ResearchOnline@JCU

This is the **Accepted Version** of a paper published in the
Journal of Communication Disorders:

JAMES COOK
UNIVERSITY
AUSTRALIA

Accepted Manuscript

Title: Communication Impairments in People with Progressive Supranuclear Palsy: A Tutorial

Author: Jae-Hyun Kim Clare M. McCann

Please cite this article as: Kim, J.-H., and McCann, C. M.,Communication Impairments in People with Progressive Supranuclear Palsy: A Tutorial, *Journal of Communication Disorders* (2015), http://dx.doi.org/10.1016/j.jcomdis.2015.06.002

Title: Communication Impairments in People with Progressive Supranuclear Palsy: A Tutorial

Author: Jae-Hyun Kim[1], Clare M. McCann[1,2]

Affiliations: [1]Speech Science, School of Psychology, The University of Auckland, [2]Centre for Brain Research, The University of Auckland

Corresponding Author: Jae-Hyun Kim
Speech Science, School of Psychology
The University of Auckland
Private Bag 92019
Auckland 1142, New Zealand
+64 9 373 7599 (ext. 85052)
jae-hyun.kim@auckland.ac.nz

Communication Impairments in People with Progressive Supranuclear Palsy: A Tutorial

1. Introduction

Five decades ago, Steele, Richardson, and Olszewski (1964) described an unusual clinical and

neuropathological profile of nine patients with a progressive neurological condition displaying

supranuclear gaze palsy, axial rigidity, dysarthria, pseudobulbar and mental signs with mild

subcortical dementia. Although some case reports of a similar combination of the clinical symptoms

can be found in the neurological literature much earlier, Steele et al. (1964) is credited with

establishing this syndrome as a new nosological entity; progressive supranuclear palsy (PSP) (also

known as Steele-Richardson-Olszewski syndrome). Over the subsequent decades, numerous clinical,

neuropathological and genetic studies have been conducted and, recently, there has been a new surge

of interest in PSP from clinical neuropsychology (e.g. Duff, Gerstenecker, & Litvan, 2013;

Gerstenecker, Mast, Duff, Ferman, & Litvan, 2013; Kobylecki et al., 2015), movement disorders (e.g.

Kemp, Harding, Halliday, Mahant, & Fung, 2013; Respondek et al., 2013) and nursing (e.g. Kent,

1

2013; Mazorra & Cadogan, 2012). On the other hand, PSP has received comparatively, and significantly, less attention in the speech-language pathology literature, even though communication impairments in patients with PSP have been documented since the initial publication of Steele et al. (1964). So far, the majority of the findings relating to speech and language impairments in people with PSP have come from studies in clinical neuropsychology, in which speech and/or language assessments were administered as part of their assessment battery. In the absence of any current guidelines for the assessment and management of communication impairments in people with PSP, speech-language pathologists (SLPs) are reliant on the descriptions provided by a neuropathological perspective. The purposes of this tutorial paper are (1) to describe the communication impairments in people with PSP, (2) to inform SLPs of areas for assessment, and (3) to present treatment considerations.

2. Overview of Progressive Supranuclear Palsy

PSP is a rare progressive neurological disorder with the age-adjusted prevalence estimated at 6.4 per 100,000 (Schrag, Ben-Shlomo, & Quinn, 1999). While individual presentations vary greatly, supranuclear gaze palsy, frequent falls (usually backwards), bradykinesia, axial rigidity, cognitive decline and communication impairments are the most commonly reported characteristics of PSP (Donker Kaat, Boon, Kamphorst, Duivenvoorden, & van Swieten, 2007; Nath, Ben-Shlomo, Thomson, Lees, & Burn, 2003; Testa et al., 2001). The initial symptoms of PSP typically emerge after the age of 60 years (Donker Kaat et al., 2007; Nath et al., 2003), with no studies reporting the onset of symptoms before the age of 40 years. PSP was considered a sporadic disease with no known cause, but recent studies have suggested possible familial aggregation (e.g. Donker Kaat et al., 2009; Pastor, 2009; Pastor et al., 2001).

Pathologically, the most specific microscopic findings of PSP are star-shaped astrocytic tufts and neurofibrillary tangles found in the basal ganglia, diencephalon and brainstem (Dickson, Ahmed, Algom, Tsuboi, & Josephs, 2010; Donker Kaat, Chiu, Boon, & van Swieten, 2011; Hauw et al., 1994; Williams & Lees, 2009). Gliosis and neuronal loss have also been documented widely (Dickson et al., 2010 for a review). The subthalamic nucleus, substantia nigra and globus pallidus are most severely

2

affected (Dickson et al., 2010; Donker Kaat et al., 2011; Hauw et al., 1994). Atrophy and the presence

of neurofibrillary tangles have also been found in the frontal regions while parietal and temporal

regions are relatively unaffected by PSP (Donker Kaat et al., 2011).

2.1. Clinical Diagnosis

Despite the advancement in the field of clinicopathology, no reliable biological markers for the ante-

mortem diagnosis of PSP have been identified. Definite diagnosis of PSP requires histological

evidence, only available post-mortem (Litvan et al., 1996). Clinical diagnosis of PSP requires a

detailed case history and accurate interpretation of behavioral assessments. To improve the specificity

and sensitivity of the diagnosis of PSP during life, the National Institute of Neurological Disorders

and Stroke and the Society for PSP (NINDS-SPSP) proposed criteria for the clinical diagnosis of PSP

(Litvan et al., 1996). Two types of clinical diagnosis were proposed; "Possible" and "Probable".

Possible diagnosis requires the following criteria: (1) gradual progression of the disease, (2) onset at

the age of 40 years or later, (3) either vertical supranuclear gaze palsy or both slowing of vertical

saccades and prominent postural instability with falls in the first year of disease onset, and (4) no

evidence of other diseases that could explain the foregoing features. The criteria for a Probable

diagnosis requires (1) gradual progression of the disease, (2) onset after the age of 40 years (3) **both**

vertical supranuclear gaze palsy **and** prominent postural instability with falls in the first year of

disease onset, and (4) no evidence of other diseases. In addition, the presence of symmetric akinesia,

rigidity (proximal more than distal), abnormal neck posture, early dysphagia and dysarthria, and early

onset of cognitive impairments (including apathy, impairment in abstract thought, decreased verbal

fluency, frontal release signs) and poor or absent response to levodopa treatment can support the

clinical diagnosis of PSP (Litvan et al., 1996).

The sensitivity and predictive values of the criteria proposed by NINDS-SPSP have been

supported (Osaki et al., 2004; Respondek et al., 2013; Williams et al., 2005). However, clinical

diagnosis of PSP still remains difficult. This is largely because clear signs only emerge in its later

stages for the majority of people. The absence of hallmark symptoms of PSP, along with the presence

of other symptoms (e.g. bradykinesia, cognitive impairments, speech/language impairments) in its

3

early stages often leads to patients being misdiagnosed with Parkinson's disease (PD), dementia, multiple system atrophy or corticobasal degeneration (Donker Kaat et al., 2007; Nath et al., 2003; Williams et al., 2005). It can take up to five years and multiple visits to different physicians before the accurate diagnosis of PSP is made for many people (O'Sullivan et al., 2008; Santacruz, Uttl, Litvan, & Grafman, 1998). The disease duration is estimated at between five and eight years (Chiu et al., 2010; Donker Kaat et al., 2007; O'Sullivan et al., 2008; Papapetropoulos, Singer, McCorquodale, Gonzalez, & Mash, 2005; Williams et al., 2005), with the most common causes of death being respiratory infection, respiratory failure, aspiration pneumonia and cardiopulmonary failure (Nath et al., 2005; Papapetropoulos et al., 2005). This suggests that with a predominant focus on respiratory and swallowing dysfunction, the motor speech and language impairments may be overlooked and many patients remain under-diagnosed during the course of the disease progression.

