Almeida. "Does anxiety cause freezing of gait in Parkinson's disease?" In: *Plos one* 9.9 (2014), e106561.

[56] Anke H Snijders et al. "Obstacle avoidance to elicit freezing of gait during treadmill walking". In: *Movement disorders* 25.1 (2010), pp. 57–63.

[57] John D Corrigan and Nancy S Hinkeldey. "Relationships between parts A and B of the Trail Making Test". In: *Journal of clinical psychology* 43.4 (1987), pp. 402–409.

[58] J.M. Hall et al. "Early phenotypic differences between Parkinson's disease patients with and without freezing of gait". en. In: *Parkinsonism & Related Disorders* 20.6 (2014), pp. 604–607. DOI: 10.1016/j.parkreldis.2014.02.028.

[59] KA Ehgoetz Martens et al. "Anxiety is associated with freezing of gait and attentional set-shifting in Parkinson's disease: a new perspective for early intervention". In: *Gait & posture* 49 (2016), pp. 431–436.

[60] Dennis J Zgaljardic et al. "An examination of executive dysfunction associated with frontostriatal circuitry in Parkinson's disease". In: *Journal of clinical and experimental neuropsychology* 28.7 (2006), pp. 1127–1144.

[61] C.de A. Faria, H.V.D. Alves, and H. Charchat-Fichman. "The most frequently used tests for assessing executive functions in aging". en. In: *Dementia & Neuropsychologia* 9.2 (2015), pp. 149–155. DOI: 10.1590/1980-57642015DN92000009.

[62] Christopher R Bowie and Philip D Harvey. "Administration and interpretation of the Trail Making Test". In: *Nature protocols* 1.5 (2006), pp. 2277–2281.

[63] J.M. Gullett et al. "Reliability of Three Benton Judgment of Line Orientation Short Forms in Idiopathic Parkinson's Disease". en. In: *The Clinical Neuropsychologist* 27.7 (2013), p. 10 1080 13854046 2013 827744. DOI: 10.1080/13854046.2013.827744.

[64] F. Scarpina et al. "Utility of Boston Qualitative Scoring System for Rey-Osterrieth Complex Figure: Evidence from a Parkinson's Diseases sample". en. In: *Neurological Sciences* 37.10 (2016), pp. 1603–1611. DOI: 10.1007/s10072-016-2631-9.

[65] Berit Agrell and Ove Dehlin. "The clock-drawing test". In: *Age and ageing* 27.3 (1998), pp. 399–404.

[66] Trey Sunderland et al. "Clock Drawing in Alzheimer's Disease". In: *Journal of the American Geriatrics Society* 37.8 (1989), pp. 725–729. DOI: https://doi.org/10.1111/j.1532-5415.1989.tb02233.x. URL: https://agsjournals.onlinelibrary.wiley.com/doi/abs/10.1111/j.1532-5415.1989.tb02233.x.

[67] J.P. Grogan et al. "Effects of Parkinson's disease and dopamine on digit span measures of working memory". en. In: *Psychopharmacology* 235.12 (2018), pp. 3443–3450. DOI: 10.1007/s00213-018-5058-6.

[68] Philip Twumasi-Ankrah Schroeder, Lyle E. Baade, and Paul S. Marshall. *Reliable Digit Span: A Systematic Review and Cross-Validation Study—Ryan W.* en. n.d.). Retrieved September 26, 2023, from. 2012. URL: https://journals.sagepub.com/doi/10.1177/1073191111428764.

[69] C. Munro Cullum. "4.11 - Neuropsychological Assessment of Adults". In: *Comprehensive Clinical Psychology*. Ed. by Alan S. Bellack and Michel Hersen. Oxford: Pergamon, 1998, pp. 303–347. ISBN: 978-0-08-042707-2. DOI: https://doi.org/10.1016/B0080-4270(73)00227-3. URL: https://www.sciencedirect.com/science/article/pii/B0080427073002273.

[70] Barbara Ravnkilde et al. "Putative tests of frontal lobe function: a PET-study of brain activation during Stroop's Test and verbal fluency". In: *Journal of clinical and experimental neuropsychology* 24.4 (2002), pp. 534–547.

[71] JM Schott and MN Rossor. "The grasp and other primitive reflexes". In: *Journal of Neurology, Neurosurgery & Psychiatry* 74.5 (2003), pp. 558–560.

[72] Rebecca Thompson et al. "Plantar Grasp sign as a screening tool for Orthostatic Tremor (OT)". In: *Clinical Parkinsonism & Related Disorders* 8 (2023), p. 100196. ISSN: 2590-1125. DOI: https://doi.org/10.1016/j.prdoa.2023.100196. URL: https://www.sciencedirect.com/science/article/pii/S2590112523000142.

[73] C. Ansuini et al. "Testing the effects of end-goal during reach-to-grasp movements in Parkinson's disease". en. In: *Brain and Cognition* 74.2 (2010), pp. 169–177. DOI: 10.1016/j.bandc.2010.07.015.

[74] R. Hashimoto and Y. Tanaka. "Contribution of the Supplementary Motor Area and Anterior Cingulate Gyrus to Pathological Grasping Phenomena". en. In: *European Neurology* 40.3 (1998), pp. 151–158. DOI: 10.1159/000007972.

[75] H.K. Walker. "The Suck, Snout, Palmomental, and Grasp Reflexes". en. In: *Clinical Methods: The History, Physical, and Laboratory Examinations*. Ed. by H.K. Walker, W.D. Hall, and J.W. Hurst. 3rd ed.). Butterworths. 1990. URL: http://www.ncbi.nlm.nih.gov/books/NBK395/.

