Published in final edited form as:

J Clin Exp Neuropsychol. 2013 June ; 35(5): 530–539. doi:10.1080/13803395.2013.798397.

The Contribution of Trail Making to the Prediction of Performance-Based IADLs in Parkinson's Disease Without Dementia

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Abstract

Performance on part B of the Trail Making Test (TMT) contributes to the prediction of ability to complete instrumental activities of daily living (IADLs) in Parkinson's disease (PD). Although this suggests that cognitive flexibility is important in the everyday functioning of individuals with PD, this may not be that case as the TMT is multifactorial, involving motor speed, visual scanning, sequencing, and cognitive flexibility. The purpose of the current study was to determine which elements of the task contribute to the prediction of IADLs in a sample of 30 non-demented individuals with PD. Correlational analyses indicated strong relationships between a performance-based measure of IADLs and measures involving scanning, sequencing, and cognitive flexibility from the Delis-Kaplan Executive Function System (D-KEFS) TMT. Results from standard regressions indicated that measures of sequencing and level of depression but not scanning, cognitive flexibility, or demographic variables made a significant, independent contribution to the prediction of IADLs. These results suggest that the sequencing element of the TMT is paramount in the prediction of IADLs in PD.

Keywords

Parkinson's disease; cognitive flexibility; trail making; IADLs

Parkinson's disease (PD) interferes with the completion of basic activities of daily living (ADLs) such as eating and bathing, as well as more complicated instrumental ADLs (IADLs) such as cooking and using the telephone (Hariz, Lindberg, Hariz, & Bergenheim, 2003; Martínez-Martín, Fontán, Frades Payo, & Petidier, 2000; Tison, Barberger-Gateau,

Dubroca, Henry, & Dartigues, 1997). The difficulties that individuals with PD experience in completing these daily tasks have been related to the level of depression (Hobson, Edwards, & Meara, 2001; Uc et al., 2005) and overall level of cognitive dysfunction (Cahn et al., 1998; Hobson et al., 2001; Rosenthal et al., 2010; Weintraub, Moberg, Duda, Katz, & Stern, 2004) that patients experience in addition to cardinal motor symptoms. Studies have also reported statistically significant correlations between daily activities and measures assessing specific elements of cognition including attention (Bronnick et al., 2006), visual memory (Uc et al., 2005) and visuospatial function (Maeshima, Itakura, Nakagawa, Nakai, & Komai, 1997); however, converging evidence suggests a specific relationship between measures of executive functions, especially cognitive flexibility, and the ability to complete daily tasks in PD (Cahn et al., 1998; Muslimovic, Post, Speelman, Schmand, & de Haan, 2008; Uc et al., 2005). This is not surprising given evidence suggesting that the various cognitive deficits exhibited by PD patients are consistent with frontostriatal circuit dysregulation (Berry, Nicolson, Foster, Behrmann, & Sagar, 1999; Bondi, Kaszniak, Bayles, & Vance, 1993; Cooper, Sagar, & Sullivan, 1993; Higginson et al., 2003; Pillon, Deweer, Agid, & Dubois, 1993; Taylor, Saint-Cyr, & Lang, 1990), and cognitive inflexibility appears to be paramount amongst the executive deficits associated with PD (Cools, Stefanova, Barker, Robbins, & Owen, 2002; Richards, Cote, & Stern, 1993).

Cognitive flexibility is also known as mental or attentional set shifting or switching, and involves “shifting back and forth between multiple tasks, operations, or mental sets” (Miyake et al., 2000, p. 55). Jacobson, Blanchard, Connolly, Cannon, and Garavan (2011) note the importance of cognitive flexibility in our day to day lives where visual stimuli occur simultaneously and “...we are required to consciously control our visual system to allow processing resources to be engaged in goal-directed behaviours.” (p. 60). Indeed, performance on measures of cognitive flexibility is related to the completion of IADLs in PD. Such a relation has also been seen in populations without frontostriatal dysregulation (e.g., Carlson et al., 1999; Farmer & Eakman, 1995).

Studies reporting a relation between cognitive flexibility and daily activities in PD have used the Trail Making Test (TMT; Reitan, 1958) to assess cognitive flexibility, a common use of this measure (Sanchez-Cubillo et al., 2009). In part A of the TMT patients are presented an array of numbered circles and asked to draw lines connecting the circles in numerical order. In part B patients are presented an array of numbered and lettered circles and asked to connect them in numerical and alphabetical order by alternating between numbers and letters, thereby involving a cognitive flexibility component. The primary performance variable is completion time. Cahn et al. (1998) found that a composite index of executive functioning based on an auditory working memory task (digit ordering) and part B of the TMT predicted a significant proportion of the variance in caregiver ratings of IADLs in a sample of individuals with PD. A follow-up regression including both executive tasks and a composite index of motor function found that only part B of the TMT made a significant contribution to the prediction of IADLs. In a study of visual dysfunction in PD, Uc et al. (2005) reported that a composite index of executive functions based on letter fluency and the TMT (time to complete part B minus time to complete part A) was significantly correlated with questionnaire ratings of ADLs, but only letter fluency made a significant contribution to the prediction of ADL ratings in a regression analysis (along with measures of motor function, visual memory, and depression). Muslimovic et al. (2008) found that a composite including both parts A and B from the TMT as well as other measures was correlated with an ADL questionnaire but the composite did not enter predictive models.