2.2. Heterogeneity

Initially, Steele et al. (1964, p. 357) reported "no pathological evidence of frontal, cortical, or white matter involvement of consequence". However, subsequent studies have reported mild atrophy and the presence of neurofibrillary tangles in the frontal regions (Dickson et al., 2010) and there has been an increasing number of studies reporting atypical PSP, in which the patients display distinguishable clinical features with the underlying pathology characterized by the presence of neurofibrillary tangles (Williams & Lees, 2009). These atypical PSP cases do not necessarily meet the clinical criteria for the diagnosis proposed by the NINDS-SPSP. For example, patients with PSP (pathologically confirmed cases) whose main symptoms are progressive non-fluent aphasia and apraxia of speech (PSP-Progressive nonfluent aphasia) have a more prominent cortical pathological distribution compared to typical PSP (PSP-Richardson's syndrome) (Josephs et al., 2005; Josephs et al., 2006). Patients who have PSP with PD-like characteristics, including asymmetric onset, tremor, early bradykinesia and a positive response to levodopa treatment (PSP-Parkinsonism), have a less severe and more restricted pathological distribution than typical PSP (Williams et al., 2005). This suggests some heterogeneity within PSP, and the common variants are summarized in Table 1 (Donker Kaat et al., 2011; Williams & Lees, 2009).

4

Table 1. Variants of Progressive Supranuclear Palsy

Variants	Clinical presentations
PSP-Richardson's syndrome*	Early falls and postural instability Early supranuclear gaze palsy Early cognitive decline
PSP-Parkinsonism	Asymmetric onset Positive levodopa response Early bradykinesia Tremor
PSP-Pure akinesia with gait freezing	Gradual onset of freezing of gait or speech Micropraphia and hypophonia No tremor No sustained response to levodopa No dementia, rigidity and gaze palsy in the first five years
PSP-Progressive nonfluent aphasia	Progressive speech and language impairments (apraxia of speech and nonfluent aphasia)
PSP-Corticobasal syndrome	Asymmetric dystonia Apraxia Alien limb syndrome Cortical sensory loss

* PSP-Richardson's syndrome is considered typical PSP

3. Speech and Language Impairments in People with Progressive Supranuclear Palsy

This section describes the speech and language impairments of typical PSP. It is worth noting that the

classification of PSP into different variants is a recent development and, therefore, not all studies

report the variant(s) of PSP. Readers are directed to Josephs and Duffy (2008) and Duffy, Strand, and

Josephs (2014) for recent reviews of PSP-Progressive apraxia of speech and/or nonfluent aphasia

(PSP-PNFA).

3.1. Speech Impairments: Dysarthria, Stuttering, Palilalia and Echolalia

Dysarthria is one of the most common and prominent manifestations of typical PSP (Donker Kaat et

al., 2007; Kluin, Foster, Berent, & Gilman, 1993; Kluin et al., 2001; Litvan et al., 1996; Nath et al.,

2003; Podoll, Schwarz, & Noth, 1991; Testa et al., 2001). Patients with PSP are affected by dysarthria

in its early stages and for many people this can eventually become anarthria (Kluin et al., 2001; Steele

et al., 1964). Cohort studies have identified a combination of the hypokinetic, spastic and ataxic

5

subtypes of dysarthria in patients with typical PSP (Hartelius, Gustavsson, Åstrand, & Holmberg, 2006; Kluin et al., 1993; Kluin et al., 2001; Skodda, Visser, & Schlegel, 2011), but the ataxic component is less frequent (Kluin et al., 2001; Skodda et al., 2011). Müller et al. (2001) reported that imprecise or slurred articulation was the most prominent speech characteristic in patients with PSP. Hypophonia, monotonous and slow speech with reduced stress/intonation, reduced respiratory support for speech and inappropriate silences have also been noted in patients with PSP (Hartelius et al., 2006; Skodda et al., 2011). There are relatively few studies reporting the speech characteristics of people with different variants of PSP. One such study, comparing typical PSP and PSP-Parkinsonism (PSP-P), found no significant differences in their speech characteristics (Skodda et al., 2011).

PSP is often misdiagnosed as PD especially in its early stages (e.g. Donker Kaat et al., 2007). Early involvement of SLPs is pertinent in order to minimize the risk of misdiagnosis. When the motor speech assessment of a patient with a clinical diagnosis of PD reveals dysarthria other than the hypokinetic subtype, then SLPs should query the clinical diagnosis of PD. In cases where spastic or ataxic components are present, PSP is a likely alternative diagnosis (Duffy, 2013). Early onset of dysarthria can also contribute to the differential diagnosis. From the onset of the initial symptoms, the average latency to the development of dysarthria is 24 months in patients with PSP but 84 months in patients with PD (Müller et al., 2001). Nath et al. (2003) also note that some patients with PSP may have "speech problems" even *at* disease onset. Regular monitoring by SLPs is required because, compared to PD, dysarthria in patients with PSP tends to be more severe, develop earlier and progress more rapidly (Goetz, Leurgans, Lang, & Litvan, 2003; Hartelius et al., 2006; Müller et al., 2001; Skodda et al., 2011).

Stuttering and palilalia are not uncommon in PSP (Kluin et al., 1993; Lebrun, Devreux, & Jousseau, 1986; Nath et al., 2003; Testa et al., 2001). Palilalia is characterized by compulsive repetitions of utterances (Christman, Boutsen, & Buckingham, 2004; LaPointe & Horner, 1981). Stuttering and palilalia are associated with the presence of hypokinetic dysarthria (Duffy, 2013). They tend to develop relatively late in the disease progression although a small number of cases have documented the presence of palilalia at disease onset (Nath et al., 2003). Lebrun et al. (1986, p. 248) reported a case study of a 55-year-old male with a clinical diagnosis of PSP whose initial symptoms

6

included "speech difficulties resembling stuttering", but the case report of their language assessment appears to be more consistent with palilalia. While, according to Kluin et al. (1993), stuttering is more common in PSP than palilalia, a description of stuttering in patients with PSP is scarce in the literature.

In a small number of studies, echolalia has also been reported (Delia Sala & Spinnler, 1998; Esmonde, Giles, Xuereb, & Hodges, 1996; Robinson, Shallice, & Cipolotti, 2006), but this is not a common feature of PSP (Donker Kaat et al., 2007; Nath et al., 2003; Testa et al., 2001). Delia Sala and Spinnler (1998) provide the most comprehensive account of echolalia in PSP. They reported a 52-year-old female with a two-year history of progressive slowness, who was initially misdiagnosed with PD. Incessant echolalia was noted during a neurological examination two years post-onset. When tested eight months later, all her responses were echolalic, which rendered formal assessments impossible. Delia Sala and Spinnler (1998, p. 159) reported that her echolalic responses were not driven by the need to communicate but reflected "sheer immediate repetition of the last two to four words, sometimes short sentences, spoken by others".

3.2. Language Impairments

Language impairments in PSP *appear* to be less common than motor speech impairments, but this may be because the importance of language impairments has been somewhat overlooked. Early studies reported only mild language impairments (e.g. Maher, Smith, & Lees, 1985) or found "no primary language changes in [PSP]" (Podoll et al., 1991, p. 1470). More recent studies, however, challenge the nature of the language impairments in PSP.

3.2.1. Comprehension

Early studies reported no comprehension difficulties in patients with PSP (Delia Sala & Spinnler, 1998; Lebrun et al., 1986; Maher et al., 1985). However, in such studies, language comprehension was not systematically investigated but relied only on observations. More recent research has suggested that people with PSP have intact single-word comprehension (Esmonde et al., 1996; Robinson et al., 2006), but Podoll et al. (1991) found that five of their six patients had a comprehension impairment at the single-word level. Studies where comprehension has been systematically investigated reveal specific patterns of impairment with action-verbs and sentences

7

(Bak et al., 2006; Daniele et al., 2013; Daniele, Giustolisi, Silver, Colosimo, & Gainotii, 1994; Esmonde et al., 1996; Kemmerer & Hershey, 1996; Podoll et al., 1991). Due to the rapid progression of the disease it is important for SLPs to assess and monitor both the single word and sentence level comprehension of people with PSP.

