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The Effects of Verbal Fluency Interventions: Phonemic versus Semantic Fluency Outcomes in Parkinson's Disease

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The Effects of Verbal Fluency Interventions:

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Abstract

Verbal fluency (VF) tasks are well-established and widely used tools in clinical assessment and research settings to evaluate executive functioning skills. They consist of verbally generating as many different items as possible that either begin with a specified letter (i.e., phonemic) or belong to a category (i.e., semantic) within 60 seconds. Due to deficits in executive functioning, individuals with Parkinson's disease (PD) have increased difficulty with phonemic compared to semantic fluency. Although VF tasks are commonly used as intervention tools within speech-language pathology clinical practice, there is limited research investigating their therapeutic benefit. The purpose of this study was to investigate the effectiveness of a VF task intervention program at rehabilitating VF performances of an individual with PD. Additionally, this study investigated any effects of intervention on other measures of executive functioning. A quasi-experimental, pretest/posttest design was used. The 10-session intervention period focused on teaching and practicing the clustering and switching approach to VF tasks. Results revealed no significant changes in VF performances after intervention. Significant changes to other executive functioning measures validate the need for further investigation into VF tasks as therapeutic tools.

Keywords: Verbal Fluency, Parkinson's Disease, Speech-Language Therapy, Executive Functions

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Chapter One

Introduction

Verbal fluency (VF) tasks are cognitive measures that have been widely used in neuropsychological assessment, clinical practice, and research (Shao et al., 2014). VF tasks are often implemented to evaluate lexical fluency and word retrieval (Patterson, 2011). They are administered in two parts: phonemic fluency and semantic fluency (Lezak et al., 2004). In the phonemic fluency task, the examinee is asked to generate as many different words as possible in 60 seconds that begin with a designated letter. There are typically three separate trials, and the most commonly used letters are F, A, and S (Spreen & Strauss, 1998). In semantic fluency tasks, the participant is asked to generate as many different words as possible in 60 seconds that belong to a particular category, most commonly *animals* (Patterson, 2011). Cognitive demands of these tasks include accessing appropriate targets from stored vocabulary and selectively inhibiting responses inappropriate to the task, such as repetitions or intrusions (i.e., responses that violate task rules, such as proper nouns or variations in word tense). Successful retrieval and task performance rely heavily on selective attention, selective inhibition, mental set-shifting, internal response generation, and self-monitoring, all of which are highly regulated by executive functioning (Patterson, 2011).

Although both VF tasks require an interplay of verbal knowledge and executive functioning, neuroimaging studies have revealed that the two different tasks may employ different areas of the brain (Patterson, 2011). For example, Stuss and colleagues (1998) found that phonemic fluency tasks relied more heavily on frontal executive functioning systems, whereas semantic fluency tasks were more dependent on stored semantic knowledge and verbal ability located within the temporal lobe. This suggests that the two tasks may measure, and therefore utilize, distinct cognitive processes. Furthermore, this has implications for differential diagnoses, such as frontal versus temporal etiologies, and for informing appropriate clinical intervention and rehabilitation.

One neurological condition worth further investigation regarding VF tasks is Parkinson's disease (PD). Similar to Alzheimer's disease, PD is a progressive neurodegenerative disorder in which executive functioning, memory, and psychomotor speed decline over time (Aarsland et al., 2010; Koerts et al., 2011). Due to dopamine depletion in nigrostriatal projections within frontal lobe structures, executive functioning is often impaired in people with PD (Tekin & Cummings, 2002). This decrease in dopamine, and therefore impairments in executive functioning skills, can lead to deficits involved with phonemic fluency tasks (Owen, 2004). However, performances in semantic fluency tasks generally remain stable since the semantic pathways of the temporal lobes are largely unaffected in PD of the non-dementia type (McDowd et al., 2011; Lange et al., 1992; Shapiro et al., 2005).

One potential strategy for rehabilitating the phonemic fluency performances of individuals with PD is the clustering and switching strategy. Troyer et al. (1998) have demonstrated that clustering and switching strategies are fundamental for optimal VF task performance. Clustering for phonemic fluency can consist of retrieving words that share similar structure (e.g., *for, fort, fortnight, fortune, fortitude,* etc., for words beginning with F), words that rhyme (e.g., *bland, brand, band,* etc., for words beginning with B), or homophones (e.g., *for, four, fore,* etc., for words beginning with F; Troyer et al., 1997; Troyer et al., 1998). Once all immediate possibilities within the current cluster have been exhausted, the participant will then switch to another cluster and begin again. Similarly, semantic clustering focuses on grouping words into subcategories (e.g., farm animals, zoo animals, pets, birds, fish, etc., for *animals*) and then switching to another cluster when immediate possibilities have been exhausted. Troyer and colleagues (1998) have additionally shown that clustering is related to temporal lobe functioning, whereas switching is related to frontal lobe functioning. Therefore, for clustering and switching to be a viable treatment strategy for individuals with PD, more emphasis on the promotion of efficient and timely switches is needed given the frontal deficits associated with PD.

Statement of the Problem

Deficits with executive functioning are among the most common cognitive complaints reported by individuals with PD and can be observed during early stages of the disease process (Muslimovic et al., 2005). These deficits include impairments in cognitive flexibility, set-switching, inhibition, selective attention, concept formation, planning, and decision-making (Kudlicka et al., 2013). Moreover, these are the same cognitive processes that are fundamental to successful word search/retrieval and performance during VF tasks, particularly for phonemic fluency (Patterson, 2011). Therefore, individuals with PD have demonstrated greater difficulties participating in phonemic fluency than semantic fluency tasks (Owen, 2004). Clustering and switching may be a viable treatment approach for rehabilitating phonemic fluency performance. However, the switching component relies heavily on frontal-related executive functioning skills, which are often impaired in PD (Troyer et al., 1998). Given the deficits associated with executive functioning in PD, it remains to be seen whether treatment focusing on the practice of clustering and switching will be beneficial in VF task performance and beyond.

Purpose of the Study

The purpose of this study was to determine the effectiveness of a 10-session intervention period focusing on the practice of clustering and switching as a strategy for rehabilitating the VF task performances of an individual with PD. This study was conducted to investigate any differences in outcomes of phonemic versus semantic fluency tasks to determine if one task was more susceptible to improvement provided the neurocognitive profile of PD. Additionally, this study investigated if the hypothesized lower performing task (i.e., phonemic fluency) could be rehabilitated to similar levels of the hypothesized higher performing task (i.e., semantic fluency). Furthermore, this study examined any changes to other measures of executive functioning after the intervention period. Due to limited research investigating the therapeutic utility of VF tasks, this study provided a step toward better understanding VF tasks as interventional tools and bridging literature gaps.

Research Questions

This study was conducted to answer the following questions: 1) Can phonemic fluency scores be improved with clustering and switching intervention given the neurocognitive profile of PD? 2) Can phonemic fluency scores be rehabilitated to levels similar to semantic fluency scores? 3) Will there be a significant effect on semantic fluency scores after intervention? and 4) Will performances on other measures of executive functioning change after the intervention period?

Significance of the Study

A study conducted by Kudlicka and colleagues (2013) found that behavioral problems related to deficits in executive functioning, as indicated by the Behavior Rating Inventory of Executive Function – Adult Version (Roth et al., 2005), most significantly predicted quality of life and health status in individuals with PD and to burden on caregivers. The authors posited that difficulties with executive functioning, such as poor planning or difficulties prioritizing activities, may contribute to hindrances of performing everyday activities. Moreover, less effective regulation of behaviors, use of problem-solving strategies, and mental flexibility could affect use of coping/compensation strategies and optimization skills (e.g., modifying activities, adjusting goals and expectations, etc.) in navigating the disease process. (Sprangers & Schwartz, 1999). Therefore, therapy targeting executive functioning skills could have beneficial outcomes for improving the quality of life and emotional well-being of individuals with PD and their caregivers. Implementation of a VF task rehabilitation program where the participant would practice planning, selective attention, working memory, inhibition, set-shifting, and so on, may be one potential tool used for targeting executive functioning goals.

Within Parkinson Voice Project's (n.d.) SPEAK OUT!® and LOUD Crowd® therapy programs, word-generating tasks are provided as cognitive exercises at the end of several lessons. These tasks are typically semantic fluency tasks in which the participant is encouraged to name three-to-five items per category. According to a summary of the SPEAK OUT!® with the LOUD Crowd® program, these cognitive-linguistic activities were designed to, "improve word retrieval and cognitive processing speed, while focusing on intentional speech" (Berhman et al., 2022, p. 273). While several studies have demonstrated the positive effects that SPEAK OUT!® and LOUD Crowd® programs have on improving voice outcomes, such as mean speech intensity, intonation, prosody, and perceptions of quality of life (Behrman et al., 2022; Behrman et al., 2020; Boutsen et al., 2018; Levitt & Walker-Batson, 2018), limited attention has been given to the outcomes of the cognitive-linguistic exercises, specifically. Furthermore, VF tasks have often been used in speech-language therapy interventions despite limited research indicating their efficacy. Therefore, this study attempted to determine the cognitive outcomes of VF-focused therapy, particularly as they relate to posttest VF task performances and other measures of executive functioning.

Overview of the Study

This study used a quasi-experimental (i.e., non-randomized; Creswell & Guetterman, 2019), pretest/posttest design to investigate the effects of intervention on both phonemic and semantic fluency task performances of an individual with PD of the non-dementia type, and to investigate performance changes on other measures of executive functioning. The study consisted of a 10-session intervention period focusing on the training and implementation of the clustering and switching strategy between the two evaluation sessions.

Baseline and posttreatment data were collected for VF and executive functioning tests to determine any performance differences. A cognitive screener was used to determine the candidacy of the participant (i.e., screen for dementia). Differences in phonemic fluency and semantic fluency performances after the treatment period were analyzed to determine which task was more sensitive to intervention given the neurocognitive profile of persons with PD (i.e., decreased executive functioning with relatively intact semantic pathways; McDowd et al., 2011; Tekin & Cummings, 2002). Clustering and switching subanalysis was used to examine any changes in response patterns between pre- and posttest performances.

Chapter Two

Review of the Literature

Background of Verbal Fluency Tasks

Verbal Fluency (VF) tasks have been used in studies of healthy and clinical populations since the 1940s (e.g., Bousfield & Sedgewick, 1944), and a standardized version of a written VF task was conceptualized by Thurstone and Thurstone in 1962. However, given the limitations of a written task for younger children or individuals with motor deficits, a standardized oral VF task was developed by Borkowski and colleagues in 1967. The authors established task letters for phonemic fluency based on word frequency in the English language, which included the letters F, A, and S (Patterson, 2011). These letters were first featured in a VF task found within the Neurosensory Center Comprehensive Examination for Aphasia by Spreen and Benton (1969, 1977).

Other letters have been used in standardized VF assessment such as C, F, L and P, R, W. These letters are found in the Controlled Oral Word Association Test, part of the Multilingual Aphasia Examination by Benton and colleagues (1994). However, these letters have been reported to skew results given the relative vocabulary size that each letter affords (Spreen & Strauss, 1998). A meta-analytic study conducted by Barry et al. (2008) found that CFL was overall more difficult than FAS. Scores within the normal range were narrower for CFL, whereas the FAS form demonstrated greater variability among normal individuals (Barry et al., 2008). Therefore, FAS is most commonly used for phonemic fluency tasks as it allows for more response choices (Spreen & Strauss, 1998). Similarly, the semantic category *animals* affords more responses than other categories, such as *fruits* or *vegetables*. This has resulted in the *animals* category as being the most commonly used and studied form for semantic fluency tasks (Patterson, 2011).

According to *A Compendium of Neuropsychological Tests* by Spreen and Strauss (1998), several studies have shown that VF tasks demonstrate strong retest reliability. In a study of adult participants, the retest reliability of VF tasks was found to be $r = .88$ after 19 – 42 days (des Rosiers & Kavanagh, 1987). One-year retest reliability of VF tasks in older adults was found to be $r = .70$ by Snow et al. (1988). Concurrent validity of phonemic fluency was established as $r = .14$ with Wechsler Adult Intelligence Scale Verbal IQ and $r = .29$ with Performance IQ (Spreen & Strauss, 1998). This result suggests that VF tasks have a stronger relationship with a measure of fluid reasoning and attention to detail (i.e., Performance IQ) than a measure of verbal ability (Yeudall et al., 1986). This is consistent with other findings that have shown VF tasks to be more closely related to executive functioning than to verbal ability, especially phonemic fluency (Henry & Crawford, 2004; Patterson, 2011; Troyer et al., 1997; Troyer et al., 1998).