As is obvious from its description, the TMT is multifactorial, involving motor speed, visual scanning, and sequencing as well as cognitive flexibility (Delis, Kaplan, & Kramer, 2001; Sanchez-Cubillo et al., 2009). Because part A is thought to incorporate all of the elements of

part B except cognitive flexibility, difference and ratio variables comparing completion time for parts A and B have been derived in an attempt to isolate the cognitive flexibility component (Drane, Yuspeh, Huthwaite, & Klingler, 2002). This is an important consideration since poor performance on part B could be due to any of the component processes. Delis et al. (2001) provide a means to determine which component processes might contribute to deficits on the task involving cognitive flexibility in their version of the TMT from the Delis-Kaplan Executive Function System (D-KEFS). The D-KEFS TMT includes five conditions, four of which are thought to assess the components other than cognitive flexibility that are elements of the task.

Although the TMT is multidimensional in nature, none of the studies finding a relation between the cognitive flexibility task and IADLs in PD assessed the component processes involved in the task to determine which elements contributed to the relation with IADLs. This is an important issue since activities such as shopping and cooking clearly require visual scanning (e.g., looking for grocery items on a shelf), sequencing (e.g., following a recipe), and motor speed (e.g., completing shopping before having to catch a bus) as well as cognitive flexibility (e.g., switching between tasks while cooking). The purpose of the current project was to use the D-KEFS TMT to address this question. Because level of depression has been related to IADLs in PD and has been related to TMT performance (Austin, Mitchell, & Goodwin, 2001; Veiel, 1997), the role of depressive symptoms in the prediction of IADLs was also evaluated.

Method

Participants

Participants consisted of a group of 30 individuals (16 female) diagnosed with idiopathic PD by a board-certified neurologist. All participants had a history of good clinical response to treatment with levodopa and/or dopamine agonist. Individuals were excluded from the study if they met Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision (DSM-IV-TR; American Psychiatric Association, 2000) criteria for any Axis I disorder other than cognitive disorder not otherwise specified (NOS); underwent previous neurosurgical intervention; or had a history of other medical condition that could impact cognitive function, such as head injury with loss of consciousness, cerebral neoplasm, stroke, and diabetes. Mean (*SD*) motor symptom severity in the “on” state as measured by Part III (Motor Examination) from the Unified Parkinson’s Disease Rating Scale (UPDRS; Fahn, Elton, & UPDRS Development Committee, 1987) was 18.0 (8.9). According to Modified Hoehn and Yahr staging scores in the “on” state, two participants were at stage 1, one was at stage 1.5, 15 were at stage 2, nine were at stage 2.5, and three were at stage 3. Demographic information for the sample is listed in Table 1.

Measures and Procedures

Following the provision of informed written consent, participants were administered the measures described below. All participants were taking antiparkinsonian medication at the time of testing and were tested while in the “on” state. This study was approved by the appropriate institutional review boards (IRB) and procedures were in compliance with relevant laws.

The D-KEFS TMT (Delis et al., 2001) was administered to assess the various component processes involved in trail making tasks. In Condition 1, Visual Scanning, examinees complete a visual cancellation task in which they draw a slash through all of the threes amongst an array of numbers and letters. In Condition 2, Number Sequencing, examinees draw lines to connect numbers in ascending order. This task is similar to part A from the

original TMT. Condition 3, Letter Sequencing, is similar to Condition 2 except letters are connected in alphabetical order. Condition 4, Number-Letter Switching, is analogous to part B from the original TMT in which examinees alternate between sequentially connecting numbers and letters. In Condition 5, Motor Speed, examinees draw along a dotted line connecting circles as quickly as possible. In all conditions the primary variable is completion time in seconds.

Symptoms of depression were measured with the Geriatric Depression Scale (Yesavage et al., 1982). The measure is composed of 30 yes/no items. Higher scores reflect greater levels of depression.