3.2.2. Single Word Production

Table 2 summarizes studies of word finding difficulties which are the most frequently reported aspect of language impairment in patients with PSP. It is noted that verbal fluency and picture naming are conceptually different tasks requiring different cognitive and linguistic skills, whereby verbal fluency requires linguistic and cognitive ability, while naming draws predominantly on linguistic ability. Evidence so far suggests that naming performance is influenced by impairments in visuospatial processing, initiation, verbal semantic memory, word-search strategies, and retrieval processes, reflecting damage in the frontal cortex and/or frontostriatal circuits (Gurd & Hodges, 1997; Milberg & Albert, 1989; Podoll et al., 1991; Rosser & Hodges, 1994; van der Hurk & Hodges, 1995). The presence and the extent of such impairments appears to be associated with disease progression, but to date, no unified clinical description of naming impairments in PSP has emerged.

8

Table 2. Single word production in progressive supranuclear palsy

Task	Study	Assessments used	Findings
Verbal Fluency	Bak et al. (2006)	Letter and category	Impaired
	Daniel et al. (1994)*	NS[1]	Impaired
	Daniel et al. (2013)	Letter and category	Impaired
	Delia Sala & Spinnler (1998)	NS	Impaired
	Esmonde et al. (1996)	Letter and category	Impaired and progressively declined over time
	Gurd & Hodges (1997)	Category only	Impaired
	Lebrun et al. (1986)	NS	Impaired
	Maher et al. (1985)	Letter only	Seven of 10 patients failed (i.e. named fewer than 14 words in 90 seconds)
	Milberg & Albert (1989)	NS	Impaired
	Robinson et al. (2006)	Letter and category	Impaired
	Rosser & Hodges (1994)	Letter and category	Impaired and more pronounced impairment in letter verbal fluency task
Confrontation Naming	Bak et al. (2006)	Graded Naming Test[2]; Noun and Verb Naming[3]	Impaired performance on Graded Naming Test and more pronounced impairment in naming action verbs than nouns
	Cotelli et al. (2006)	60 actions and 60 objects	More pronounced impairment in naming action verbs than nouns but no difference in naming performance between manipulation and non-manipulation action verbs
	Daniel et al. (1994)*	Oral Confrontation Naming[4]	Selective impairment in naming verbs
	Daniel et al. (2013)	Oral and Written[5] Confrontation Naming	Impaired performance in naming verbs on both tasks
	Delia Sala & Spinnler (1998)	Aachen Aphasia Test[6] (Italian version)	Moderate impairment

9

Esmonde et al. (1995)	NS picture naming	Normal or near normal naming performance
Gurd & Hodges (1997)	Speeded Picture Naming[7]	Considerable slowing in picture naming
Lebrun et al. (1986)	NS	Normal performance
Maher et al. (1985)	Graded Naming Test[2]	Mild word finding difficulty in seven of 25 patients
Milberg & Albert (1989)	Boston Naming Test[8]	Impaired but less pronounced than verbal fluency impairment
Podoll et al. (1991)	Aachen Aphasia Test[6] (Object and Color Naming subtests)	Mild word finding difficulty in two of six patients
Robinson et al. (2006)	Category Naming Test[9]	Normal performance and no difference in naming performance between action verbs and nouns
van der Hurk & Hodges (1995)	Boston Naming Test[8]	Significant impairment

* Case 2 (GG) only

[1] not specified; [2] McKenna and Warrington (1983); [3] Bak, O'Donovan, Xuereb, Boniface, and Hodges (2001); [4] Miceli, Silveri, Nocentini, and Caramazza (1988); [5] Daniele et al. (1994); [6] Huber, Poeck, and Willmes (1984); [7] 60 pictures from Snodgrass and Vanderwart (1980); [8] Kaplan, Goodglass, and Weintraub (1983)

10

In general, word finding difficulties in PSP "are similar to those of PD patients but they are more severe" (Gurd & Hodges, 1997, p. 39). In particular, pronounced deficits on verbal fluency tasks have been found consistently. Reflecting the progressive nature of PSP, verbal fluency performance in patients with PSP declines over time (Esmonde et al., 1996). In contrast, they tend to perform considerably better on confrontation picture naming (e.g. Esmonde et al., 1996; Lebrun et al., 1986; Maher et al., 1985; Milberg & Albert, 1989; Robinson et al., 2006). This could suggest that the single word production impairments are secondary to executive dysfunction. However, systematic investigations of the association between language impairment and executive dysfunction in people with PSP are scarce and there is only one published study examining the changes in verbal fluency performance over time (Esmonde et al., 1996).

All the studies reviewed in Table 2 indicate that people with PSP have word finding difficulties, but the nature of their poor performance on naming tasks is unclear. For example van der Hurk and Hodges (1995) found significant impairment in naming on the Boston Naming Test (BNT) (Kaplan et al., 1983). Common error types included semantically related and circumlocutory responses, suggesting a breakdown in the retrieval process. On the other hand, Podoll et al. (1991) reported that 67% of all incorrect responses were visual misperceptions, due to the visuospatial processing difficulty related to gaze palsy. Moreover, they found no evidence of naming impairment in spontaneous language generation tasks. Therefore, SLPs must conduct a thorough analysis of the error responses to determine whether poor performance on naming tasks reflects an impaired retrieval process or whether it reflects visuospatial difficulties. In addition, SLPs should assess verb retrieval as part of naming assessments because selective action-verb naming is consistently impaired in people with PSP (Bak et al., 2006; Cotelli et al., 2006; Daniele et al., 2013; Daniele et al., 1994). No studies have been found that report a selective object-noun naming impairment. In clinical practice, therefore, the use of naming assessments including both action verbs and nouns could provide a more comprehensive picture of a patient's naming ability.

3.2.3. Sentence Production

Table 3 summarizes three studies which have examined sentence production tasks and discourse in PSP. Robinson et al. (2006) reported a patient (KAS) with preserved skills in various sentence

11

completion (single words and word pairs) and sentence production tasks (sentences and pictures),

albeit with long delays. It is a remarkable finding, given that KAS had almost abolished propositional

language skills. On the other hand, Esmonde et al. (1996) report two patients who produced a

considerable number of errors, including non-responses and unrelated or bizarre responses, and

claimed that the errors arose from, among other things, perseverations. With disease progression,

perseverative errors became more pronounced. In Podoll et al. (1991), six patients completed a

sentence generation task from the Aachen Aphasia Test (AAT) (Huber et al., 1984). They performed

significantly worse than the control group. Podoll et al. (1991, p. 1465) suggested that the patients had

"an inability to convey the information presented in the stimulus pictures", although the syntactic

structures they produced were acceptable.

With respect to discourse-level language production, there are only a limited number of studies

in patients with PSP. To our knowledge, no studies have exclusively examined functional

conversations in everyday contexts. Podoll et al. (1991) reported that there was no evidence of

agrammatism and concluded that there were no primary aphasic disorders in PSP. They suggested that

the majority of what appeared to be linguistic deficits were due to the presence of dysarthria. However,

as stated in the previous sections, we need to interpret this conclusion cautiously, because no formal

language assessment was used. Robinson et al. (2006) elicited what they call "topic-based discourse"

which was essentially a series of three monologues and "interviews". The participant performed

worse than healthy controls using the Quantitative Production Analysis (QPA) (Berndt, Wayland,

Rochon, Saffran, & Schwartz, 2000) and novelty measures. However, they may not be an appropriate

measure of conversational discourse, because these are designed to capture sentence-level abilities.