Neurocognition Underlying VF Performance

Despite the relative ease of VF task administration, generally requiring no more than a stopwatch, paper, and pencil, the clinical information of underlying neurocognitive processes is robust. VF tasks can measure processing speed, executive functions, semantic and phonemic lexicons, and reveal deterioration of cognitive processes associated with word retrieval (Pekkala, 2012). They also employ the cognitive processes of working memory, sustained attention, selective inhibition, and strategic search for lexical information (Patterson, 2011; Pekkala, 2012). As a result, VF tasks make for efficient screening tools for general lexical ability and executive functioning (Shao et al., 2014). In fact, the phonemic fluency task was found to be among the top 5 out of 18 tests from the Halstead-Reitan Neuropsychology Battery (Reitan & Wolfson, 1993) to discriminate between patients with brain damage and non-neurologically impaired controls (Spreen & Strauss, 1998).

Frontal versus Temporal Functions

At face value, both phonemic and semantic VF tasks appear quite similar. They are both word-generating tasks that require a level of efficient task monitoring and word retrieval to participate (Patterson, 2011). However, evidence from neuroimaging studies have suggested that the two VF tasks activate distinct neuroanatomic regions of the brain, reflecting different lexical retrieval systems and cognitive processes (Mummery et al., 1996).

A study conducted by Tupak et al. (2012) used functional near-infrared spectroscopy to record the frontal and temporal lobe oxygenation levels of healthy participants when performing VF tasks. The investigators found that phonemic fluency tasks, but not semantic, activated the prefrontal cortex and that semantic word retrieval led to activation of temporal and inferior frontal regions (Tupak et al., 2012). Another study conducted by Glikmann-Johnston et al. (2015) had participants perform VF tasks during functional magnetic resonance imaging scans. These researchers found a greater change in activity of the left and right hippocampi (i.e., structures with connection to the temporal lobe) during semantic fluency tasks than during phonemic fluency tasks (Glikmann-Johnston et al., 2015). Both of these studies illuminate the differential activation of neuroanatomical structures involved in each task, while implicating the effects on VF performance following insult to frontal and/or temporal structures.

Even when the two tasks are broken down conceptually, these distinctions become clear. While completing a semantic fluency task, the participant must select from words that share the same category label (Mummery et al., 1996). This requires activation of the semantic pathways found within the temporal lobe (Shapiro et al., 2005). In contrast, during phonemic fluency tasks, the participant does not have to adhere to any categorical restraints, word meaning, or semantic relationships. Instead, the participant can freely select from words that share the same initial letter or sound. Thus, there is decreased involvement of temporal functions relative to the frontal functions of selective attention, selective inhibition, and set shifting during phonemic fluency tasks (Mummery et al., 1996).

Further discussion on VF task localization is found within a meta-analysis of 31 studies with 1791 participants conducted by Henry and Crawford (2004). These researchers were interested in determining the sensitivity of VF tasks to the presence of focal lesions. While Henry and Crawford (2004) found that both phonemic and semantic fluency tasks were sensitive to frontal damage and executive functions (e.g., initiation, efficient organization, self-monitoring, etc.), patients with temporal pathology were more impaired on semantic fluency (r = .61) than patients with frontal pathology (r = .54).

Additionally, Henry and Crawford (2004) performed analyses comparing performances on the Wisconsin Card Sorting Test (WCST; Grant & Berg, 1948) with phonemic fluency performances of patients with frontal lesions. The WCST, another assessment of executive functioning, measures problem-solving behavior using *Categories Completed* (CC) and the ability to maintain/shift set using *Perseverative Errors* (PE; Strauss et al., 2006). Henry and Crawford (2004) found that phonemic fluency was more sensitive to frontal damage than either WCST CC and WCST PE (rs = .58, .40, and .50, respectively). Furthermore, phonemic fluency was found to have better specificity toward frontal pathology than WCST CC or WCST PE since it accounted for more variance in frontal versus non-frontal groups (PV = 34.0%, 16.2%, and 24.7%, respectively; Henry & Crawford, 2004). Overall, this study demonstrated the sensitivity and specificity of VF tasks in detecting the presence of focal lesions with phonemic fluency being particularly sensitive and specific to frontal damage (Henry & Crawford, 2004).

Clinical and Diagnostic Applications

From a clinical standpoint, these distinctions between frontal and temporal etiologies have beneficial applications for informing differential diagnoses, rehabilitation goals, and treatment plans. For example, Jones and colleagues (2006) found that persons with preclinical Alzheimer's disease (AD; i.e., temporal etiology) and vascular dementia (VaD; i.e., frontal etiology) performed similarly on phonemic fluency tasks. However, persons with preclinical VaD outperformed those with preclinical AD on semantic fluency tasks (Jones et al., 2006). These results suggest that temporal-mediated functions were predominantly spared in persons with preclinical VaD, serving as a discriminator for diagnosis between preclinical AD. However, it should be noted that this differentiation between frontal and temporal etiologies as assessed by VF task performances was only useful during the earliest stages of the disease processes. Performances for both etiologies became equally impaired as the diseases progressed (Jones et al., 2006).

Zhao et al. (2013) found additional diagnostic utility of VF tasks, relating specifically to clustering and switching during a semantic fluency task. Participants included in this study were patients with AD, VaD, mild cognitive impairment (MCI), vascular cognitive impairment of the non-dementia (VCIND) type, and a comparison group of cognitively normal senior controls. The investigators used total correct score, number of subcategories, cluster sizes, and number of switches as parameters for analysis. They found that the subcategory and switching scores could successfully distinguish patients with AD from those with VaD (Zhao et al., 2013). That is, patients with VaD made fewer clusters and number of switches compared to their AD counterparts. Zhao and colleagues (2013) also found that the switching score could be used to discriminate between MCI and VCIND, in which individuals with VCIND made fewer switches than their MCI counterparts. Both these results are consistent with vascular etiologies affecting frontal-mediated executive functions such as switching (Troyer et al., 1998). This study helps further elaborate upon the diagnostic applications of VF tasks and further implicates the distinct cognitive processes at work.

Summary of VF Neurocognition

In sum, the interplay of, and distinctions between, frontal-mediated executive functions and temporal-mediated semantic knowledge as revealed by VF task performances add depth to the diagnostic utility of VF tasks. This is particularly important since accurate differential diagnoses between frontal and temporal etiologies are imperative for informing appropriate pharmaceutical and other therapeutic strategies in pursuit of modifying the course of the disease process (Zhao et al., 2013). Additionally, understanding of these distinctions can help clinicians inform their treatment goals and approach. Despite the wealth of diagnostic utility VF tasks provide, there is limited information as to how VF tasks can be used as therapeutic tools in the literature.

Current Speech Therapy Applications of VF Tasks and Literature Gaps

Speech-language pathologists (SLPs) and other clinicians use VF tasks in isolation as efficient diagnostic measures of lexical fluency, word retrieval, and executive functioning for a variety of patient populations. VF tasks are also included as subtests in commonly used cognitive screeners, such as the Montreal Cognitive Assessment test (Nasreddine et al., 2005), or as parts of larger assessment batteries like the Arizona Battery for Cognitive-Communicative Disorders (Bayles & Tomoeda, 2020) or the Cognitive Linguistic Quick Test (Helm-Estabrooks, 2001).

These larger assessment batteries are used by SLPs as a means of identifying cognitive impairments, such individuals with suspected dementia, cognitive-communicative impairment, or aphasia (Bayles & Tomoeda, 2020; Helm-Estabrooks, 2001). Whether used in isolation or as part of a larger assessment battery, VF tasks help clinicians identify deficits in word retrieval and executive functioning, which are commonly associated with specific conditions such as AD, traumatic brain injury (TBI), or PD.

For therapeutic purposes, SLPs have often used VF tasks when working with individuals with cognitive-communication needs. Cognitive-communication can be defined as "[the] thought processes that allow humans to function successfully and interact meaningfully with others" (Northeastern University, n.d., par. 1). Such thought processes include orientation/awareness, attention, memory, problem-solving, executive functioning, and language abilities (Northeastern University, n.d.). Overall, these components facilitate independent living skills and mediate healthy relationships (ASHA, n.d.). Individuals within this population include those with dementia, aphasia, TBI, brain tumors, developmental delays, post-stroke symptoms, genetic disorders, and movement disorders (e.g., PD; ASHA, n.d.).

Based on previous discussion in this paper, VF tasks address at least four of the six cognitive-communication components listed above (e.g., attention, memory, executive functioning, language). Theoretically, this would make VF tasks a powerful tool for SLP cognitive-communication intervention given their efficiency and simplicity. However, there is limited research in determining the therapeutic effectiveness of VF tasks beyond their evaluative utility. To this author's knowledge, only one study investigating the benefits of VF tasks as a means of cognitive intervention was found after extensive review of the literature. This study will be discussed later in the chapter.

As such, clinical practice for SLPs should be informed by evidence-based practices. According to the American Speech-Language-Hearing Association (ASHA), evidence-based practice is the integration of three central tenets: clinical expertise, external and internal evidence, and perspectives of the client and caregivers. When all three tenets are considered, clinicians can make informed decisions toward providing high quality care (ASHA, n.d.). However, the external evidence either in support or opposition of VF tasks as an intervention method is limited. This means that SLPs are currently unable to best inform their clinical practice regarding the therapeutic implementation of VF tasks. Therefore, it is necessary to explore the interventional use of VF tasks to fill in literature gaps and contribute to evidence-based practices.

Parkinson's Disease

According to the Parkinson's Foundation (n.d.), PD is defined as "a neurodegenerative disorder that predominantly affects the dopamine-producing ('dopaminergic') neurons in a specific area of the brain called the substantia nigra," located in the basal ganglia (par. 1). The degeneration of dopaminergic neurons is responsible for the primary symptoms of PD such as rigid body movements, bradykinesia (i.e., slowness in the planning, initiation, and execution of voluntary movements), and resting tremors, in addition to abnormal gait, posture, and balance (Berardelli et al., 2001; Tysnes & Storstein, 2017). Similarly, hypokinetic dysarthria (i.e., weakness in speech muscles that results in rigidity and reduced range of motion; Duffy, 2019) has been reported to occur in up to 90% of individuals with PD (Behrman et al., 2022). Changes in motor function can also result in restricted movements of facial expressions (i.e., masked facies); difficulties swallowing and chewing (i.e., dysphagia); and small, cramped handwriting (i.e., micrographia; Mayo Clinic, n.d.; Parkinson's Foundation, n.d.).

PD is a progressive disorder in which symptoms worsen over time. According to Aarsland and Kurz (2010), at least 75% of 136 patients with PD in a longitudinal study developed PD with dementia (PDD) after 10 years. Criteria for meeting a diagnosis of PDD include significant cognitive decline from previous levels of performance in at least two cognitive domains and the need for assistance in completing activities of daily living (American Psychiatric Association, 2013). There is no known cause of PD, though genetic mutations and external factors such as head injury or exposure to pesticides are likely to increase the risk of developing the disease (MJFF, n.d.). Men are 1.5 times more likely to develop PD than women, and risk for PD increases with age (Mayo Clinic, n.d.; Parkinson's Foundation, n.d.).

Motor Pathways and Philosophy of "Intent"

There are two main motor pathways found within the basal ganglia: the polysynaptic indirect (i.e., extrapyramidal) pathway and the monosynaptic direct (i.e., pyramidal) pathway. The extrapyramidal pathway connects with sensory and motor cortices to regulate habitual movements. The pyramidal pathway connects with the frontal cortex to regulate goal-directed movements and motor learning. In individuals with PD, the extrapyramidal pathway is disproportionately impacted by dopamine depletion, resulting in motor inhibition and impairment of spontaneous, automatic behaviors like walking, writing, and speaking (Behrman et al., 2020). Meanwhile, the pyramidal pathway is less affected by the reduced levels of dopamine. Therefore, activation of the pyramidal pathway through increased attention and deliberate cognitive effort can override the adverse effects of the diminished extrapyramidal pathway (e.g., bradykinesia, hypophonia, hypokinetic dysarthria, etc.; Parkinson Voice Project, n.d.).

The differentiation of dopamine in pathways of the basal ganglia and overriding of reduced abilities through intentional effort is the hypothesis behind the “live with intent” treatment philosophy of the SPEAK OUT!® and LOUD Crowd® therapy programs (Parkinson Voice Project, n.d.). Individuals with PD were able to improve their movement accuracy, speed, and range of motion when prompted to increase attention and deliberation to automatic behaviors (Oliveira et al.,1997). Similarly, participation in SPEAK OUT!® and LOUD Crowd®, which targets “speaking with intent” and maintaining vocal loudness, has been shown to improve mean speech intensity, intonation, and scores on a voice-related quality of life questionnaire (Behrman et al., 2022).

