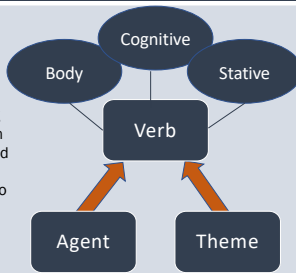




An intensive voice treatment, focused on the respiratory-laryngeal system, affected improved action word production in connected language in individuals with PD. This treatment effect was independent of cognitive status or neuropsychological test performance.

Given the role of voice in language expression, we pose that optimizing vocal function may lead to improved language production. Verb production is an area of language deficit in PD (1), particularly for verbs associated with an individual's location of impairment (upper vs. lower limbs (2)). Deficits in action processing are seen early in PD pathogenesis and are evidenced in access to lexical representations for comprehension and production and their contextual interactions (e.g., 3-4). However, the context or type of verbs does not appear to influence action processing in PD (5). These findings indicate a unique interaction between the motor and language systems, likely centered in cortico-striatal loops. However, verb processing in PD appears unrelated to motor impairment severity, unlike in other motor disorders (e.g., ALS in (5); cervical dystonia in (6)). Thus, it remains unclear whether action word processing in PD is the motor system impairment.



An approach that may clarify the language-motor systems in PD is to determine whether treatment affecting motor function is associated with changes in verb production.

Here, we use this approach to address:
1. Replicate that verb production differs in PD relative healthy controls.
2. Whether participation in an intensive voice treatment facilitates verb production.

METHOD

INTERVENTION: a 4-week voice treatment (TX) in an IRB-approved randomized controlled voice treatment trial (7).

STUDY GROUPS:

- 20 participants with PD (TXPD)
- 20 untreated PD (UNTXPD)
- 20 age-matched neurotypical control (HC)

DEPENDENT VARIABLES: All participants provided 1-minute picture description narratives at baseline (V1) and after 4-weeks of treatment (V2). Language samples were transcribed by raters blinded to group and analyzed using Computer Language Analysis (8). Neuropsychological measures of executive functions (subtests of the *Delis-Kaplan Executive Functions System*) and memory (*California Verbal Learning Test*, *Digits-Forward and Backward*) were administered as potential predictors of treatment effects on language performance. The *Modified Communicative Effectiveness Index* (CETI-M) was also administered and assessed as a predictor of treatment effects.

DATA ANALYSIS

Pre-TX between-group comparisons established differences in demographic, PD severity, and language variables (Table 1). Pre-Post within- and between-group comparisons identified effects of visit and isolated treatment effects in the TXPD relative to UNTXPD and HC groups.

Transcription of the language samples, and reliability of transcriptions, proceeded as follows: the 120 samples were separated into 4 sets, divided across groups. A set of 12 samples were used for training and the rest of the samples were evaluated for intra-rater reliability using ICC statistics. All variables reported in the language samples had good to excellent reliability.

Univariate linear models were used to identify whether performance on the MMSE or neuropsychological assessments are predictive of language change (performance at V2 - V1). Variables predicting change at $p < .05$ served as predictors in generalized linear models.

RESULTS

	TREATED PD	UNTREATED PD	CONTROL
N	20	20	20
AGE	67 ± 8	65 ± 9	64 ± 9
GENDER (M:F)	16:4	13:7	13:7
HANDEDNESS (R:L)	18:1	16:4	19:1
BECK DEPRESSION INVENTORY II (BDI)	9.75 ± 6	7.3 ± 5	2.85 ± 3
MINI-MENTAL STATUS EXAM	28.7 ± 1	29.0 ± 1	29.3 ± 1
HOEHN & YAHR SCALE	2.13 ± 0	2.03 ± 1	-
YEARS SINCE DIAGNOSIS	4.99 ± 7	4.73 ± 4	-

TABLE 1. Subject demographics and symptoms. The groups did not differ for age, gender or handedness distribution, or for *Mini-Mental Status Exam* score. The TXPD group endorsed more symptoms of depression on the BDI, $H(2) = 18.25, p < .0001$, but only two participants scored above the clinical cutoff of 17. The PD groups did not differ for motor symptom severity or years since diagnosis.

LANGUAGE VARIABLES:

The groups had only subtle differences in the classes of words that they used to describe the pictures. Figure 1 presents the % of different word types produced at pre- and post-TX. As presented in Figure 2, the groups differed for language at the utterance level.

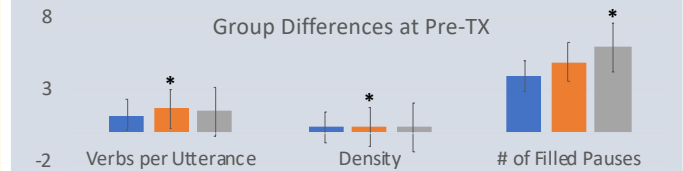
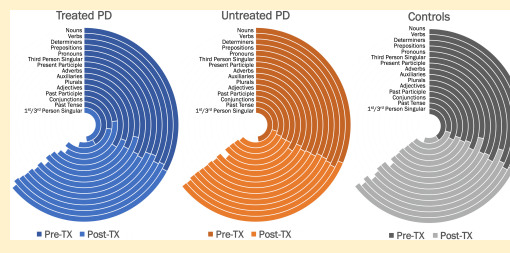


FIGURE 2. The only significant between-group differences for the language variables were for verbs per utterance, $F(2,57) = 6.3, p = .02$, density, $F(2,57) = 4, p = .02$, and the number of filled pauses, $H(2) = 7, p = 0.03$. Density: a measure of propositional idea density, approximated by the proportion of verbs, adjectives, prepositions, and conjunctions to the total number of words produced.

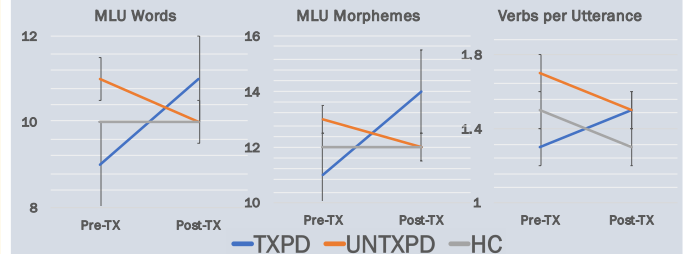


FIGURE 3. Following treatment, the TXPD group had significant increases in MLU Words, $F(2,57) = 3.8, p = .028$; MLU Morphemes, $F(2,57) = 4.3, p = .02$; and Verbs per Utterance, $F(2,57) = 4.9, p = .01$. Effect sizes were small, ranging from .12-.15 (partial eta²). None of the mental status or neuropsychological measures predicted these changes from V1-V2. The CETI-M was the only pre-TX variable that associated with change, specifically for MLU words ($p = .024$) and morphemes ($p = .015$).

SUMMARY

Intervention improving vocal loudness was associated with improved verb use in PD. No cognitive variables predicted this change, suggesting that the voice TX enhanced motor system engagement as well as access to verbs. Linguistic theory posits that verbs are the core of sentence development; thus, improving verb use also led to production of more complex grammar. These findings provide further evidence of the interaction between the motor and language systems in PD, particularly for action words. They also suggest that changing one effector system influences the other, and posits that the cognitive system, often nominated as the driver of the language effects in PD, does not explicitly play a role in the improvement of language following a motor intervention. Future study will explore the relationship between CETI-M and increases in MLU words and morphemes and will further clarify the classes and context of verbs associated with this change.