Table 3. Sentence production and discourse in progressive supranuclear palsy

	Assessments used	Major findings
Esmonde et al. (1996)*	Phrase completion	Bizarre responses that did not take the prosodic and semantic information in the cue or unable to formulate a response
	Picture description	Progressive decline of the total number of morphemes Omission of appropriate function words Perseverations

12

	Amsterdam-Nijmegen Everyday Language Test[1]	One patient had reduced content, laconic and telegraphic responses but the other performed within the normal range
Podoll et al. (1991)	Aachen Aphasia Test[2]	Normal syntactic structures in two patients
		Short and simple, and sometimes incomplete, sentences in four patients
		No evidence of agrammatism, or WFD
Robinson et al. (2006)	Phrase completion	No errors
	Sentence construction	No errors or almost at ceiling
	Topic-based discourse	Fewer words and sentences compared to the control groups
		Reduced proportion of novel words and sentences
		Impaired ability to produce multiple connected sentences
		Perseverations
	Two interviews (one with substantial verbal prompting and the other with little or no verbal prompting)	Fewer words and sentences; fewer novel words and sentences compared to the control groups
		Significantly worse when no prompting was provided
		Perseverations
		Considerably greater proportion of echolalia with prompting

* Patient 1 did not complete the Amsterdam-Nijmegen Everyday Language Test.
[1] Blomert, Kean, Koster, and Schokker (1994); [2] Huber et al. (1984)

3.3. Other Impairments: Cognitive impairment and Executive dysfunction

The evidence appears to be conflicting, but cognitive impairments and executive dysfunction are

frequently present in patients with PSP. Brown et al. (2010, p. 2389) concluded that "there is little

reliable or consistent evidence on the prevalence of cognitive impairment or dementia in progressive

supranuclear palsy". Nonetheless, Magherini and Litvan (2005) summarized the additional cognitive

and behavioral aspects of PSP identified since its first description (Steele et al., 1964). Of note in this

review article was mild-moderately impaired recall and access to stored information, bradyphrenia

(cognitive slowing), but no deficits in recognition. In their large scale prospective study of people

with PSP (n = 311) and multiple system atrophy (n = 372), Brown et al. (2010) examined the nature

of the cognitive impairments. They reported Initiation/Perseveration was the main impairment,

followed by impaired Memory, then impaired Conceptualization, Construction and lastly Attention, as

13

measured by the Dementia Rating Scale-2 (Jurica, Leitten, & Mattis, 2001). Gerstenecker et al. (2013) assessed the cognitive abilities of 200 people with PSP. 85% of their sample were impaired on one or more cognitive measures, broadly mirroring the findings of Brown et al. (2010). More recently, Kobylecki et al. (2015) retrospectively reviewed the medical files of 62 people with Probable or Possible PSP and identified 58% with cognitive or behavioral symptoms as a prominent presenting feature. Executive dysfunction was most common, followed by bradyphrenia and inefficient memory recall. The exact nature of this inefficient recall was not made clear, but is reportedly related to executive and attentional disturbances (see Magherini & Litvan, 2005).

3.4. Speech-Language Pathology Diagnosis?

We have presented the communication impairments observed in people with PSP. While the motor speech impairments are undeniably consistent with mixed dysarthria (hypokinetic, spastic ataxic subtypes), it is not clear how to classify the language impairments. One possibility is the primary progressive aphasia-plus (PPA+) diagnosis described in Mesulam and Weintraub (2008). PPA+ was suggested as a variant of PPA (see Leyton & Hodges, 2014 for a recent review on PPA), in which progressive language impairments are accompanied by cognitive and motor deficits. However, Mesulam and Weintraub (2008, p. 577) specifically propose that the cognitive and motor deficits "arise in the middle or late stages of the disease". This does not fit with the clinical symptoms seen in PSP, as cognitive and motor deficits are apparent from the early stages. A second possibility is that the language impairments in PSP are consistent with dynamic aphasia, a subtype of transcortical motor aphasia (Berthier, 2000). For example, Robinson, Shallice, and Cipolotti (2005) supported this subtypes of dynamic aphasia (pure and mixed) (see also Goldstein, 1948). *Pure* dynamic aphasia refers only to impaired spontaneous language generation with preserved speech and nominal language skills, while *mixed* dynamic aphasia is associated with additional motor, phonological, lexical and/or syntactic deficits. Both subtypes have been described in patients with PSP (e.g. mixed subtype in Esmonde et al., 1996; pure subtype in Robinson et al., 2006). The diagnosis of transcortical motor aphasia would also be consistent with the finding of Daniele et al. (2013) which showed dysfunction in the cortical regions anterior or superior to Broca's area (Goodglass, 1993).

14

However, it is questionable to label the language impairments in PSP a subtype of aphasia when there is both executive dysfunction and a pervasive motor speech component involved. Would it be possible to designate a new diagnostic label for the communication impairments observed in PSP in much the same way as subtypes of PPA have been explicated by Duffy et al (2014)? If this were to happen, it would need to encompass the early motor and cognitive symptoms, mild comprehension deficits, preserved nominal skills, overall reduction in verbal output and relatively more impaired spontaneous language generation that worsens over time plus stuttering, palilalia and echolalia that are associated with subcortical as well as cortical damages.

The primary purpose of this tutorial paper is *not* to engage in a detailed theoretical discussion about the interrelationship between language impairments and cognitive impairments. However, we consider it important for SLPs to be aware of the alternative views because this will likely have clinical implications and it will guide collaborative management of the language impairment and executive dysfunction seen in people with PSP.

4. Considerations for Assessment

SLPs are most likely to be consulted for the presence of dysarthria for patients with PSP, as dysarthria is one of the early and prominent manifestations of PSP. Given the rapid progression of dysarthria in PSP (Goetz et al., 2003; Hartelius et al., 2006), some patients may even develop anarthria while waiting for speech evaluation (Kluin et al., 2001). Early involvement of SLPs is therefore recommended. This involvement will likely include a detailed motor speech assessment of dysarthria which can easily be repeated in order to monitor progressive deterioration over time.

Prominent speech characteristics include imprecise or slurred articulation (Müller et al., 2001). Hypophonia, monotonous and slow speech with reduced stress/intonation, reduced respiratory support for speech and inappropriate silences are also common features (Hartelius et al., 2006; Skodda et al., 2011). Due to the similarities in presentation between PSP and PD, there is often a misdiagnosis. In order to clarify the speech characteristics of the two conditions and to aid differential diagnosis, Table 4 below illustrates the major differences.

15

Table 4. Predominant speech characteristics and dysarthria subtypes of progressive supranuclear palsy (PSP) and Parkinson's disease (PD) (adapted from Duffy, 2013 and Müller et al. 2001)

	PSP	PD
Prominent characteristics		
	Imprecise articulation	Monotone
	Monopitch	Vocal flutter
	Hoarseness	Reduced loudness
	Nasal emission	Tremor
	Hypernasality	Breathiness
	Excess and equal stress	Reduced stress
	Slow rate	Rapid rate
Onset		
	Early onset	Later onset
Subtype		
	Mixed	Hypokinetic

Assessing the nature and the extent of language impairments can be a challenge to clinicians because of the cognitive impairments/executive dysfunction that are frequently present in patients with PSP (Brown et al., 2010; Gerstenecker et al., 2013; Kobylecki et al., 2015; Magherini & Litvan, 2005). In particular, an impairment in initiation and bradyphrenia can affect performance on time-limited tasks, such as verbal fluency tasks (Gurd & Hodges, 1997). Therefore, it will be essential for SLPs to work with clinical neuropsychologists for a comprehensive and accurate language assessment. In addition, there are several other clinical features of PSP which SLPs should take into consideration when assessing speech and language impairments in people with PSP. Along with the supranuclear gaze palsy, other visual problems (e.g. blurred vision, diplopia) are common in patients with PSP (Donker Kaat et al., 2007; Nath et al., 2003). Such difficulties can affect their ability to see and process visual information therefore reducing their performance on tasks involving pictures (e.g. word-to-picture and sentence-to-picture matching) or written material. Using a book stand to present the assessment material at the eye level of patients with PSP may facilitate the assessment procedure. Sleep disorders in PSP have also been documented in several studies (e.g. Arnulf et al., 2005; Gama et al., 2010; Nomura, Inoue, Takigawa, & Nakashima, 2012), which can lead to fatigue during the day and therefore affect their performance on assessments.