Cognition and VF Task Performance

Beyond deficits in motor function, cognitive changes are common with PD including changes in memory, language, executive functioning, psychomotor speed, and visuospatial abilities (Aarsland et al., 2010; Koerts et al., 2011; Machado et al., 2016). Changes in executive functioning abilities are particularly prominent (Adwani et al., 2016). Elgh et al. (2009) found that 30% of individuals in the initial stage of PD had deficits in the executive functioning domain. Dopamine depletion of nigrostriatal projections within prefrontal structures interrupts normal activation and deactivation of the frontal cortex, therefore executive functions such as attention and inhibitory control are impacted (Machado et al., 2016; Tekin & Cummings, 2002). These disruptions can further impact the performances of other neuropsychological processes such as memory, perception, and language (Diamond, 2013).

The cognitive changes in attention, working memory, and other executive functions become most apparent during tasks such as Trails Making Test (TMT) B, Digit Span Backward (DSB), and VF tasks (Bayles et al., 2020; Warden et al., 2016). For TMT B, participants must connect dots between numbers and letters in an alternating fashion. Individuals with PD of the non-dementia type often have impaired vigilance and fluctuating attention (Bayles et al., 2020). This affects their ability to meet the task demands of TMT B such as divided attention, planning, response inhibition, and mental flexibility (Aarsland et al., 2009; Muslimovic et al., 2005). Short-term storage and mental manipulation of information through working memory are also impacted, as evidenced by greater performance difficulties with DSB relative to healthy controls (Warden et al., 2016). Furthermore, individuals with PD can have slower processing speed which affects their ability to problem solve, sequence information, shift set, and plan. This, among other deficits in executive functioning skills, contributes to lower performances on VF tasks (Bayles et al., 2020).

For further discussion on VF tasks, a study conducted by Herrera and colleagues (2012) found that participants with PD who were not on medication showed deficits in phonemic fluency tasks. When given dopamine treatment, these differences were restored to similar levels of controls (Herrera et al., 2012). That said, people without PDD or in early-stage PD generally show intact semantic content pathways relative to people with lesions of the temporal lobe, such as those with AD or PDD (McDowd et al., 2011). Nouns, the typical targets for semantic fluency tasks, are stored by temporal lobe neurons (Shapiro et al., 2005). The relatively intact semantic pathways of temporal neurons facilitate more successful retrieval of target words (Shapiro et al., 2005). Therefore, semantic categories are not usually impaired in individuals with PD of the non-dementia type (Lange et al., 1992). Although dopamine treatment appears to be beneficial in improving phonemic fluency performances, there is limited evidence in the literature to support if VF task intervention would produce similar results.

Summary of PD

To summarize, PD is a neurodegenerative disorder in which dopamine is depleted in neurons of the basal ganglia. This results in the rigidity, tremors, dysarthria, and cognitive changes associated with the disease. Deliberate, intentional effort can help override the negative effects on habitual motor behaviors, such as walking and speech. Deficits in attention, working memory, set shifting, and other executive functions are particularly evident in persons with PD. Persons with PD have difficulties with phonemic fluency tasks due to frontal deficits, though semantic fluency is usually spared. Phonemic fluency performances can be improved with dopamine treatment; however, it is unclear if VF task rehabilitation will have similar effects.

Previous Studies in VF Intervention

While the literature regarding VF task assessment is abundant, the literature regarding the rehabilitation and therapeutic use of VF tasks is scarce. However, a study conducted by Sutter et al. (2013) found that a telephone-based, VF intervention program totaling 90 minutes was successful in improving the cognitive performances of healthy older adults relative to an active control group. In this study, participants were 105 older adults (mean age = 72.3; *SD* = 5.7; range = 64 – 92 years). Of these participants, 84 were randomly assigned to one of three training groups or an active control group, and 21 participants were assigned to a no-contact control group (Sutter et al., 2013).

Prior to the intervention period, each participant underwent a battery of cognitive tests to determine baseline performance. This cognitive battery consisted of VF tasks (Regensburg Word Fluency Test; Aschenbrenner et al., 2000), tests of processing speed (*Digit Symbol Substitution Test* from the Nuremberg Aging Inventory; Oswald & Fleischmann, 2006), set shifting (Trail Making Test, Reitan; 1992), inhibition and working memory (Tests of Attentional Performance;

Zimmerann & Fimm, 2007), and long-term memory (Verbal Learning and Memory Test; Helmstaedter et al., 2001). A posttest evaluation comprised of the same tests was carried out to evaluate for any performance changes after treatment.

The three training groups and active control group participated in 15 sessions that were carried out over the phone, each one lasting 6 minutes. The training groups participated in two trials per session. Training group A was assigned to initial letter (i.e., phonemic) fluency training. In this condition, participants were asked to produce as many different words as they could think of beginning with a designated initial letter for 3 minutes. Training group B was assigned to phonemic switching, in which participants were asked to produce words alternating between two designated initial letters (e.g., *fruit, apple*, *fox*, *ape,* etc. for letters F and A) for 3 minutes. Training group C was assigned to the excluded letter fluency condition. Participants in this group were asked to produce as many different words as they could think of that did *not* contain a designated letter anywhere in the word. The active control group D was engaged in conversation about assorted topics (e.g., movies, books, etc.) for 6-minute sessions, though did not participate in direct VF therapy. Those participants assigned to the no-contact group E did not receive any training or additional contact outside of the pre- and posttesting sessions (Sutter et al., 2013).

In regard to training gains, the authors found that time in training had a significant main effect ($p < 0.001$) for the initial letter and phonemic switching groups A and B, meaning that performances significantly improved over training sessions for these groups. Moreover, there was no significant difference ($p = 1.000$) in training gains between the initial letter and phonemic switching groups. Participants in the excluded letter training group C did not show significant improvement during training ($p = 0.159$; Sutter et al., 2013).

After the 15-session intervention period, the participants completed the posttest evaluation consisting of the same materials as the pretest. Analysis of results from posttest VF tasks revealed that participants in the initial letter training group A only improved scores for the initial letter task, whereas participants in the phonemic switching training group B improved scores for both phonemic switching and initial letter tasks. Group C (i.e., excluded letter) was not included in further analyses due to limited training improvement. Interestingly, participants in the active control group D, who engaged in discussion about different topics every session, improved semantic fluency task performance more than training groups A and B. The authors posited that this open conversation may have inadvertently helped unlock pathways of semantic knowledge, leading to increased performance gains (Sutter et al., 2013).

In regard to transfer effects to untrained tasks of executive functioning and memory, no significant interaction effect was found among groups A, B, D, and E and other measures except for Digit Span. Other contrasts were run to compare Digit Span performances of the four groups. No significant differences in Digit Span performance were revealed when active groups A, B, and D were compared to the no-contact control group E. When comparing each active group separately (i.e., A vs. D, B vs. D), initial letter fluency training revealed a “marginally” significant finding ($p = 0.052$) compared to the active control group, and phonemic switching revealed a significant finding ($p = 0.007$) compared to the active control group (Sutter et al., 2013, p. 61). There was no significant difference in Digit Span performance between initial letter and phonemic switching groups (Sutter et al., 2013).

Overall, this study demonstrated that VF performance could be improved through a short-term intervention program for older adults. Additionally, it demonstrated that both initial letter and phonemic switching training improved Digit Span performance with phonemic switching having a larger effect (Sutter et al., 2013). These results are encouraging for the development of a VF rehabilitation program for individuals with PD.

Literature Summary

VF tasks have a long history and have been shown to be closely linked to executive functioning skills through correlational and brain imaging studies. Phonemic fluency in particular depends more heavily on frontal executive functioning relative to the temporal semantic demands of semantic fluency. Given the executive functioning deficits often present in PD, phonemic fluency tasks are more difficult than semantic. Despite the wealth of research investigating diagnostic applications of VF tasks, there is limited research investigating their potential for executive functioning intervention. Results from the Sutter et al. (2013) investigation show promise for the implementation of VF tasks as interventional tools.

Chapter Three

Methods

The purpose of this study was to determine the effectiveness of a 10-session intervention period on phonemic and semantic fluency task performances of a participant with Parkinson's disease (PD). This study was conducted to investigate any differences in intervention outcomes of phonemic versus semantic fluency tasks to determine if one task was more susceptible to improvement given the neuropsychological profile of PD. Additionally, this study investigated if the hypothesized lower performing task (i.e., phonemic fluency) could be rehabilitated to similar levels of the hypothesized higher performing task (i.e., semantic fluency). Furthermore, this study examined any changes in performances of executive functioning tasks (i.e., Trails Making Test and Digit Span Forward & Backward) after the treatment period.

Research Design

This quasi-experimental study (i.e., non-randomized; Creswell & Guetterman, 2019) was approved by the Minnesota State University – Moorhead (MSUM) Institutional Review Board (IRB) for single-subject design, which focused on providing the participant with compensatory strategies for verbal fluency (VF) tasks during an intervention period (see Appendix A for IRB approval letter). The participant was seen for a total of 12 sessions: a pretest session, 10 intervention sessions, and a posttest session. The pretest/posttest design was used for comparison to determine any changes in the cognitive profile, as indicated by changes in assessment results, following the intervention period. Prior to study enrollment, consent was obtained (see Appendix B for consent form) and a cognitive screener was used to screen for dementia to determine the candidacy of the participant. The pretest battery consisted of a phonemic fluency task, a semantic fluency task, and two cognitive tests of executive functioning. The posttest consisted of the same tasks and versions of materials with no cognitive screener.

Research Participant

Recruitment sampling was used. The investigators collaborated with area speech-language pathology (SLP) practices and medical clinics to recruit participants. With permission, the investigators posted or distributed IRB-approved recruitment flyers (see Appendix C) at five sites. Only one participant was recruited for this study.

The participant was a right-handed, 72-year-old male with a medical diagnosis of PD. He reported having completed 17 years of formal education and worked as a tradesman. The participant passed the dementia screener with a score of 30/30 points. While the participant did have observable tremors, this did not impede fine motor demands for written tasks (e.g., Trails Making Test). Regarding prior SLP services, he reported starting the SPEAK OUT!® program in spring of 2019 and has since been active in a LOUD Crowd® group. He had not received other SLP services outside of SPEAK OUT!® and LOUD Crowd®. Self-reported SLP goals consisted of speaking louder and with more intent. In addition to SLP services, he had received occupational and physical therapy services since spring of 2019.

When asked about previous experience with VF tasks, he reported participating in the word-generating tasks included in the SPEAK OUT!® and LOUD Crowd® cognitive activities. In these activities, participants must come up with three-to-five examples of words that either begin with a certain letter or belong to a certain category. Additionally, he reported completing phonemic fluency tasks for occupational therapy. He denied familiarity with clustering and switching, and he denied prior practice or explicit instruction with said strategies. The participant's vision was corrected with glasses, and he denied any additional concerns with vision or hearing. Medication information was not obtained.

Research Tools

This study used a variety of cognitive tools and assessments, including the Controlled Oral Word Association Test (Benton et al., 1994) for the phonemic and semantic VF tasks. Different letters and categories for the VF tasks were used during the intervention period to minimize practice effects and to facilitate the generalization of learning, as is standard practice in skilled SLP interventions. Pretest measures were used to determine a baseline for comparison with performances on posttest measures. The pre- and posttest batteries consisted of the Controlled Oral Word Association Test, Trails Making Test, and Digit Span Forward & Backward. The same forms and versions were used for both the pre- and posttest. The Mini-Mental State Exam was used as a cognitive screener to screen for dementia prior to participant enrollment. The following sections provide a brief description of each tool and how it was used in this study.

Controlled Oral Word Association Test

The primary research tool used in this investigation was the Controlled Oral Word Association Test (COWAT, Benton et al., 1994), which consisted of phonemic and semantic fluency portions. In the phonemic fluency portion of this test, the participant must generate as many different words as possible in 60 seconds that begin with a given letter. The participant must also refrain from violating any rules such as repeating words, using proper nouns, or changing word tenses. There are three separate trials, each with a different target letter, and the number of words across all three trials is added up for a total score. The difference in total number of words between pre- and posttest scores using the same target letters was used to determine any differences in performance following the intervention period.

The letters used in this investigation included the commonly administered FAS from the Halstead-Reitan Neuropsychology Battery (Reitan & Wolfson, 1993) as well as the letters CL and PRW from the Multilingual Aphasia Examination (Benton et al., 1994), D and T from the Test of Verbal Conceptualization and Fluency (TVCF; Reynolds & Horton, 2006), and B and H from the Delis-Kaplan Executive Function Scale (Delis et al., 2001). These letters were chosen for this study as they are featured in published neuropsychological assessments. FAS was only used for pre- and posttest evaluations to avoid practice effects. Additional letters included E, G, I, M, N, and O. These letters were chosen as they are among the most frequent initial position letters in the English language (Norvig, n.d.). Each intervention session consisted of practice trials with three intervention letters, similar to clinical administration of the COWAT. These letters were used in different combinations throughout the intervention period to avoid practice effects.