[76] James A Cooper et al. "Slowed central processing in simple and go/no-go reaction time tasks in Parkinson's disease". In: *Brain* 117.3 (1994), pp. 517–529.

[77] D.J. Simmonds, J.J. Pekar, and S.H. Mostofsky. "Meta-analysis of Go/No-go tasks demonstrating that fMRI activation associated with response inhibition is task-dependent". en. In: *Neuropsychologia* 46.1 (2008), pp. 224–232. DOI: 10.1016/j.neuropsychologia.2007.07.015.

[78] Daniel L Segal et al. "Development and initial validation of a self-report assessment tool for anxiety among older adults: The Geriatric Anxiety Scale". In: *Journal of anxiety disorders* 24.7 (2010), pp. 709–714.

[79] Albert FG Leentjens et al. "The Parkinson Anxiety Scale (PAS): development and validation of a new anxiety scale". In: *Movement Disorders* 29.8 (2014), pp. 1035–1043.

[80] Lucy Yardley et al. "Development and initial validation of the Falls Efficacy Scale-International (FES-I)". In: *Age and ageing* 34.6 (2005), pp. 614–619.

[81] O. Rascol et al. "Rasagiline as an adjunct to levodopa in patients with Parkinson's disease and motor fluctuations (LARGO". en. In: *Lasting effect in Adjunct therapy with Rasagiline Given Once daily, study): A randomised, double-blind, parallel-group trial. Lancet* 365.9463 (2005), pp. 947–954. DOI: 10.1016/S0140-6736(05)71083-7. URL: https://doi.org/10.1016/S0140-6736(05)71083-7.

[82] Franco Franchignoni et al. “Using psychometric techniques to improve the Balance Evaluation System’s Test: the mini-BESTest”. In: *Journal of rehabilitation medicine: official journal of the UEMS European Board of Physical and Rehabilitation Medicine* 42.4 (2010), p. 323.

[83] Alfonso Fasano et al. “Falls in Parkinson’s disease: a complex and evolving picture”. In: *Movement disorders* 32.11 (2017), pp. 1524–1536.

[84] Cathy Haines Ciolek and Sin Yi Lee. “Cognitive issues in the older adult”. In: *Guccione’s Geriatric Physical Therapy E-Book* (2019), p. 425.

[85] M. Calamia et al. “Developing a Short Form of Benton’s Judgment of Line Orientation Test: An Item Response Theory Approach”. en. In: *The Clinical Neuropsychologist* 25.4 (2011), pp. 670–684. DOI: 10.1080/13854046.2011.564209.

[86] Federica Scarpina and Sofia Tagini. “The Stroop Color and Word Test”. In: *Frontiers in Psychology* 8 (2017). ISSN: 1664-1078. DOI: 10.3389/fpsyg.2017.00557. URL: https://www.frontiersin.org/articles/10.3389/fpsyg.2017.00557.

[87] Robert Thomas Manning. “The serial sevens test”. In: *Archives of internal medicine* 142.6 (1982), pp. 1192–1192.

[88] Aaron Smith. “The Serial Sevens Subtraction Test”. In: *Archives of Neurology* 17.1 (July 1967), pp. 78–80. ISSN: 0003-9942. DOI: 10.1001/archneur.1967.00470250082008. URL: https://doi.org/10.1001/archneur.1967.00470250082008.

[89] J.D. Henry and J.R. Crawford. “Verbal fluency deficits in Parkinson’s disease: A meta-analysis”. en. In: *Journal of the International Neuropsychological Society: JINS* 10.4 (2004), pp. 608–622. DOI: 10.1017/S1355617704104141.

[90] Rena Matison et al. ““Tip-of-the-tongue” phenomenon in Parkinson disease”. In: *Neurology* 32.5 (1982), pp. 567–567. ISSN: 0028-3878. DOI: 10.1212/WNL.32.5.567. eprint: https://n.neurology.org/content/32/5/567.full.pdf. URL: https://n.neurology.org/content/32/5/567.

[91] F.C. Donders. “On the speed of mental processes”. In: *Acta Psychologica* 30 (1969), pp. 412–431. ISSN: 0001-6918. DOI: https://doi.org/10.1016/0001-6918(69)90065-1. URL: https://www.sciencedirect.com/science/article/pii/0001691869900651.

[92] Adrian Meule. “Reporting and Interpreting Task Performance in Go/No-Go Affective Shifting Tasks”. In: *Frontiers in Psychology* 8 (2017). ISSN: 1664-1078. DOI: 10.3389/fpsyg.2017.00701. URL: https://www.frontiersin.org/articles/10.3389/fpsyg.2017.00701.

A APPENDIX

A.1 MEDICATION AND DEMOGRAPHIC DATA

1. Date of Birth
2. Age
3. Sex
4. Occupation
5. Education
6. Addiction
7. Clinical data

7.a Initial Predominant Symptom (tremor or akinetic-rigid syndrome)

7.b Disease Duration

7.c Presence of motor fluctuations and Dyskinesia

8. Motor symptoms:

8.a Tremor

8.b Rigidity

8.c Slowness

8.d Loss of balance

8.e Gait issues

8.f Speech and swallowing

9. Non motor symptoms:

9.a Pain

9.b Sleep

9.c Memory

9.d Depression

9.e Psychiatric issues

9.f Bladder

9.g Bowel

9.h GI issues

9.i Autonomic disturbance

9.j Other issues

10. Other medical complaints (if any)
11. Handedness (Left/Right)
12. Comorbid conditions (Diabetes/ Hypertension/ CAD/ COPD/ Asthama/ Thyroid)
13. Antiparkinsonian Drugs (name, dosage and frequency)