16

Although early studies considered language impairments in PSP negligible, our review of the literature presents a strong case for the need to consider a language assessment alongside a motor speech assessment. We therefore recommend that SLPs should always conduct a language assessment with patients with PSP, even if there are no initial signs of language impairment. Table 5 outlines possible assessment options for people with PSP. Assessments should be chosen such that they can be repeated over time to monitor progression of the condition (Nickels, Taylor, & Croot, 2011). A recently developed clinical instrument to monitor the progression of PPA, the Progressive Aphasia Severity Scale (PASS) (Sapolsky, Domoto-Reilly, & Dickerson, 2014) may be useful for people with PSP. It is important to note that mild impairments, especially in comprehension, will only be revealed with a systematic investigation (e.g. Esmonde et al., 1996). In the early stages, sensitive measures are recommended to ascertain the presence of a mild language impairment, especially to avoid a ceiling effect (Harciarek, Sitek, & Kertesz, 2014).

Formal assessments should always be supplemented with a spontaneous or conversational language task. There are two reasons why this is necessary when assessing language impairment in people with PSP. First, SLPs can judge the appropriateness of language production tasks depending on the presence of stuttering, echolalia, palilalia and/or cognitive impairments in the language sample. For echolalia and palilalia, an analysis of the spontaneous language sample is the only option as there are no formal assessments designed to assess them. Second, given the evidence for preserved nominal skills and impaired spontaneous language generation (e.g.Robinson et al., 2006), clinical decisions regarding the extent of language impairment solely on the basis of standardized language assessments may be incomplete. In addition, if SLPs suspect that a semantic memory impairment is contributing to poor naming performance the Sydney Language Battery (SYDBAT) (Savage et al., 2013) is recommended. This assessment is a picture-based single-word processing assessment. It has four subtests, one of which requires selecting (from a choice of four semantically-related items) the one picture most closely associated with the target picture.

Increasingly, SLPs are compelled to consider the wider impact of communication difficulties in people with PSP. Previous research (Schrag et al., 2003; Schrag, Selai, Quinn, & Hobart, 2005; Schrag et al., 2006) acknowledges the inclusion of patient-reported outcome measures as an

17

"important adjunct to clinical data" (Schrag et al., 2005, p. 246). It was on this basis that the PSP-Quality of Life (PSP-QoL) scale was developed. While only six of the 45 items in the scale are *directly* related to communication, several other items could be influenced by impaired communication (e.g. "*In the last four weeks have you felt the relationship with your spouse/partner has changed?*"). Nonetheless, it is recommended that the PSP-QoL be considered, because it is the only Quality of Life scale developed specifically people with PSP.

Table 5. Assessment options for people with progressive supranuclear palsy

Areas of assessment	Options
Motor Speech	
	Frenchay Dysarthria Assessment (Enderby & Palmer, 2008)
	Procedure outlined in Duffy (2013) and Freed (2012)
Language	
	Western Aphasia Battery (Kertesz, 2006) or equivalent language battery
	Verbal Fluency
	Boston Naming Test (Kaplan, Goodglass, & Weintraub, 2000)
	Northwestern Assessment of Verbs and Sentences (Thompson, 2011)
	Sydney Language Battery (Savage et al., 2013) or equivalent semantic memory assessment
Other	
Stuttering	Stuttering Severity Instrument (Riley, 2008)
	Procedure outlined in Ringo and Dietrich (1995) and Helm-Estabrooks (1999) for neurogenic stuttering
Symptom progression	Progressive Aphasia Severity Scale (Sapolsky et al., 2014)
Quality of life	PSP-Quality of Life Scale (Schrag et al., 2006)

5. Considerations for Treatment

All management decisions must be based on a comprehensive case history, an accurate assessment of communication impairments (including co-morbidities), and consideration of pharmacological interventions. It is essential that treatment plans are individually tailored and reflect the prognosis, motivation and desire of patients (Kinzbrunner, Maluso-Bolton, & Schlecter, 2011). Clinical decisions regarding the best treatment approach are difficult to make because there is a significant lack of research on effectiveness of treatment for people with PSP. Hanson and Metter (1980) is one of very few studies to provide evidence of treatment for dysarthria in PSP. They reported a case of a 59-year-

18

old male with PSP, who presented with severe hypokinetic dysarthria. His speech was aided with the use of delayed auditory feedback (DAF). This improved his speech rate, loudness and intelligibility and the effects were maintained over a period of three months while the device was used daily. Another more recent study is that of Countryman, Ramig, and Pawlas (1994), who examined the utility of the Lee Silverman Voice Treatment (LSVT®) in three patients with Parkinson's Plus Syndrome (consistent with Shy-Drager syndrome, multiple system atrophy and PSP). They reported that despite the rapid progression (and possible cognitive impairments) seen in the participants, LSVT® was successful due to the consistent and simple nature of the intervention. However, this finding needs to be regarded with caution, because it includes a single patient with PSP, and was carried out over 20 years ago. Furthermore, no subsequent studies have been published using this technique.

In the absence of other published studies, we propose the framework illustrated in Figure 1 which conceptualizes treatment approaches. Due to the heterogeneity of the condition, this list of approaches is not exhaustive. Rather, it is intended to be the starting point for SLPs when considering how to manage patients with PSP. Of particular importance is the distinction between facilitation approaches (which directly target the motor speech and/or language impairments) and compensation approaches (which address the communication environment). Management plans should consider the progressive nature of PSP and be aware of its impact on both the patient and his/her family members. Given the prognosis, treatment may be best achieved in conjunction with other health professionals who specialize in palliative approaches. Augmentative and alternative communication support should be considered from the early stages. However, SLPs should not simply choose a compensation approach over facilitation in treatment, because people with PSP could still benefit from impairment-based therapy (Countryman et al., 1994).
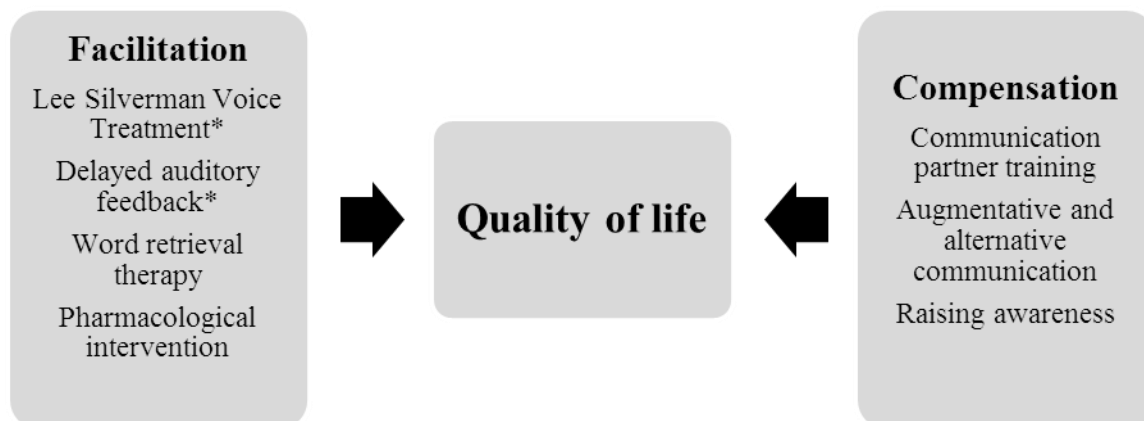
19

Figure 1. Conceptualization of treatment for people with progressive supranuclear palsy

* the evidence for these therapy techniques is based on two single cases of people with PSP

Central to both facilitation and compensation illustrated in Figure 1 is improving quality of life

for people with PSP and their family members. Collaboration between caregivers as well as other

medical professionals, particularly in end-of-life care, can contribute to improving quality of life

(Lorenz et al., 2008). Raising awareness of the presence of communication impairments in people

with PSP is pertinent in improving their quality of life. For family members, specific intervention and

education can relieve their burden and lead to effective overall management of people with PSP

(Schrag et al., 2003). For other healthcare professionals, the role of SLPs should be promoted,

because SLPs may not have a prominent role in the management of patients with PSP and may not

even be involved in the early stages. This is particularly important as Schrag et al. (2003) found that

communication difficulty was among the most relevant issues for quality of life in people with PSP.