In the semantic fluency portion of the COWAT, the participant must generate as many different words as possible in 60 seconds that belong to a certain category. The participant must also refrain from violating any rules such as responding with repetitions or intrusions (i.e., nontarget responses). Only one trial of semantic fluency is administered. The categories used in this study included *animals*, *food and drink*, *home goods*, *transportation*, and *clothing* from the TVCF. The category *animals* was only used for pre- and posttest purposes to avoid practice effects. Other intervention categories included *body parts*, *colors*, *cities*, *jobs*, *plants*, and *tools*. Each intervention session consisted of a single practice trial with one of the intervention categories, similar to clinical administration of the COWAT. The difference in total number of words between pre- and posttest scores using the same category (i.e., *animals*) was used to determine any differences in performance following the intervention period.

Mini-Mental State Exam

To screen for dementia, the Mini-Mental State Exam (MMSE) was used. The MMSE is a 30-point screening tool used to screen for cognitive impairment in adult and geriatric populations (Strauss et al., 2006). This tool includes tests of orientation, attention, memory, language, and visuospatial skills. A score of < 24 is generally used as a cutoff score to discriminate between normal cognitive functioning and suspected cognitive impairment (Dick et al., 1984). For purposes of this study, the participant had to score 24 or higher in order to be considered for enrollment in the study. The study participant scored a 30/30 on MMSE.

Trails Making Test

The Trails Making Test (TMT) consists of two parts, A and B. In TMT A, the participant must visually scan an array of randomly placed targets numbered 1 to 25 and connect the targets in order as fast as possible while minimizing errors. In TMT B, the participant must also visually scan through an array of randomly placed targets, though these targets consist of numbers and letters. The participant must shift between number and letter in correct ascending order (e.g., 1 to A, A to 2, 2 to B, etc.) as fast as possible while minimizing errors. While TMT A measures visual scanning, graphomotor speed, and visuomotor processing speed, TMT B measures working memory and inhibition control; both relevant components of executive functioning (Llinàs-Reglà et al., 2015). Practice pages are provided for both parts before administration of the test conditions per standardized protocol (Strauss et al., 2006). Differences in completion times between pre- and posttest measures were used to gauge changes in performance after the intervention period. This measure was included to investigate generalization of VF training to an untrained executive functioning task, similar to the Sutter et al. (2013) investigation. The Halstead-Reitan (1993) version of TMT was used for the current investigation.

Digit Span Forward & Backward

Digit Span Forward & Backward (DS F&B) requires the participant to recite increasingly longer strings of numbers back to the examiner either in forward order (i.e., as presented) or in reverse order for backward. Kaplan and colleagues (1991) have posited that Digit Span Forward serves as a measure of attention span, or how many units can be mentally held at one time, whereas Digit Span Backward serves as a measure of mental manipulation and working memory. The Longest Digit Span Forward (LDSF) is the longest string of digits that the participant can successfully recite in the forward direction. The Longest Digit Span Backward (LDSB) is the longest string of digits that the participant can successfully recite in the backward direction. Differences in DS F&B scores between pre- and posttest measures were used to gauge changes in these executive functioning patterns after the intervention period. LDSF and LSDB were used to qualitatively analyze the maximum number of digits recalled. This measure was included to determine the generalization of VF training to an untrained executive functioning task, similar to the Sutter et al. (2013) investigation. The DS F&B form used in this investigation came from the Multi-Ethnic Study of Atherosclerosis by Fitzpatrick et al. (2015).

Intervention Measures

The participant was seen for 10 intervention sessions. These intervention sessions consisted of teaching the participant how to use the clustering and switching strategy and practice with said strategy during timed trials for each target letter and semantic category. Each target letter was practiced twice throughout the intervention period for phonemic fluency and each category was practiced once for semantic fluency (see Appendix D for intervention schedule).

Prior to administration of all timed practice trials, the participant was instructed on various clustering strategies for phonemic fluency tasks (see Appendix E for lesson example). These consisted of retrieving words that share similar structure (e.g., *fright, fry, fridge, from, frozen, frequent*, etc., for words beginning with F), words that rhyme (e.g., *slay, stray, say, stay*, etc., for words beginning with S), and words that are homophones (e.g., *mousse* and *moose* for words beginning with M; Troyer et al., 1997; Troyer et al., 1998). Words that share similar structure were taught as words that start with the same two letters, most commonly identified as either vowels or the consonants L and R for the second letter. Additional clustering strategies unique to this study (i.e., not used in Troyer et al., 1997) included retrieving words that start with the same sound regardless of spelling (e.g., *time, titan, type, typhoon,* etc., for words beginning with T) and words that share a semantic relationship (e.g., *legal, law, lawsuit, lawyer, litigation,* etc., for words beginning with L). Once all immediate responses within that cluster had been exhausted, the participant was instructed to switch to another cluster and begin again. The participant was given the opportunity to practice generating his own "string" of clusters and switches prior to administration of the timed trials (e.g., *do, dew, doe, deer, day, date,* etc.). Timed trials for phonemic fluency were administered for 60 seconds after teaching clustering and switching strategies for each target letter.

For the first five intervention sessions, the participant was provided with two-letter clusters for the target letter and a list of words for each cluster during teaching sections. This was done to demonstrate the concept of clustering by structure and to prime for appropriate responses during the timed practice trials. The two-letter clusters were visual cues left on-screen (without the word lists) for the participant to reference during the timed trials to facilitate timely switches between the two-letter clusters. The participant was encouraged to practice shifting between clusters when making switches to maximize his switching fluency. Supports were gradually faded as intervention sessions progressed to promote the independence required for the posttest evaluation. Beginning with Session 6, lists of words for each two-letter cluster were no longer provided during teaching sections. For the final two sessions, the two-letter clusters were no longer provided during the timed practice trials.

For semantic fluency, the participant was instructed to group words into subcategories of the target category (e.g., produce, meat, dairy, Mexican, Italian, etc., for *food and drink*) and then switch to another subcategory (i.e., cluster) when immediate responses had been exhausted. The participant was provided with a list of ideas for subcategories prior to administration of the timed practice trials (see Appendix E). This list was a visual cue left on-screen for the participant to reference during timed trials to promote practice with making timely switches between clusters. For the final two sessions, the list of subcategories was no longer provided to promote the independence of strategy use required for the posttest evaluation.

The concept of executive functioning was emphasized at the start of each session as a reminder of which skills were being targeted through intervention. Executive functioning was outlined with the following three tenants: 1) Plan your work. 2) Work your plan. 3) How did your plan work? After completion of each letter or category, the participant was encouraged to engage in self-reflection, ask questions, and was provided clinical feedback with cues and shaping strategies.

Procedures

Prior to enrollment in the study, the participant was provided with a consent form that outlined the purpose and procedures of the study (see Appendix B). Once consent was given, the participant was seen for a pretest evaluation consisting of the MMSE, COWAT (i.e., FAS and *animals*), TMT, and DS F&B. These assessments were administered as per standardized protocol.

Experimental Method

After completion of the pretest evaluation, the participant was seen for 10 sessions during the intervention period over the course of 5 weeks. These sessions consisted of teaching the participant the clustering and switching strategy and allowing time for practice and feedback. The frequency of these sessions was twice per week. During each session, the participant practiced clustering and switching using three different letters for phonemic fluency and one category for semantic fluency, as is similar to clinical administration of the COWAT. The letters F, A, and S were excluded from the phonemic fluency portions, and the *animals* category was excluded from the semantic fluency portions to avoid practice effects for posttest measurements.

Prior to all timed practice trials, the participant received pre-teaching instructions, which verbally and visually addressed the clustering and switching strategy for each target letter and semantic category. This instruction consisted of how to create clusters for both tasks (e.g., similar structure, rhymes, homophones, semantic relationships, subcategories, etc.) and strategies for efficient switching (e.g., if *fl*- words have been exhausted, switch to the next vowel [*fo*-] or nearest appropriate consonant [*fr*-]). Pre-teaching instructions were gradually faded or minimized as the intervention period progressed and as the participant became more competent at using this strategy. Supports, such as presentation of sample words during pre-teaching and two-letter clusters during timed trials, were gradually faded as well.

If the participant experienced difficulty making a switch during timed practice trials (e.g., response latency > 5 seconds), the examiner provided a prompt (e.g., “Switch to *mo*-”) or a cue (e.g., “Switch”). Prompting and cueing was adapted to fit the needs of the participant and modified as the intervention period progressed (e.g., prompt after 15 seconds for earlier sessions, prompt after 10 seconds for middle sessions, cue after 5 seconds for later sessions, etc.). After administration of each letter and category, the participant received clinical feedback on task performance and effectiveness of strategy use. Self-reflection and discussion on shaping and cueing also occurred. As with pre-teaching instructions, feedback and debriefing after trials were gradually faded or minimized as the treatment period progressed and as the participant became more competent at using targeted strategies.

After the 10-session treatment period, the participant was seen for the posttest evaluation. The posttest evaluation consisted of forms identical to the pretest for COWAT (i.e., FAS and *animals*), TMT, and DS F&B. The MMSE was not included for posttest. All assessments were administered per standardized protocol. The participant did not receive any additional instruction, review, or priming prior to posttest administration other than a reminder to use the skills that had been taught. Data from the posttest was compared with data obtained from the pretest. Differences between pre- and posttest values for phonemic and semantic fluency total words, TMT completion times, and DS F&B scores were calculated to determine any changes.

Data Analysis

To determine statistically or clinically significant differences between pre- and posttest scores, a variety of analytic tools and approaches were used. The availability of parameters (i.e., test-retest reliability) provided by normative sources or cutoff scores cited in the literature largely dictated when each tool or parameter was used.

One tool used for statistical analysis was the Reliable Change Index (RCI) developed by Jacobson & Truax (1991) and cited by Unicomb et al. (2015) for use in speech, language, and hearing case studies. RCI is calculated as $(X_2 – X_1)/S_{diff}$, where X_1 and X_2 are the pre- and posttest scores, respectively, and S_{diff} is the standard error of difference between the two scores (Unicomb et al., 2015). A test-retest reliability coefficient is required to calculate S_{diff}. If the calculated value was > ±1.96, then the change was considered reliable and significant at the p = .05 level (Jacobson & Truax, 1991; Unicomb et al., 2015; Wise, 2004).

When test-retest reliability coefficients were not reported by the normative sources, cited reliable cutoff scores or the *SD* method were used to determine clinical significance. Reliable cutoff scores used in this investigation were derived from Lezak (1983) and Spreen and Strauss (1991). When neither test-retest reliability coefficients nor reliable cutoff scores were provided or available, the *SD* method for determining clinical significance was applied. The *SD* method was calculated as $(X_2 – X_1)/SD$, where X_1 and X_2 are the pre- and posttest scores, respectively, and *SD* is the standard deviation reported by the normative source (Barker-Collo & Purdy, 2013). Alternatively, the *SD* method can be applied as any z-score difference that met or exceeded ± 1 *SD* (Nietzel et al., 1987; Wise, 2004). Calculations that met or exceeded a change of ± 1 *SD* were considered reliable and, therefore, clinically significant (Barker-Collo & Purdy, 2013).

Delivery Method

Both pre- and posttest sessions were held face-to-face at the MSUM Speech-Language & Hearing Clinic. To accommodate for busy schedules and travel times, all intervention sessions were held remotely via telepractice. Sessions occurred over an encrypted Zoom-platform meeting in compliance with the Health Insurance Portability and Accountability Act (HIPAA). The supervising investigator, a certified SLP with licensure to practice in the state where the client was located, was present for all sessions. Instructions were taught verbally over the computer, and a Microsoft Word document containing teaching materials was presented on-screen through screen sharing.

Scoring

Phonemic Fluency. Scoring procedures for the phonemic fluency portion of the COWAT followed the scoring guidelines set forth in the Halstead-Reitan Neuropsychology Battery (Reitan & Wolfson, 1993). The participant had 60 seconds to think of as many different words as possible that begin with a designated letter. Any word that did not start with the target letter was considered an intrusion and did not receive credit. During administration, the participant was reminded of the target letter following any deviations from the target letter.

Any responses that were proper nouns did not receive credit. This included the proper names of people, places, days, months, or brands. If a response was ambiguous such as *ford* (i.e., either the automotive manufacturer [proper] or shallow place of a river [common]), the examiner asked, “What did you mean by *ford*?” at the end of the trial. If the participant referred to the automotive manufacturer, the response *ford* would not receive credit. If the participant referred to the shallow place of a river, the response *ford* would receive credit. During administration, the participant was reminded not to use proper nouns if any occurred.

Additionally, the participant had to refrain from changing the tense of words. For example, the participant was not permitted to use the words *sits, sat,* or *sitting* if the word *sit* was used first. Comparatives and superlatives (e.g., *bigger* and *biggest*) were also not permitted. Words such as *farm* and *farmer* both received credit as one refers to the place and the other to the person. However, *farms, farmed,* and *farming* could not be subsequently used since only the tense was changed. Similarly, words such as *fun* and *funny* or *atom* and *atomic* all received credit since one is a noun and the other is an adjective. If frequent tense changes occurred during administration, the participant was reminded not to change the tense of words.

Furthermore, the participant had to refrain from repetitions or plurals. Any response that was repeated did not receive credit. Generally, the participant indicated the difference between homophones by spelling out the word or mentioning that the intended word was different from the one already mentioned (e.g., "*Fair*…then the other kind of *fare*," etc.). However, since this can take extra time, the participant was not expected to make these distinctions every time. Therefore, the examiner used best judgment in making these types of scoring decisions. Words such as *sun, shine,* and *sunshine* all received credit. However, a word such as *fire truck* did not receive credit if the word *fire* had already been said since *fire truck* is two separate words with *fire* already being stated and *truck* starting with T (i.e., nontarget letter for F). Continuing this example, *firefighters* and *fireplace* would both receive credit since they are compound words. Words such as *somewhere, somehow, something,* etc., all received credit.

The participant could only use responses that were numbers twice per letter. If the participant continued with a third number within a given trial, the participant was prompted to stop using numbers. The third and subsequent numbers would not receive credit.

Semantic Fluency. Scoring procedures for the semantic fluency portion of the COWAT followed the scoring guidelines set forth in the Halstead-Reitan Neuropsychology Battery (Reitan & Wolfson, 1993). The participant had 60 seconds to think of as many different words as possible that belonged to a specified category. The participant received credit for all responses that were reasonable within a particular category. This included broad categories and subsequent sets of those categories. For example, during the *animals* category, the participant could respond with *birds*, *raptors*, *falcons*, *peregrine*, etc., and receive credit for all responses. The participant could also receive credit for different names of the same target (e.g., *cougar* and *puma*), male and female distinctions of the same target (e.g., *heifer* and *bull*), distinct stages of growth of the same target (e.g., *puppy* and *dog*), and fictional animals (e.g., *dragons*, *unicorns*, etc.). During administration, the examiner provided the correct category if the participant forgot or deviated from the target category.

The participant did not receive credit for plurals (e.g., *mouse* and *mice*), repetitions, or for responses that were deemed off-task or unreasonable. For example, if during the *animals* category, the participant responded with *humans, kids, uncles, aunts,* etc., the participant could receive credit for *humans* and *kids* since kids are the immature forms of human adults (as puppies are to dogs), but would not receive credit for *aunts, uncles,* and other familial relations since these are off-task. For the transportation category, the participant could receive credit for *horses, yaks,* and *elephants* since these animals have been used for transportation purposes. However, animals such as *giraffes* or *zebras* would not receive credit since they have not been used as transportation and are therefore unreasonable. The examiner made best judgment calls when assessing the reasonability of a response.

Clustering and Switching. This study followed the scoring criteria for clustering and switching as proposed by Troyer et al. (1997) for pre- and posttest VF analysis. For phonemic fluency, clusters were defined as consecutive words that either began with the same two letters, rhymed, differed by only a vowel sound (e.g., *sight, seat, soot*, etc.), or were homonyms. Additional clustering strategies for phonemic fluency that were unique to this investigation (i.e., shared semantic relationship and shared initial sounds) were not counted toward clusters for sake of scoring consistency. For semantic fluency, clusters were defined as consecutive words that belonged to the same subcategory. Broadly speaking, different subcategories for the *animals* category were specified by living environment, human use, or zoological characteristics (e.g., mammals, reptiles, etc.).

Cluster sizes were counted starting with the second response within the identified cluster. A cluster containing 2 words before a switch had a size of 1, 3 words had a size of 2, and so on. Errors and repetitions were included per Troyer et al. (1997). Mean cluster size for phonemic fluency was computed by adding up cluster sizes across all three trials and then dividing by the total number of clusters for all three trials. The same procedure was followed for the one trial of semantic fluency (Troyer et al., 1997).

Switches were counted as any transitional words that did not belong to the current cluster. This included single responses. The number of transitions between clusters and individual words across all three phonemic trials constituted the total number of switches. Errors and repetitions were included in this count. The same procedure was followed for the one trial of semantic fluency (Troyer et al., 1997).

Confidentiality

In accordance with HIPAA, MSUM IRB, and MSUM Speech-Language & Hearing Clinic policies, all electronic or hardcopy data, protocols, forms, documents, and records were deidentified. Materials containing identifiable information (e.g., consent form) were stored in a deidentified folder kept in secured storage in the principal investigator's office. Deidentified hardcopies of data and protocols were kept in a separate deidentified folder in secured storage in the principal investigator's office. All electronic data was deidentified and kept on a password-protected computer. All virtual sessions occurred over secured, HIPAA-compliant Zoom-platform meetings.

Compensation

To compensate for the participant's time and to show gratitude for his participation, the participant received a $25 general-use gift card after approval by the university IRB and the MSUM Department of Speech-Language Hearing Sciences mini-grant committee.

Chapter Four

Results

This study was designed to investigate the effectiveness of a verbal fluency (VF) intervention program targeting the clustering and switching strategy for an individual with Parkinson's disease. Additionally, this study investigated any performance changes on other tasks of executive functioning after VF intervention. Data was collected from pre- and posttest evaluations, as well as timed practice trials during the intervention period. Given the limited sample size of only one participant for this study, statistical analysis for significance between pre- and posttest performances was limited and only able to be applied where parameters were known. When these parameters were unknown, clinical significance was established using reliable change cutoffs derived from Lezak (1983) and Spreen and Strauss (1991), or the *SD* method where changes exceeding ±1 *SD* were considered clinically significant (Barker-Collo & Purdy, 2013; Nietzel et al., 1987; Wise, 2004).

VF Task Performances After Intervention

Pretest and posttest scores were compared for both phonemic and semantic fluency tasks. Raw scores (i.e., total number of words) were used to calculate z-scores based on normative data from Tombaugh et al. (1999). Percentile rankings from this source were used.

Table 1 summarizes the performances of phonemic fluency tasks. Posttest phonemic fluency total words decreased by 5 words, lowering the percentile ranking from the 50^{th} – 60^{th} percentile range to the 40^{th} percentile. Following procedures outlined by Jacobson & Truax (1991) and Unicomb et al. (2015), a reliable change index (RCI) was calculated using the difference between pre- and posttest totals then dividing by the standard error of difference. The standard error of difference was calculated using the reported test-retest reliability coefficient for phonemic fluency from Tombaugh et al. (1999). RCI analysis revealed that the computed value was not equal to or greater than the RCI limits of ± 1.96, indicating that the difference between the two performances was not significant at the p = .05 significance level.

Table 1

Phonemic Fluency Pretest and Posttest Comparison

Phonemic (FAS)	Pretest	Posttest	$RC_{VF\ Letter}$ (95% CrI)
Raw (total words)	43	38	
Z-score [a]	0.08	-0.33	-0.58*
Percentile [a]	50-60	40	

Note. $RC_{VF\ Letter}$ = reliable change index for phonemic fluency; CrI = credible interval. [a] Based on norms from Tombaugh et al. (1999). *$RC_{VF\ Letter}$ < ± 1.96, not significant at p = .05 level (Jacobson & Truax, 1991; Unicomb et al., 2015).

Table 2 summarizes the performances of semantic fluency tasks. Posttest semantic fluency total words increased by 2 words, raising the percentile ranking from the 50th – 75th percentile range to the 75th percentile. Since a test-retest reliability coefficient was not reported from the normative source (i.e., Tombaugh et al., 1999), RCI analysis could not be conducted. Therefore, clinical significance between the two scores was established if the performance change was greater than ± 1 *SD*. The difference between pre- and posttest z-scores revealed an increase of 0.47 < ± 1 *SD*, indicating no clinically significant difference between the two scores.

Table 2

Semantic Fluency Pretest and Posttest Comparison

Semantic (animals)	Pretest	Posttest	Δ Performance
Raw (total words)	20	22	+2
Z-score [a]	0.43	0.90	+0.47
Percentile [a]	50-75	75	+0 – 25

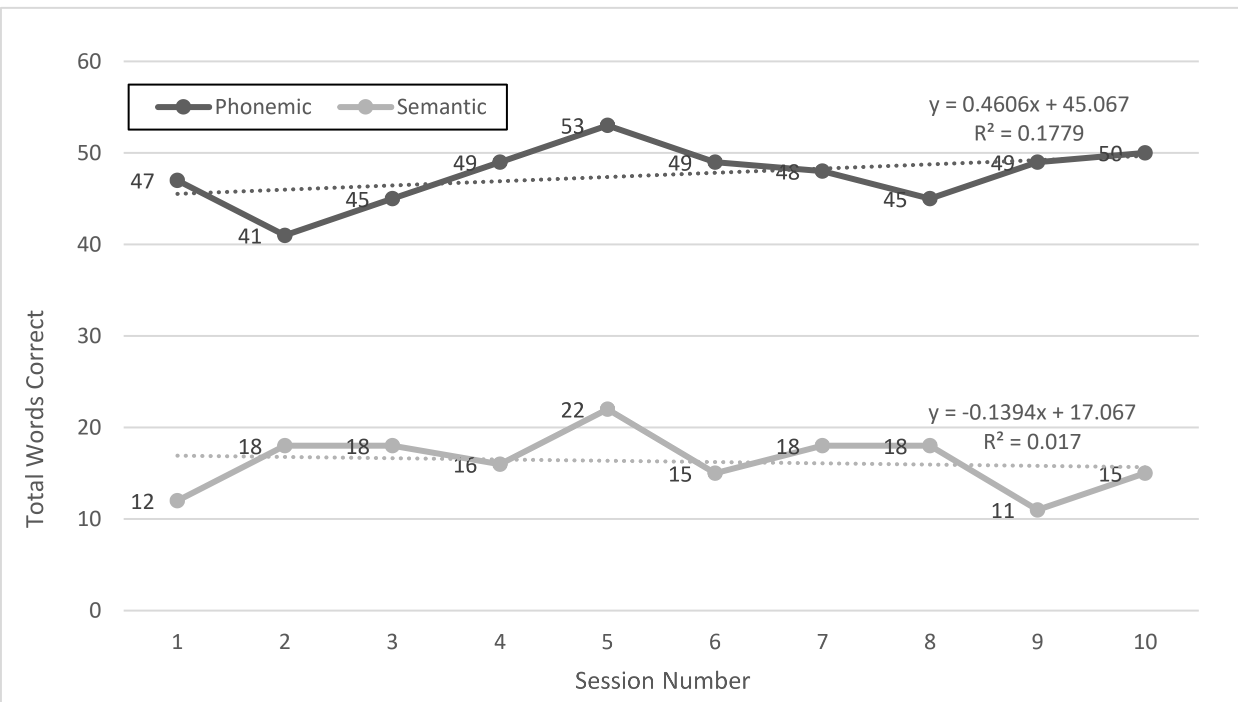
[a] Based on norms from Tombaugh et al. (1999).

Progress During the Intervention Period

Progress and trends throughout the intervention period were monitored by recording the total number of words produced during the timed practice trials for both phonemic and semantic fluency tasks each session. Figure 1 illustrates the observed performance trends. Linear regression of phonemic fluency performances revealed no significant relationship (p = .225) between number of sessions and total words produced (R^2 = 0.18) with an increase of 0.46 words per session. Linear regression of semantic fluency performances revealed no significant relationship (p = .719) between number of sessions and total words produced (R^2 = 0.02) with a decrease of 0.14 words per session.

Figure 1

Trends in Verbal Fluency Practice Trials During Intervention



Each letter for timed phonemic fluency practice trials was used twice and in a different letter combination (e.g., letter B targeted in BCD for first attempt then BGM for second attempt).

To account for inherent limitations in total number of words due to letter combinations (see *Background of Verbal Fluency Tasks* in Chapter Two for further discussion on difficulty differences between VF task forms), first attempt and second attempt performances with the same letter were directly compared to determine performance changes over time. Figure 2 represents these comparisons graphically, whereas Table 3 summarizes these comparisons. Semantic categories were only practiced once each, thus similar comparisons could not be made.