6. Conclusion

This article has reviewed communication impairments in patients with PSP and provides clinical

guidelines for assessment and treatment. The presence of dysarthria is almost a universal finding and

20

language impairments may be more common than initially thought. It has been and still is a subject of debate as to whether the language impairments are consistent with aphasia (and/or one of its subtypes) or secondary to executive dysfunction. Either way, patients with PSP do have *communication* impairments which should justify the active involvement of SLPs in assessment and treatment. Furthermore, the possibility of establishing a new diagnostic description and label for the communication impairments seen in people with PSP has been postulated.

The motivation for this tutorial article was the lack of SLP-specific guidelines for assessment and management of communication impairments in people with PSP. Although we have provided a clinical description, it is evident from the literature that there are areas requiring further research in order to establish evidence-based management for people with PSP.

We have suggested some communication assessment tools based on the current literature. However, there is no assessment specifically designed to monitor the progression of communication impairments in people with PSP. Given the important role SLPs undertake in managing people with progressive neurological conditions, such as PSP, it is worth considering the development of an assessment tool sufficiently sensitive to detect mild language impairment at an early stage and to measure change over time (including the impact of medications).

There are only two studies reporting treatment for people with PSP, both of which focused on motor speech impairment, with no studies reporting treatment for the management of language difficulties. Therefore, there is a need for a more systematic investigation of language difficulties, beyond the single word level and possible treatment approaches. Carefully designed prospective longitudinal studies will contribute to understanding the course of disease progression thereby informing SLP management approaches.

Although PSP is relatively rare, communication impairments observed in people with PSP are more severe and worsen more rapidly than other progressive neurological conditions. It is worth considering the establishment of an international effort to devise best practice guidelines for SLPs which can enable early involvement, accurate assessment and effective intervention.

21

References

Arnulf, I., Merino-Andreu, M., Bloch, F., Konofal, E., Vidailhet, M., Cochen, V., . . . Agid, Y. (2005). REM sleep behavior disorder and REM sleep without atonia in patients with progressive supranuclear palsy. *Sleep, 28*(3), 349-354.

Bak, T. H., O'Donovan, D. G., Xuereb, J., Boniface, S., & Hodges, J. R. (2001). Selective impairment of verb processing associated with pathological changes in Brodmann areas 44 and 45 in the motor neuron disease-dementia-aphasia syndrome. *Brain, 124*, 103-120.

Bak, T. H., Yancopoulou, D., Nestor, P. J., Xuereb, J. H., Spillantini, M. G., Pulvermüller, F., & Hodges, J. R. (2006). Clinical, imaging and pathological correlates of a hereditary deficit in verb and action processing. *Brain, 129*(2), 321-332.

Berndt, R. S., Wayland, S., Rochon, E., Saffran, E., & Schwartz, M. (2000). *Quantitative production analysis: A training manual for the analysis of aphasic sentence production*. Hove, UK: Psychology Press.

Berthier, M. L. (2000). *Transcortical Aphasias*. Hove, UK: Psychology Press.

Blomert, L., Kean, M. L., Koster, C., & Schokker, J. (1994). Amsterdam-Nijmegen Everyday Language Test: Construction, reliability and validity. *Aphasiology, 8*(4), 381-407.

Brown, R. G., Lacomblez, L., Landwehrmeyer, B. G., Bak, T., Uttner, I., Dubois, B., . . . Leigh, N. P. (2010). Cognitive impairment in patients with multiple system atrophy and progressive supranuclear palsy. *Brain, 133*(8), 2382-2393.

Chiu, W. Z., Donker Kaat, L., Seelaar, H., Rosso, S. M., Boon, A. J., Kamphorst, W., & van Swieten, J. C. (2010). Survival in progressive supranuclear palsy and frontotemporal dementia. *Journal of Neurology, Neurosurgery & Psychiatry, 81*(4), 441-445.

Christman, S. S., Boutsen, F. R., & Buckingham, H. R. (2004). Perseveration and other repetitive verbal hehaviors: Functional dissociations. *Seminars in Speech and Language, 25*(4), 295-307.

Cotelli, M., Borroni, B., Manenti, R., Alberici, A., Calabria, M., Agosti, C., . . . Cappa, S. (2006). Action and object naming in frontotemporal dementia, progressive supranuclear palsy, and corticobasal degeneration. *Neuropsychology, 20*(5), 558-565.

Countryman, S., Ramig, L. O., & Pawlas, A. (1994). Speech and voice deficits in Parkinson plus syndromes: Can they be treated? *Journal of Medical Speech-Language Pathology, 2*, 211-226.

Daniele, A., Barbier, A., Di Giuda, D., Vita, M. G., Piccininni, C., Spinelli, P., . . . Gainotti, G. (2013). Selective impairment of action-verb naming and comprehension in progressive supranuclear palsy. *Cortex, 49*(4), 948-960.

Daniele, A., Giustolisi, L., Silver, M. C., Colosimo, C., & Gainotii, G. (1994). Evidence for a possible neuroanatomical basis for lexical processing of nouns and verbs. *Neuropsychologia, 32*(11), 1324-1341.

Delia Sala, S., & Spinnler, H. (1998). Echolalia in a case of progressive supranuclear palsy. *Neurocase, 4*, 155-165.

Dickson, D. W., Ahmed, Z., Algom, A. A., Tsuboi, Y., & Josephs, K. A. (2010). Neuropathology of variants of progressive supranuclear palsy. *Current Opinion in Neurology, 23*, 394-400.

Donker Kaat, L., Boon, A. J. W., Azmani, A., Kamphorst, W., Breteler, M. M. B., Anar, B., . . . van Swieten, J. C. (2009). Familial aggregation of parkinsonism in progressive supranuclear palsy. *Neurology, 73*(2), 98-105.

Donker Kaat, L., Boon, A. J. W., Kamphorst, W., Duivenvoorden, H. J., & van Swieten, J. C. (2007). Frontal presentation in progressive supranuclear palsy. *Neurology, 2007*(69), 723-729.

Donker Kaat, L., Chiu, W., Boon, A., & van Swieten, J. (2011). Recent advances in Progressive Supranuclear Palsy: A review. *Current Alzheimer Research, 8*(3), 295-302.

Duff, K., Gerstenecker, A., & Litvan, I. (2013). Functional impairment in progressive supranuclear palsy. *Neurology, 80*(4), 380-384.

Duffy, J. R. (2013). *Motor Speech Disorders: Substrates, Differential Diagnosis, and Management* (3rd ed.). St. Louis, MO: Elsevier Mosby.

Duffy, J. R., Strand, E. A., & Josephs, K. A. (2014). Motor speech disorders associated with primary progressive aphasia. *Aphasiology, 28*(8-9), 1004-1007.

Enderby, P., & Palmer, R. (2008). *Frenchay Dysarthria Assessment-Second Edition (FDA-2)*. Austin, TX: Pro-Ed.

23

Esmonde, T., Giles, E., Xuereb, J., & Hodges, J. (1996). Progressive supranuclear palsy presenting with dynamic aphasia. *Journal of Neurology, Neurosurgery, and Psychiatry, 60*(4), 403-410.

Freed, D. B. (2012). *Motor Speech Disorders* (2nd ed.). Clifton Park, NY: Cengage.

Gama, R. L., Távora, D. G., Bomfim, R. C., Silva, C. E., de Bruin, V. M., & de Bruin, P. F. (2010). Sleep disturbances and brain MRI morphometry in Parkinson's disease, multiple system atrophy and progressive supranuclear palsy-A comparative study. *Parkinsonism & Related Disorders, 16*(4), 275-279.