Figure 2

Comparisons of Same Letter Phonemic Fluency Practice Trials per Attempt

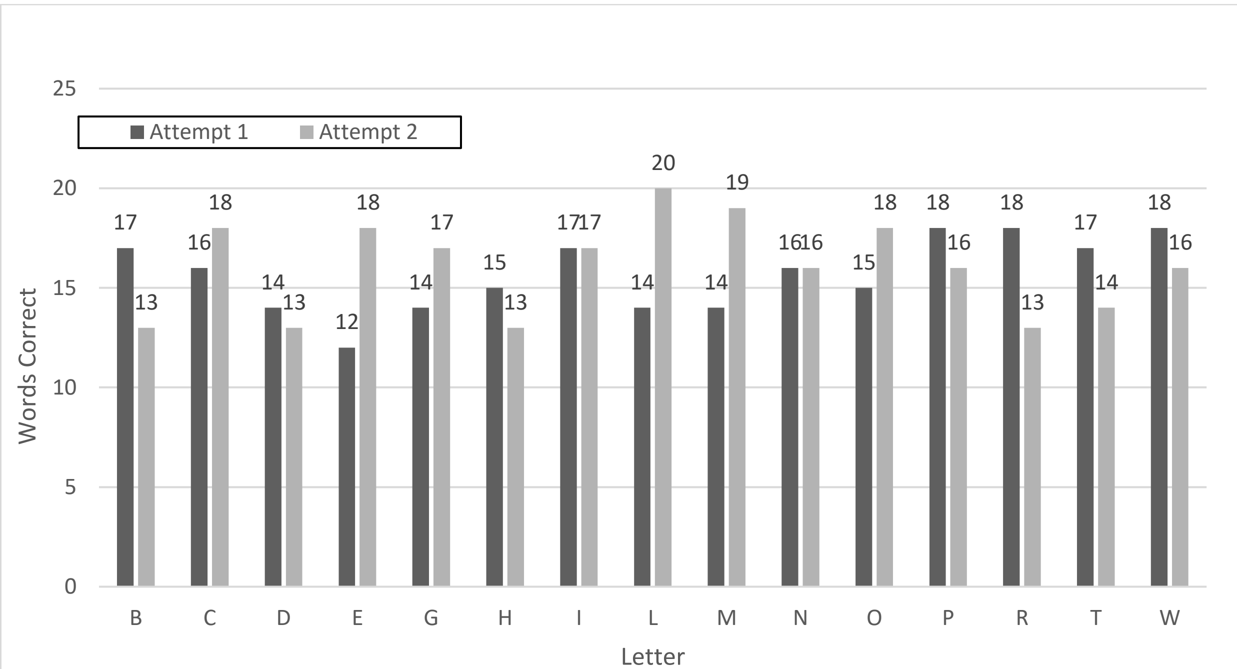


Table 3

Changes in Phonemic Fluency Practice Trial Performances by Letter

Δ Performance	Total	Letters
Increases	6	C, E, G, L, M, O
Decreases	7	B, D, H, P, R, T, W
No Difference	2	I, N

Clustering and Switching Subanalysis

Subanalysis for clustering and switching was conducted to investigate any differences in response patterns after the intervention period. Table 4 summarizes these comparisons. For phonemic fluency, the number of clusters increased by 3 and the number of switches decreased by 8. The largest cluster size increased from 3 words on pretest to 5 words on posttest, and mean cluster size increased by 0.34 words. For semantic fluency, the number of clusters decreased by 2 and the number of switches decreased by 4. The largest cluster size increased from 4 words on pretest to 8 words on posttest, and mean cluster size increased by 2.33 words.

Table 4

Clustering and Switching in Verbal Fluency (VF) Pretest and Posttest Comparison

VF Task	Pretest	Posttest
Phonemic (FAS)		
Clusters	9	12
Switches	31	23
Largest cluster	3	5
$\bar{x}$ cluster size	1.33	1.67
Semantic (Animals)		
Clusters	6	4
Switches	7	3
Largest cluster	4	8
$\bar{x}$ cluster size	2.17	4.50

Observed Changes to Executive Functioning Tasks

To study generalization of executive functioning skills following VF intervention, pre- and posttest comparisons were made for other tasks of executive functioning. These tasks included the Trails Making Test and Digit Span Forward & Backward.

Trails Making Test

Table 5 summarizes the comparisons for both parts of the Trails Making Test (TMT). Pre- and posttest performances for both parts of TMT were compared. Raw scores (i.e., completion time in seconds) were used to calculate z-scores based on normative data from Tombaugh (2004). Z-scores were converted to percentiles using a scoring computer program created by Odland (2017).

Posttest performance for TMT A decreased by 5 seconds, increasing the percentile ranking from the 34th to the 48th percentile. Z-score on posttest performance increased by 0.35. There were no errors made on either pre- or posttest performance. No test-retest reliability was provided by the normative source (i.e., Tombaugh 2004), therefore no RCI analysis for statistical significance could be conducted. Clinical significance between the two scores was established by determining if the performance change met or exceeded the reliable change cutoff for TMT A derived from Lezak (1983) and Spreen and Strauss (1991). TMT A performance on posttest decreased by 5 seconds < ± 12-second reliable change cutoff, indicating no clinically significant difference between the two scores.

Posttest performance for TMT B decreased by 32 seconds, increasing the percentile ranking from the 22nd to the 71st percentile. Z-score on posttest performance increased by 0.77. Errors were reduced from 2 errors on pretest to 0 errors on posttest. Similar to TMT A, no test-retest reliability was provided, therefore RCI analysis for statistical significance could not be conducted. Clinical significance between the two scores was determined by following the same procedure as TMT A. Posttest TMT B performance decreased by 32 seconds > ± 24-second reliable change cutoff, indicating a clinically significant difference between the two scores.

Table 5

Trails Making Test (TMT) Pretest and Posttest Comparison

TMT Form	Pretest	Posttest	Δ Performance
Raw (time in seconds)	46	41	-5[*]
Z-score [a]	-0.41	-0.06	+0.35
Percentile [b]	34	48	+14
Errors	0	0	0
Raw (time in seconds)	105	73	-32[**]
Z-score [a]	-0.78	0.55	+0.77
Percentile [b]	22	71	+49
Errors	2	0	-2

[a] Based on norms from Tombaugh (2004). [b] Calculated with scoring program from Odland (2017). [*] -5 < ± 12 reliable change cutoff, not significant (Lezak, 1983; Spreen & Strauss, 1991). [**] -32 > ± 24 reliable change cutoff, significant (Lezak, 1983; Spreen & Strauss, 1991).

Digit Span Forward & Backward

Table 6 summarizes the comparisons for Digit Span Forward (DSF) and Digit Span Backward (DSB). Pre- and posttest performances for both DSF and DSB were compared. Raw scores were used to calculate z-scores based on normative data from the source of the Digit Span form used in this investigation (i.e., Fitzpatrick et al., 2015). Z-scores were converted to percentiles using a scoring computer program created by Odland (2017).

Table 6

Digit Span Pretest and Posttest Comparison

Digit Span	Pretest	Posttest	Δ Performance
Forward			
Raw (total)	7	8	+1
Z-score [a]	-0.96	-0.61	+0.35
Percentile [b]	17	27	+10
LDSF	4	4	0
Backward			
Raw (total)	6	9	+3
Z-score [a]	0.13	1.38	+1.25*
Percentile [b]	55	92	+37
LDSB	4	5	+1

Note. LDSF = longest digit span forward; LDSB = longest digit span backward. [a] Based on norms from Fitzpatrick et al. (2015). [b] Calculated with scoring program from Odland (2017). * +1.25 > ± 1 *SD*, significant.

Posttest performance on DSF increased by 1 item correct, increasing the percentile ranking from the 17th to the 27th percentile. LDSF did not change. No test-retest reliability was reported by the normative source (i.e., Fitzpatrick et al., 2015), therefore RCI analysis for statistical significance could not be conducted. Clinical significance between the two performances was established if the performance change was greater than ± 1 *SD*. The difference between pre- and posttest z-scores revealed an increase of 0.35 < ± 1 *SD*, indicating no clinically significant difference between the two scores.

Posttest performance on DSB increased by 3 items correct, increasing the percentile ranking from the 55th to the 92nd percentile. LDSB increased by 1 digit. Similar to DSF, RCI analysis for DSB could not be conducted since test-retest reliability was not reported in the normative source. Clinical significance between the two performances was established if the performance change was greater than ± 1 *SD.* The difference between pre- and posttest z-scores revealed an increase of 1.25 > ± 1 *SD*, indicating a clinically significant difference between the two scores.

Summary

Statistically significant change for phonemic fluency after VF intervention was not observed. Nor was there a clinically significant change on semantic fluency performance. Analysis of practice scores over the intervention period revealed no significant relationship between total number of words produced and progression of intervention for both phonemic and semantic conditions. Clinically significant changes were observed on two of four subtests of executive functioning measures (i.e., TMT B and DSB). In the following chapter, these findings will be placed into context of the literature, as well as discussion on study limitations and proposals for future directions.

Chapter Five

Discussion

The purpose of this study was to determine the effectiveness of a 10-session verbal fluency (VF) task intervention period in improving VF task performance of an individual with Parkinson's disease (PD). In addition, this study investigated if any changes were noted in other pre- and posttest measures of executive functioning. Performance changes were deemed statistically or clinically significant if they met criteria outlined in Chapter Three. Four research questions were investigated: 1) Can phonemic fluency scores be improved with clustering and switching intervention given the neurocognitive profile of PD? 2) Can phonemic fluency scores be rehabilitated to levels similar to semantic fluency scores? 3) Will there be a significant effect on semantic fluency scores after intervention? and 4) Will performances on other measures of executive functioning change after intervention? Moreover, this study was designed to determine the effectiveness of VF tasks as therapeutic tools and clustering and switching as an intervention approach for improving overall executive function performance.

Changes in Phonemic Fluency Performance

Pre- and Posttest Comparisons

The findings from this study did not show any significant change or improvement in phonemic fluency performance after clustering and switching per this intervention (see Table 1). The total number of words from posttest evaluation decreased by 5 words and resulted in a decrease from performance at the 50^{th} – 60^{th} percentile range to the 40^{th} percentile. While still considered within the average range at the 40^{th} percentile, pretest performance was stronger compared to posttest performance. Reliable Change Index (RCI) analysis revealed that this change was not significant at $p = .05$ level. Therefore, phonemic fluency performance was not improved with the clustering and switching intervention in this investigation.

However, response latency times during the posttest evaluation did decrease. During one trial of the pretest evaluation (i.e., letter A), response latency was greater than 15 seconds. For the posttest evaluation, there were no response latencies that exceeded 15 seconds, and at least 1 response (whether correct or not) was given within each 15-second interval on all trials. It should be noted that the participant did lose set during one trial of the posttest evaluation (i.e., letter A) and required redirection, though latency times between responses on this trial were still decreased. Set losses were not observed on pretest.

Effect on Clustering and Switching

When evaluating participant performance within the context of this study, too much emphasis may have been placed on creating and extending clusters at the expense of making switches. Additionally, deliberate practice with clustering may have further enhanced the semantic pathways of the temporal lobe, which are related to clustering performance and already relatively intact in PD (Lange et al., 1992; Troyer et al., 1998). This becomes apparent when comparing the number of clusters, switches, and mean cluster size between pretest and posttest performances (see Table 4).

Fewer clusters were observed on pretest evaluation. Cluster sizes were smaller, while there were more switches overall than the posttest evaluation. There were 9 clusters and 31 switches overall on pretest performance and 12 clusters and 23 switches on posttest performance. The largest pretest cluster on all trials was 3 words, whereas the largest posttest cluster was 5 words. Mean cluster size increased from 1.33 to 1.67 words on posttest performance. This performance finding is further corroborated by Troyer et al. (1997), who suggested that "overall performance on phonemic fluency is more highly correlated with switching than with clustering" (p. 143). Thus, with fewer switches being made at the expense of larger clusters, phonemic fluency performance may not have improved.

In this case, the prescribed treatment plan (see *Intervention Measures* in Chapter Three for details) may have failed in promoting the use of timely switches. While efforts were made to promote switching, such as general instruction/practice and listing two-letter clusters to switch between during most timed practice trials, perhaps more explicit teaching and practice with switching would be beneficial. For example, Sutter et al. (2013) had participants switch back and forth between two target letters for switch training in their investigation. This type of switch training improved both initial letter and phonemic switching performances on posttest (Sutter et al., 2013). Since phonemic switching is not included in the Controlled Oral Word Association Test (COWAT), the VF task used in this investigation, it was not targeted in training.

Medication Effects

As previously discussed in Chapter Three, medication information was not obtained during the pretest evaluation. Nor was medication status noted during the posttest evaluation. The effect of medication may have impacted the observed performances in this study. Although hand tremors were observed during the pretest session, they did not seem as frequent or remarkable as during the posttest session. This discussion is brought up in accordance with findings from Herrera et al. (2012), in which individuals with PD on dopamine treatment performed similarly to controls on phonemic fluency, while those off-medication performed less. To further obfuscate this explanation, therapy sessions were held remotely in which only the participant's face was in view of the camera. Therefore, the investigators could not accurately gauge what degree of hand tremors was considered "normal" or controlled for the participant.

Moreover, both evaluations were scheduled at different times from one another and therapy sessions, meaning that dosage effects could have manifested depending on when (if at all) medication was taken.

Dosage of Intervention

Cited literature (i.e., Sutter et al., 2013) suggested that 90 minutes total over a period of 3 weeks and 15 sessions was sufficient enough to increase VF performances for “healthy” older adults (p. 53). However, the same cannot necessarily be said for specific neurological populations. Efforts in the aforementioned study were made to identify participants with general anxiety and/or depression as indicated by State-Trait Anxiety Inventory (Spielberger et al., 1983) and Geriatric Depression Scale (Sheikh & Yesavage, 1986) scores, though no neurological populations (e.g., PD) were included or identified. Therefore, the argument arises that neurological populations such as PD may require longer periods of intervention to achieve comparable results.

Intervention sessions during this investigation were held twice per week for 5 weeks, totaling 10 sessions. Each session lasted 30 to 60 minutes to cover most (though by no means exhaustive) potential clustering and switching strategies for both phonemic and semantic fluency tasks, and to provide opportunities to practice for each target letter and semantic category. The twice-weekly regimen for this study easily exceeded the 90-minute intervention program proposed by Sutter et al. (2013) over the course of 10 sessions, although there were fewer sessions overall in the present study. More research is needed to determine an appropriate VF intervention dosing for neurological populations such as PD.

Phonemic Compared to Semantic Fluency

In this investigation, phonemic fluency scores were not rehabilitated to levels similar to semantic fluency scores after intervention. Posttest semantic fluency performance was at the 75th percentile with an increase of 2 words, whereas posttest phonemic fluency was at the 40th percentile with a decrease of 5 words (see Tables 1 and 2). Both phonemic and semantic posttest scores remained within the average range. However, using ± 1 *SD* as a guideline (Barker-Collo & Purdy, 2013; Nietzel et al., 1987; Wise, 2004), posttest semantic fluency would be considered clinically different than posttest phonemic fluency with a difference of 1.23 *SD* between the two scores. Likewise, posttest phonemic performance (z = -0.33) did not achieve levels similar to pretest semantic performance (z = 0.43). In other words, semantic fluency continued to outperform phonemic fluency, and performance at similar levels was not achieved. These observed VF performance disparities are consistent with cited literature for individuals with PD (McDowd et al., 2011; Owen, 2004; Shapiro et al., 2005).

Changes in Semantic Fluency Performance

Results from this study did not show any clinically significant change or improvement to semantic fluency performance after clustering and switching intervention (see Table 2). That is, this result would not be sufficient enough to alter clinical impressions of the individual's neurocognitive profile. Although improvement in semantic fluency was not clinically significant from baseline, changes in clustering and switching response patterns were apparent between pre- and posttest performances. For the pretest semantic fluency trial, a total of 6 clusters and 7 switches were observed with a mean cluster size of 2.17 words. The largest cluster size was 4 words. Meanwhile, the posttest semantic fluency trial saw a total of 4 clusters and 3 switches with a mean cluster size of 4.5 words. The largest cluster size on posttest was 8 words, which is double the largest cluster size from the pretest (i.e., 4 words).

This result does become difficult to untangle, especially given the neurocognitive profile of PD where semantic clustering is more intact relative to switching (Troyer et al., 1998). While semantic fluency did receive less time overall during the intervention period (i.e., compared to three separate trials targeting clustering and switching for phonemic fluency per session), training in semantic subcategorization may have been sufficient in producing greater cluster sizes for semantic fluency.

Moreover, instruction in clustering for phonemic fluency may have had an influence in shaping responses for the posttest semantic fluency performance, though this is difficult to conclude. Given the findings from Sutter et al. (2013), conversation on different topics was hypothesized to be sufficient enough to unlock semantic knowledge, in which these participants performed better on semantic fluency than both initial letter and phonemic switching training groups. Similarly, it is possible that specific clustering practice for phonemic conditions (i.e., unlocking categoric/semantic knowledge) may have incidentally introduced additional clustering strategies for semantic conditions in this current study. Nonetheless, it is intriguing that relative to the pretest performance, posttest semantic fluency saw a near two-fold increase in mean cluster size and a reduction by half in number of switches.

Training Progress

Performances of timed practice trials were variable on a daily and weekly basis (see Figure 1), as is to be expected with a single participant and the inherent changes in word availability with different targets and combinations (see *Background of Verbal Fluency Tasks* in Chapter Two for further discussion on difficulty differences between FAS and CFL forms).

Phonemic Fluency

For phonemic fluency trials, performances saw a steady increase and peaked at Session 5. After, performances saw a steady decline until Session 9 when performances steadily increased again. Linear regression of phonemic fluency performances revealed a meager positive trend over time with $R^2 = 0.18$, indicating a low correlation between session number (i.e., progress over time) and total words produced ($p = .225$).

To account for inherent differences in total words produced per session due to different letter combinations and combined word availability, first attempt performances were compared with second attempt performances for each letter trial (see Figure 2 and Table 3). These comparisons revealed 6 gains, 7 declines, and 2 instances of no change between performances of the same letter. If intervention was promoting true improvement, there would likely be a majority of gains made on second attempt performances relative to declines when using the same initial letter. Additionally, there was no decrease in total words when supports were faded in later sessions (e.g., removal of target clusters during timed trials).

These findings, that performance gains were near equivalent to performance declines for the same letter, indicate that changes in performance over time were more likely due to individual variability than any benefit (or detriment) of the intervention program or training modifications such as fading. As these findings have not been found in existing literature, these add to the overall profile of VF intervention.

Semantic Fluency

Likewise, performances of semantic fluency trials saw variability on a daily and weekly basis in terms of total words, though more pronounced than phonemic fluency trials. Linear regression of semantic fluency performances revealed $R^2 = 0.02$, indicating a near-zero correlation with total words over time (p = .719). This would suggest that training had little to no effect on semantic fluency outcomes during the intervention period. However, the semantic knowledge required to perform optimally in each semantic category varies and must be considered (Strauss et al., 2006). For example, unless one is a botanist or of a related field, it is less likely that the average person would be able to produce as many total words for the *plants* category as the *body parts* or *food and drink* categories without prior practice or knowledge. Similarly, certain categories may be inherently more difficult due to the number of responses each category affords (e.g., *animals* vs. *fruits*; Patterson, 2011). The relative quantities and differing levels of semantic knowledge required for each category may help explain this outcome (see Figure 1 for total words and Appendix D for semantic categories). Since each semantic category was only practiced once, first attempt and second attempt comparisons could not be made to gauge progress within the same category.

Changes to Other Tasks of Executive Functioning

In addition to investigating phonemic and semantic fluency VF task performances, this study investigated any changes to other measures of executive functioning following the intervention period.

Trails Making Test

The first measure of executive functioning performance was the Trails Making Test (TMT). The first part of TMT (i.e., TMT A) requires the participant to visually scan through an array of numbered targets and connect the targets in correct sequential order as fast as possible. This portion of the test predominately serves as a control for the subsequent test, TMT B, although it can still be used to gauge processing speed and visual search (Llinàs-Reglà et al., 2015). Relative to the pretest performance for TMT A, posttest performance saw a decrease of 5 seconds from a completion time of 46 down to 41 seconds (see Table 5). Using the reliable change cutoff for TMT A derived from Lezak (1983) and Spreen and Strauss (1991), this decrease of 5 seconds did not meet or exceed the ± 12-second threshold for a clinically significant difference. That is, this improvement would not be sufficient enough to alter clinical impressions of the individual's neurocognitive profile. There were no errors in either performance for TMT A.

For TMT B, the participant must not only identify and connect targets as fast as possible but must also accurately switch between numbered and lettered targets in the correct sequential order (e.g., 1 to A, A to 2, 2 to B, B to 3, etc.). Therefore, TMT B serves as the primary test of executive functioning wherein the participant must successfully use divided attention, switching, and inhibition control to successfully complete this trial (Llinàs-Reglà et al., 2015). Relative to pretest performance, posttest performance for TMT B saw a decrease in completion time from 105 seconds to 73 seconds (see Table 5). This increased the percentile ranking from the 22nd to the 73rd percentile. Using the reliable change cutoff for TMT B derived from Lezak (1983) and Spreen and Strauss (1991), this decrease of 32 seconds exceeded the ± 24-second threshold for a clinically significant difference. Here, it would seem that clinical impressions would change based on improved TMT B performance. The number of errors on posttest TMT B decreased from 2 errors to 0 errors.

Clinically significant improvement on TMT B performance is surprising given that the trained executive functioning task (e.g., phonemic fluency) did not improve and that the number of switches decreased on posttest phonemic fluency. However, studies have demonstrated that TMT B is susceptible to practice effects after 1 to 6 weeks following initial administration (Atkinson et al., 2006; Bates et al., 2005). Basso et al. (1999) have suggested that a period of 1 year may be necessary to resolve practice effects associated with TMT B. Since TMT posttest took place 5 weeks after the pretest, clinically significant improvement in TMT B scores due to practice effects is possible and cannot be entirely ruled out.

Digit Span Forward & Backward

The second measure of executive functioning performance was Digit Span Forward & Backward (DS F&B). For the first part, Digit Span Forward (DSF), the participant must recite increasingly longer strings of numbers back to the examiner in the same order the numbers were presented in. DSF primarily serves as a measure of mental carrying capacity, referring to the number of units of information that an individual can store in working memory at a given time (Kaplan et al., 1991). Relative to the pretest performance of DSF, posttest performance saw an increase of 1 item correct from raw = 7 to raw = 8 (see Table 6). This increased the percentile ranking from the 17^{th} to the 27^{th} percentile. Improvement between the two DSF scores was not considered clinically significant. The Longest Digit Span Forward did not change for DSF.

For the second part, Digit Span Backward (DSB), the participant must recite increasingly longer strings of numbers back to the examiner in the opposite order the numbers were presented in. DSB serves as a measure of working memory and mental manipulation, which are facets of executive functioning (Kaplan et al., 1991). When compared to pretest DSB performance, posttest performance saw an increase of 3 items correct from raw = 6 to raw = 9 (see Table 5). This increased the percentile ranking from the 55^{th} to the 92^{nd} percentile. Improvement between the two DSB scores was considered clinically significant with a z-score difference of 1.25 > ± 1 *SD*. The Longest Digit Span Backward increased by 1 digit from 4 to 5 maximum digits correctly recalled.

Similar to TMT B, it is surprising that an untrained task saw clinically significant improvement whereas the trained task did not. However, significant improvements in DS F&B were noted by Sutter and colleagues (2013) for the initial letter training group, whose training most closely resembled the paradigm used in this investigation. While the initial letter training group achieved significant improvements in DS F&B performance relative to an active control group ($p = 0.052$), it should be noted that there was a stronger effect on DS F&B performance for the phonemic switching group ($p = 0.007$; Sutter et al., 2013).

Moreover, DS F&B paradigms as used in the Repeatable Battery for the Assessment Neuropsychological Status (Randolph, 1998) and as a component of the Working Memory Index in the Wechsler Adult Intelligence Scale – III (The Psychological Corporation, 1997) have shown resistance to practice effects (Bartels et al., 2010; Basso et al., 2002). However, these studies investigated practice effects after periods of time that were longer than 5 weeks. Therefore, it is possible that VF intervention led to DS F&B improvement, though this result should be interpreted cautiously due to potential practice effects and limitations of this single-subject study.

Limitations

The current study has limitations beyond unknown medication status and practice effects, which were introduced in previous discussion. Since only one participant was recruited for this study, there were no other participants to assign to either control or treatment conditions. This affected interpretation of the results and limited statistical analysis. While both gains in TMT B and DSB were deemed clinically significant, the limitations of this study prevent any causational conclusions from being made. That is, there was no control group in this study to determine if VF intervention was responsible for the differences seen between pre- and posttest outcomes.