Gerstenecker, A., Mast, B., Duff, K., Ferman, T. J., & Litvan, I. (2013). Executive dysfunction is the primary cognitive impairment in progressive supranuclear palsy. *Archives of Clinical Neuropsychology, 28*(2), 104-113.

Goetz, C. G., Leurgans, S., Lang, A. E., & Litvan, I. (2003). Progression of gait, speech and swallowing deficits in progressive supranuclear palsy. *Neurology, 60*, 917-922.

Goldstein, K. (1948). *Language and Language Disturbances*. New York, NY: Grune and Stratton.

Goodglass, H. (1993). *Understanding Aphasia: Foundations of Neuropsychology*. Sand Diego, CA: Acadmemic Press.

Gurd, J. M., & Hodges, J. R. (1997). Word-retrieval in two cases of progressive supranuclear palsy. *Behavioural Neurology, 10*(1), 31-41.

Hanson, W. R., & Metter, E. J. (1980). DAF as instrumental treatment for dysarthria in progressive supranuclear palsy: A case report. *Journal of Speech and Hearing Disorders, 45*, 268-276.

Harciarek, M., Sitek, E. J., & Kertesz, A. (2014). The patterns of progression in primary aphasia: Implications for assessment and management. *Aphasiology, 28*(8-9), 964-980.

Hartelius, L., Gustavsson, H., Åstrand, M., & Holmberg, B. (2006). Perceptual analysis of speech in multiple system atrophy and progressive supranuclear palsy. *Journal of Medical Speech-Language Pathology, 14*(4), 241-247.

Hauw, J.-J., Daniel, S. E., Dickson, D., Horoupian, D. S., Jellinger, K., Lantos, P. L., . . . Litvan, I. (1994). Preliminary NINDS neuropathologic criteria for Steele-Richardson-Olszewski syndrome (progressive supranuclear palsy). *Neurology, 44*(11), 2015-2019.

24

Helm-Estabrooks, N. (1999). Stuttering associated with acquired neurological disorders. In R. Curlee (Ed.), *Stuttering and Related Disorders of Fluency* (2nd ed., pp. 255-268). New York, NY: Thieme.

Huber, W., Poeck, K., & Willmes, K. (1984). The Aachen Aphasia Test. *Advances in Neurology, 42*, 291-303.

Josephs, K. A., Boeve, B., Duffy, J., Smith, G., Knopman, D., Parisi, J., . . . Dickson, D. (2005). Atypical progressive supranuclear palsy underlying progressive apraxia of speech and nonfluent aphasia. *Neurocase, 11*(4), 283-296.

Josephs, K. A., & Duffy, J. R. (2008). Apraxia of speech and nonfluent aphasia: A new clinical marker for corticobasal degeneration and progressive supranuclear palsy. *Current Opinion in Neurology, 21*, 688-692.

Josephs, K. A., Duffy, J. R., Strand, E. A., Whitwell, J. L., Layton, K. F., Parisi, J. E., . . . Petersen, R. C. (2006). Clinicopathological and imaging correlates of progressive aphasia and apraxia of speech. *Brain, 129*, 1385-1398.

Jurica, P., Leitten, C., & Mattis, S. (2001). *Dementia Rating Scale-2*. Lutz, FL: Psychological Assessment Resources.

Kaplan, E. F., Goodglass, H., & Weintraub, S. (1983). *The Boston Naming Test*. Philadelphia, PA: Lea & Febiger.

Kaplan, E. F., Goodglass, H., & Weintraub, S. (2000). *The Boston Naming Test*. Philadelphia, PA: Lea & Febiger.

Kemmerer, D., & Hershey, L. (1996). Sentence comprehension deficits in progressive supranuclear palsy (PSP). *Journal of International Neurological Society, 2*, 5.

Kemp, S., Harding, A. J., Halliday, G. M., Mahant, N., & Fung, V. S. C. (2013). Cortical limb myoclonus in pathologically proven progressive supranuclear palsy. *Movement Disorders, 28*(13), 1804-1806.

Kent, A. (2013). Progressive supranuclear palsy. *Nursing Standard, 27*(51), 48-57.

Kertesz, A. (2006). *Western Aphasia Battery-Revised (WAB-R)*. San Antonio, TX: Harcourt Assessment, Inc.

25

Kinzbrunner, B. M., Maluso-Bolton, T., & Schlecter, B. (2011). Neurological symptoms at the end of life. In B. M. Kinzbrunner & J. S. Policzer (Eds.), *End-of-Life Care: A Practical Guide* (2nd ed., pp. 243-255). New York, NY: McGraw-Hill Medical.

Kluin, K. J., Foster, N. L., Berent, S., & Gilman, S. (1993). Perceptual analysis of speech disorders in progressive supranuclear palsy. *Neurology, 43*(3), 563-566.

Kluin, K. J., Gilman, S., Foster, N. L., Sima, A. A., D'Amato, C. J., Bruch, L. A., . . . Johanns, J. (2001). Neuropathological correlates of dysarthria in progressive supranuclear palsy. *Archives of Neurology, 58*(2), 265-269.

Kobylecki, C., Jones, M., Thompson, J. C., Richardson, A. M., Neary, D., Mann, D. M. A., . . . Gerhard, A. (2015). Cognitive-behavioural features of progressive supranuclear palsy syndrome overlap with frontotemporal dementia. *Journal of Neurology, 262*, 916-922.

LaPointe, L. L., & Horner, J. (1981). Palilalia: A descriptive study of pathological reiterative utterances. *Journal of Speech and Hearing Disorders, 46*, 34-38.

Lebrun, Y., Devreux, F., & Jousseau, J.-J. (1986). Language and speech in a patient with a clinical diagnosis of progressive supranuclear palsy. *Brain and Language, 27*, 247-256.

Leyton, C. E., & Hodges, J. R. (2014). Differential diagnosis of primary progressive aphasia variants using the international criteria. *Aphasiology, 28*(8-9), 909-921.

Litvan, I., Agid, Y., Calne, D., Campbell, G., Dubois, B., Duvoisin, R. C., . . . Zee, D. S. (1996). Clinical research criteria for the diagnosis of progressive supranuclear palsy (Steele-Richardson-Olszewski syndrome): Report of the NINDS-SPSP international workshop. *Neurology, 47*, 1-9.

Lorenz, K. A., Lynn, J., Dy, S. M., Shugarman, L. R., Wilkinson, A., Mularski, R. A., . . . Shekelle, P. G. (2008). Evidence for improving palliative care at the end of life: A systematic review. *Annals of Internal Medicine, 148*, 147-159.

Magherini, A., & Litvan, I. (2005). Cognitive and behavioral aspects of PSP since Steele, Richardson and Olszewski's description of PSP 40 years ago and Albert's delineation of the subcortical dementia 30 years ago. *Neurocase, 11*(4), 250-262.

Maher, E. R., Smith, E. M., & Lees, A. J. (1985). Cognitive deficits in the Steele-Richardson-Olszewski syndrome (progressive supranuclear palsy). *Journal of Neurology, Neurosurgery, and Psychiatry, 48*(12), 1234-1239.

Mazorra, L., & Cadogan, M. P. (2012). Progressive supranuclear palsy. *Journal of Gerontological Nursing, 38*(2), 8-11.

McKenna, P., & Warrington, E. K. (1983). *Graded Naming Test*. Windsor: NFER-Nelson.

Mesulam, M., & Weintraub, S. (2008). Primary progressive aphasia and kindred disorders. In C. Duyckaerts & I. Litvan (Eds.), *Handbook of Clinical Neurology* (Vol. 89, pp. 573-587). Amsterdam, The Netherlands: Elsevier.

Miceli, G., Silveri, M. C., Nocentini, U., & Caramazza, A. (1988). Patterns of dissociation in comprehension and production of nouns and verbs. *Aphasiology, 2*(3-4), 351-358.