Furthermore, limitations of single-subject design contributed to the lack of more rigorous and consistent data analysis. While both the RCI and *SD* method are commonly cited methods for determining clinically significant levels of change (Barker-Collo & Purdy, 2013), inclusion of more participants would have facilitated more robust statistical testing and power. This also would have promoted more internal consistency within the study. For example, the findings for TMT B have different interpretations depending on which method is used (i.e., reliable change cutoffs for TMT vs. the *SD* method). Since these cutoffs were specific to TMT, they were used over the *SD* method. However, the z-score difference of + 0.77 for TMT B would not meet the threshold of ± 1 *SD*, which had been used to determine clinically significant differences on other measures in this study.

Future Directions

This study provided a step toward better understanding the therapeutic utility of VF tasks. Since results from this study are inconclusive given the limitations provided above, more research is required to fully explore the applications of VF tasks in therapy. This section will address potential avenues for future investigations.

As discussed previously, the ability to cluster words together and switch between clusters are important components of VF task performance (Troyer et al., 1997). The treatment plan in the current study used this strategy as a blueprint to structurally rehabilitate VF performance in PD. However, implementation of this study's treatment plan failed to adequately promote more switches, which is most affected in PD and correlated with phonemic fluency performance (Troyer et al., 1997; Troyer et al., 1998). The approach of this treatment plan could be revised to better facilitate switching. This could be achieved with drill-and-practice in which the clinician initially instructs the participant to switch between designated cluster types of the target letter (e.g., "switch to *fa*-, switch to *fr*-, switch to *fo*-," etc.). Dictation of cluster types can be faded once the participant achieves a certain level of competence and can then be allowed to switch on their own. One caveat to this "forced" switching approach is that it could potentially detract from the spontaneity of responses by dictating which cluster the participant should use, resulting in responses that are more "mechanical" or rehearsed rather than freely generated.

Another possible direction is to further investigate the intervention approach used in Sutter et al. (2013). This study used both initial letter (i.e., phonemic) fluency and phonemic switching conditions in their investigation. It was found that participants in the phonemic switching group not only improved performances on their trained task but also improved performances on both initial letter and DS F&B (Sutter et al., 2013). Although phonemic switching is not a condition of the COWAT, the most commonly used VF paradigm for assessment and research (Patterson, 2011; Shao et al., 2014; Strauss et al., 2006) and the paradigm used in the current study, it merits further investigation as a therapeutic approach given this finding. Additionally, future studies using the phonemic switching approach should include neurological conditions such as PD in their investigations. It may be possible that phonemic switching tasks produce more beneficial outcomes for VF rehabilitation and generalization to other tasks of executive functioning. However, more research is required to further investigate this possibility.

For future case studies exploring either approach, a repeated-measures experimental design may be beneficial (Creswell & Guetterman, 2019). In this way, investigators can collect multiple data points to inform modifications to the intervention approach. A repeated-measures design may be additionally beneficial for determining an appropriate intervention dosage for neurological populations. As a final suggestion, medication status should be obtained prior to data collection for any research paradigm.

Summary

Findings from this study showed that the 10-session VF intervention period as prescribed was unable to rehabilitate the phonemic fluency performance of an individual with PD. Intervention with clustering and switching strategies did not lead to significant improvements in semantic fluency, though semantic fluency continued to outperform phonemic fluency. Clinically significant improvements were observed on two measures of executive functioning, TMT B and DSB, though study limitations and potential practice effects prevent any causational conclusions from being made. These findings warrant further investigation into the therapeutic utility of VF tasks as a part of speech-language pathology practice.

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Appendix A

Approval Letter

Institutional Review Board

MINNESOTA STATE UNIVERSITY MOORHEAD

DATE:	August 29, 2022
TO:	Joni Mehrhoff, PhD, Principal Investigator
FROM:	Dr. Robert Nava, Chair Minnesota State University Moorhead IRB
ACTION:	**APPROVED**
PROJECT TITLE:	[1935754-1] The Effects of Verbal Fluency Interventions: Phonemic vs. Semantic Fluency Outcomes in Parkinson's Disease
SUBMISSION TYPE:	New Project
APPROVAL DATE:	August 23, 2022
EXPIRATION DATE:	
REVIEW TYPE:	Expedited Review

Thank you for your submission of New Project materials for this project. The Minnesota State University Moorhead IRB has APPROVED your submission. This approval is based on an appropriate risk/benefit ratio and a project design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission.

This submission has received Expedited Review based on the applicable federal regulation.

Please remember that informed consent is a process beginning with a description of the project and insurance of participant understanding followed by a signed consent form. Informed consent must continue throughout the project via a dialogue between the researcher and research participant. Federal regulations require that each participant receives a copy of the consent document.

Please note that any revision to previously approved materials must be approved by this committee prior to initiation. Please use the appropriate revision forms for this procedure.

All UNANTICIPATED PROBLEMS involving risks to subjects or others and SERIOUS and UNEXPECTED adverse events must be reported promptly to the Minnesota State University Moorhead IRB. Please use the appropriate reporting forms for this procedure. All FDA and sponsor reporting requirements should also be followed.

All NON-COMPLIANCE issues or COMPLAINTS regarding this project must be reported promptly to the Minnesota State University Moorhead IRB.

This project has been determined to be a project. Based on the risks, this project requires continuing review by this committee on an annual basis. Please use the appropriate forms for this procedure. Your documentation for continuing review must be received with sufficient time for review and continued approval before the expiration date of .

Please note that all research records must be retained for a minimum of three years after the completion of the project.

If you have any questions, please contact the Minnesota State University Moorhead IRB. Please include your project title and reference number in all correspondence with this committee.

Appendix B

Consent Form

Institutional Review Board

MINNESOTA STATE UNIVERSITY MOORHEAD

MSUM Research Participant Consent Form

Please read this consent agreement carefully before agreeing to participate in this study.

Title of Study: The Effects of Verbal Fluency Interventions: Phonemic versus Semantic Fluency Outcomes in Parkinson's Disease

Purpose of the study: To investigate if there is any difference in intervention outcomes between letter and categorical fluency tasks. To examine any transfer effects of treatment to other cognitive tasks.

What you will do in this study: You will receive coaching and teaching on strategies that can be used in either letter or categorical fluency tasks. A baseline pretest will be performed to determine current level of performance for naming items with specific letters and categories. During this pretest, you will also participate in other activities that target attention, executive function, and working memory. After a 10-session treatment period consisting of instruction and practice using these strategies in various letter or categorical fluency tasks, a post-test will be performed to determine any changes. The post-test will consist of the same procedures as the pretest.

Time required:

- 1 pretest session, approximately 30 minutes
- 10 intervention sessions, 2 sessions for 5 weeks approximately 15-20 minutes each
- 1 post-test session, approximately 20 minutes

Risks: This study will ask you to find words with a time pressure constraint. As a result, you may feel "put on the spot"; however, aside from potential discomfort, frustration, or embarrassment associated with performing the task itself, there are no other risks to this study.

Benefits: You will learn compensatory strategies that can be used to facilitate word-finding difficulties in everyday life and conversation. As available at the completion of this study, you may also receive a $20 gift card that can be used anywhere or anyhow you like.

Confidentiality: All HIPAA-related practices that are part of the Speech-Language & Hearing Clinic will apply to this study. Any and all data gathered will be de-identified in accordance with HIPAA and Good Clinical Practice guidelines. You will be assigned a pseudonym that only the investigators will know. This will not be reported anywhere else. Your private information will be safeguarded on a password-protected computer. Your responses may be recorded on a digital voice recorder or a password-protected computer. Sessions may be recorded using a secured video/audio recording system used in clinical therapy sessions for review. These recordings will be permanently deleted after each session. All protocols, documents, data, video, and voice recordings will be de-identified and securely stored. Any hard copy protocols will be digitally scanned to a password-protected computer and subsequently destroyed. Any electronic records will be stored on a password-protected computer and destroyed after 3 years. Reported data from the study will be de-identified. Only general information such as age, gender, handedness, and education level would be reported, with your permission.

Participation and withdrawal: Participation in this study is voluntary and you have the right to withdraw at any time. Withdrawal from the study will not be met with prejudice or repercussions from the investigators or with Minnesota State University Moorhead. You will not be excluded from your regularly scheduled speech-language therapy sessions if you are enrolled in those and decide to withdraw from this study at any time.

Contact: For any questions, please contact:

- Dr. Joni Mehrhoff, PhD, MS, CCC/SLP, Principal Investigator
  Dept. of Speech-Language & Hearing Sciences
  Phone: (218) 477-2725 Email: joni.mehrhoff@mnstate.edu

- Brian Connelly, B.S., Co-Investigator
  Dept. of Speech-Language & Hearing Sciences
  Phone: (701) 412-1341 Email: brian.connelly@mnstate.edu

Whom to contact about your rights in this experiment:

- Dr. Joni Mehrhoff, PhD, MS, CCC/SLP Principal Investigator
  Dept. of Speech-Language & Hearing Sciences
  Phone: (218) 477-2725 Email: joni.mehrhoff@mnstate.edu

Or else you may contact Dr. Robert Nava, Chair of MSUM Institutional Research Board, at irb@mnstate.edu, or 218-477-2699.

Agreement:

The purpose and nature of this research have been sufficiently explained and I agree to participate in this study. I understand that I am free to withdraw at any time and my withdrawal will not affect any future relationship with Minnesota State University Moorhead or the **MSUM Speech-Language & Hearing Clinic.**

In signing this agreement, I also affirm that I am at least 18 years of age or older.

Signature: ____ Date: ________________

Name (print): ____

Appendix C

Recruitment Flyer

Appendix D

Training Schedule

1. BCD & Food and Drink	**6. BGM & Colors**
2. EGH & Home Goods	**7. CHI & Cities**
3. ILM & Transportation	**8. DPW & Jobs**
4. NOP & Clothing	**9. EOR & Plants**
5. RTW & Body Parts	**10. LNT & Tools**

Appendix E

Lesson Example

Executive Function: "Plan your work, work your plan, how did your plan work?"

Letters: BGM

First Letter: B

- Ba
  - Ball, bat, base, baseball, barbecue, balance
- Be
  - Bend, bent, between, betwixt, beyond, beside
- Bi
  - Bill, bind, bid, bin, billow, bison, bishop, bird
- Bo
  - Boil, body, bode, bottom, box, bought, bones
- Bu
  - Butt, but, build, bud, buddy, butte, butter
- Bl
  - Bland, blind, blow, blue, black, blower, blink
- Br
  - Brown, brain, brat, broke, bring, brave

- Same cluster and sound
  - Bias -> bison -> bicycle -> bicentennial -> bite -> bight -> bipedal -> biology
- Relationships
  - Birch -> bark
  - Birth -> born -> birthday
- Clustering and switching (combination)
  - Bear -> bare -> back-> bar -> bartender -> bark -> birch -> birth -> birthday -> born -> boring
- Barn, bear, bare, bale, born, baby, basic, base, baste, batter

- Ba
- Be
- Bi
- Bo
- Bu
- Bl
- Br

Second Letter: G

- Ga
    - Gas, gape, gap, gable
- Ge
    - Gene, genie, general, germ,
- Gi
    - Gill, gin, ginger, gingerbread
- Go
    - Go, gobble, gong, goon
- Gu
    - Guppy, gutter, gusset, gullible, gully
- Gl
    - Glow, globe, glob, glad
- Gr
    - Grain, green, grown, group

- Same sound
    - Get -> guest -> gecko
- Same cluster and sound
    - Gray -> grain -> great -> grace -> grape
- Relationships
    - Goo -> gone
    - Glow -> gold
    - Geese -> goat -> gopher
- Clustering and switching (combination)
    - Goo -> gone -> glue -> glow -> gold -> goat -> geese -> green -> great
- Gas, gasket, gape, grape, group, grown, green, geese, gown

- Ga
- Ge
- Gi
- Go
- Gu
- Gl
- Gr

Third Letter: M

- Ma
    - May, maybe, male
- Me
    - Me, meet, meat, meal
- Mi
    - Mix, milk, mile, mint
- Mo
    - Mood, mode, model, mop
- Mu
    - Mud, mullet, mule, mug

- Homophones
    - Male -> mail
    - Made -> maid
- Same cluster and sound
    - Mad -> math -> master -> matter -> mat
- Relationships
    - Mouse -> mini
    - Mad -> mean
    - Milk -> moo
- Clustering and switching (combination)
    - Me -> mean -> meet -> meat -> meal -> milk -> mill -> mile -> mine -> mind
- May, maybe, made, male, mail, mix, milk, mine, mind, mile, middle, mid,

- Ma
- Me
- Mi
- Mo
- Mu

Semantic Category: Colors

- Paint
- Color wheel
- Rainbow
- Shades
- Tints
- Combinations