Milberg, W., & Albert, M. (1989). Cognitive differences between patients with progressive supranuclear palsy and Alzheimer's disease. *Journal of Clinical and Experimental Neuropsychology, 11*(5), 605-614.

Müller, J., Wenning, G. K., Verny, M., McKee, A., Chaudhuri, K., Jellinger, K., . . . Litvan, I. (2001). Progression of dysarthria and dysphagia in postmortem-confirmed parkinsonian disorders. *Archives of Neurology, 58*(2), 259-264.

Nath, U., Ben-Shlomo, Y., Thomson, R. G., Lees, A. J., & Burn, D. J. (2003). Clinical features and natural history of progressive supranuclear palsy. *Neurology, 60*, 910-916.

Nath, U., Thomson, R. G., Wood, R., Ben-Shlomo, Y., Lees, A., Rooney, C., & Burn, D. (2005). Population based mortality and quality of death certification in progressive supranuclear palsy (Steele-Richardson-Olszewski syndrome). *Journal of Neurology, Neurosurgery & Psychiatry, 76*, 498-502.

Nickels, L., Taylor, C., & Croot, K. (2011). Clinical assessment of progressive aphasia. *ACQuiring Knowledge in Speech, Language and Hearing, 13*(2), 73-78.

Nomura, T., Inoue, Y., Takigawa, H., & Nakashima, K. (2012). Comparison of REM sleep behaviour disorder variables between patients with progressive supranuclear palsy and those with Parkinson's disease. *Parkinsonism & Related Disorders, 18*(4), 394-396.

27

O'Sullivan, S., Massey, L., Williams, D., Silveira-Moriyama, L., Kempster, P., Holton, J., . . . Lees, A. (2008). Clinical outcomes of progressive supranuclear palsy and multiple system atrophy. *Brain, 131*(5), 1362-1372.

Osaki, Y., Ben-Shlomo, Y., Lees, A. J., Daniel, S. E., Colosimo, C., Wenning, G., & Quinn, N. (2004). Accuracy of clinical diagnosis of progressive supranuclear palsy. *Movement Disorders, 19*(2), 181-189.

Papapetropoulos, S., Singer, C., McCorquodale, D., Gonzalez, J., & Mash, D. C. (2005). Cause, seasonality of death and co-morbidities in progressive supranuclear palsy (PSP). *Parkinsonism & Related Disorders, 11*(7), 459-463.

Pastor, P. (2009). Familial neurodegeneration in progressive supranuclear palsy: More frequent than expected? *Neurology, 73*(2), 86-87.

Pastor, P., Pastor, E., Carnero, C., Vela, R., Gracía, T., Amer, G., . . . Olivia, R. (2001). Familial atypical progressive supranuclear palsy associated with homozigosity of the delN296 mutation in the tau gene. *Annals of Neurology, 49*(2), 263-267.

Podoll, K., Schwarz, M., & Noth, J. (1991). Language functions in progressive supranuclear palsy. *Brain, 114*(3), 1457-1472.

Respondek, G., Roeber, S., Kretzschmar, H. A., Troakes, C., Al-Sarraj, S., Gelpi, E., . . . Höglinger, G. U. (2013). Accuracy of the National Institute for Neurological Disorders and Stroke/Society for Progressive Supranuclear Palsy and neuroprotection and natural history in Parkinson plus syndromes criteria for the diagnosis of progressive supranuclear palsy. *Movement Disorders, 28*(4), 504-509.

Riley, G. D. (2008). *Stuttering Severity Instrument-Fourth Edition (SSI-4)*. Austin, TX: Pro-Ed.

Ringo, C. C., & Dietrich, S. (1995). Neurogenic stuttering: An analysis and crtique. *Journal of Medical Speech-Language Pathology, 3*, 111-122.

Robinson, G., Shallice, T., & Cipolotti, L. (2005). A failure of high level verbal response selection in progressive dynamic aphasia. *Cognitive Neuropsychology, 22*(6), 661-694.

28

Robinson, G., Shallice, T., & Cipolotti, L. (2006). Dynamic aphasia in progressive supranuclear palsy: A deficit in generating a fluent sequence of novel thought. *Neuropsychologia, 44*(8), 1344-1360.

Rosser, A., & Hodges, J. R. (1994). Initial letter and semantic category fluency in Alzheimer's disease, Huntington's disease, and progressive supranuclear palsy. *Journal of Neurology, Neurosurgery, and Psychiatry, 57*, 1389-1394.

Santacruz, P., Uttl, B., Litvan, I., & Grafman, J. (1998). Progressive supranuclear palsy: A survey of the disease course. *Neurology, 50*(6), 1637-1647.

Sapolsky, D., Domoto-Reilly, K., & Dickerson, B. C. (2014). Use of the Progressive Aphasia Severity Scale (PASS) in monitoring speech and language status in PPS. *Aphasiology, 28*(8-9), 993-1003.

Savage, S., Hsieh, S., Leslie, F., Foxe, D., Piguet, O., & Hodges, J. R. (2013). Distinguishing subtypes in primary progressive aphasia: Application of the Sydney Language Battery. *Dementia and Geriatric Cognitive Disorders, 35*, 208-218.

Schrag, A., Ben-Shlomo, Y., & Quinn, N. P. (1999). Prevalence of progressive supranuclear palsy and multiple system atrophy: A cross-sectional study. *Lancet, 354*, 1771-1775.

Schrag, A., Selai, C., Davis, J., Lees, A. J., Jahanshahi, M., & Quinn, N. (2003). Health-related quality of life in patients with progressive supranuclear palsy. *Movement Disorders, 18*(12), 1461-1469.

Schrag, A., Selai, C., Quinn, N., & Hobart, J. (2005). Measuring health-related quality of life in patients with progressive supranuclear palsy. *Neurocase, 11*(4), 246-249.

Schrag, A., Selai, C., Quinn, N., Lees, A., Litvan, I., Lang, A., . . . Hobart, J. (2006). Measuring quality of life in PSP: The PSP-QoL. *Neurology, 67*(1), 39-44.

Skodda, S., Visser, W., & Schlegel, U. (2011). Acoustical analysis of speech in progressive supranuclear palsy. *Journal of Voice, 25*(6), 725-731.

Snodgrass, J. G., & Vanderwart, M. (1980). A standardized set of 260 pictures: Norms for name agreement, image agreement, familiarity, and visual complexity. *Journal of Experimental Psychology: Human Learning and Memory, 6*(2), 174-215.

29

Steele, J. C., Richardson, J. C., & Olszewski, J. (1964). Progressive supranuclear palsy: A heterogeneous degeneration involving the brain stem, basal ganglia and cerebellum with vertical gaze and pseudobulbar palsy, nuchal dystonia and dementia. *Archives of Neurology, 10*, 333-359.

Testa, D., Monza, D., Ferrarini, M., Soliveri, P., Girotti, F., & Filippini, G. (2001). Comparison of nautural histories of progressive supranulcear palsy and multiple system atrophy. *Neurological Sciences, 22*, 247-251.

Thompson, C. K. (2011). *Northwestern Assessment of Verbs and Sentences* Evanston, IL: Northwestern University.

van der Hurk, P. R., & Hodges, J. R. (1995). Episodic and semantic memory in Alzheimer's disease and progressive supranuclear palsy: A comparative study. *Journal of Clinical and Experimental Neuropsychology, 17*(3), 459-471.

Williams, D. R., de Silva, R., Paviour, D. C., Pittman, A., Watt, H. C., Kilford, L., . . . Lees, A. J. (2005). Characteristics of two distinct clinical phenotypes in pathologically proven progressive supranuclear palsy: Richardson's syndrome and PSP-parkinsonism. *Brain, 128*(6), 1247-1258.

Williams, D. R., & Lees, A. J. (2009). Progressive supranuclear palsy: Clinicopathological concepts and diagnostic challenges. *The Lancet Neurology, 8*(3), 270-279.

30