The Timed Instrumental Activities of Daily Living scale (TIADL; Owsley et al., 2002) was used to assess performance of IADLs. The TIADL uses everyday stimuli involving communication, finances, food, shopping, and medicine. Specific tasks are finding a telephone number for a specific individual in a phone book (time limit = 3 min), producing 67 cents from a handful of change (time limit = 2 min), finding and reading the ingredients on a can of food (time limit = 2 min), finding a can of tomato soup and a box of macaroni and cheese on a shelf of assorted grocery items (time limit = 2 min), and finding and reading the directions on a medicine bottle (time limit = 2 min). Items are scored according to completion time with time penalties for errors, producing a measure that integrates both speed and accuracy of performance (Owsley et al., 2002). Following the authors' procedure, "minor errors" such as misreading a single digit in the phone number, producing change within 2 cents of the 67 cent correct response, initially reading information other than ingredients on the can of food, initially selecting an incorrect food item on the shelf, or initially reading information other than directions on the medication bottle, were penalized by adding 1 *SD* to their time based on participants that completed the task without error. Other errors were considered "major errors" and resulted in a time score equal to the time limit. A total score (in seconds) was computed by adding the time plus penalty scores for the five items.

Data Analysis

After the Pearson correlation coefficients between all conditions of the D-KEFS TMT, GDS, UPDRS Motor Examination, age, education, and TIADL were evaluated, standard multiple regression was used to determine which elements of the D-KEFS TMT accounted for the relationship with TIADLs. D-KEFS TMT conditions that significantly correlated ($\alpha = .05$) with TIADL performance were simultaneously entered into the regression predicting TIADL scores. The standardized beta weight (and the statistical significance of the *t* value associated with it) for each variable was evaluated to ascertain that variable's contribution to the prediction of TIADL scores independent of the other predictors. D-KEFS TMT conditions that predicted significant independent variance in TIADL scores were then entered into a second standard multiple regression with age, education, GDS, UPDRS Motor Examination, should any of these additional variables significantly correlate with TIADL scores. The purpose of this second regression was to ensure that any relationship between D-KEFS TMT conditions and TIADL scores could not be explained by demographic, psychological, or disease-related variables. This two-step approach to data analysis was employed to minimize the number of predictors in the model in light of the sample size. Statistical assumptions were examined by reviewing variable tolerances, standardized residuals, and a normal probability plot (Pallant, 2005). Analyses were performed on raw scores rather than scores adjusted for age or education because our interest was in absolute level of performance rather than performance relative to peers. This approach has been recommended in studies using neuropsychological measures to predict daily functioning (Silverberg & Millis, 2009) because evidence suggests that raw scores are better predictors of daily functioning than demographically adjusted scores (Barrash et al., 2011). Statistical

analyses were performed via the personal computer version of the Statistical Package for the Social Sciences (SPSS 18; IBM, Armonk, NY).

Results

Variable means, standard deviations, and ranges are listed in Table 1. Mean (*SD*) score on the GDS was 5.7 (5.2). Scores on the GDS predominantly fell in the “normal” range between 0 and 9 ($n = 24$). The remaining six scores were in the “mild” range between 10 and 19. All participants were able to complete all TIADL tasks without committing a major error. Two participants committed minor errors while finding the phone number and one participant each committed a minor error making change and locating food items. Mean scaled scores for the various D-KEFS TMT conditions indicate average performance relative to peers but score ranges indicate a good deal of variability in level of performance on the tasks.

Variable correlations are listed in Table 2. Excluding D-KEFS TMT Condition 5, Motor Speed, all TMT measures were significantly correlated with TIADL scores, representing large effects (Cohen, 1988). Regarding demographic, psychological, and disease-related variables, the GDS and UPDRS Motor Examination were also significantly correlated with TIADL scores, producing large effects. In addition, the correlation between age and TIADL scores was medium in size and approached significance ($p = .11$), but the correlation between education and TIADL scores was not statistically significant.

Because performance on D-KEFS TMT Condition 2 (Number Sequencing) was highly correlated with performance on Condition 3 (Letter Sequencing), it was thought to measure the same underlying cognitive process as Condition 3 (i.e., sequencing) and was excluded as a predictor in the regression analyses. Therefore, D-KEFS TMT Conditions 1 (Visual Scanning), 3 (Letter Sequencing), and 4 (Number-Letter Switching), were entered into the regression to predict TIADL scores.

Results of the first regression analysis using D-KEFS TMT conditions to predict TIADL scores are listed in Table 3. Evaluation of standardized residuals and a normal probability plot revealed that there were no residual outliers, and assumptions of linearity and homogeneity of variance were met. The smallest variable tolerance value was 0.39, well above the value of 0.20 suggestive of significant multicollinearity (Pallant, 2005). Taken together, the predictors accounted for 74% of the variance in TIADL performance, $F(3, 26) = 25.05$, $p = .0001$. Evaluation of the beta weights indicates that D-KEFS TMT Condition 3 (Letter Sequencing), $t = 5.95$, $p = .0001$, predicted significant, independent variance in TIADL scores but D-KEFS TMT Condition 4 (Number-Letter Switching), $t = -0.45$, $p = .65$, and D-KEFS TMT Condition 1 (Visual Scanning), $t = -0.30$, $p = .77$, did not.

To determine whether the predictive ability of D-KEFS TMT Condition 3 (Letter Sequencing) was due to sequencing in general or the sequencing of letters specifically, the regression was repeated using Condition 2 (Number Sequencing) in place of Condition 3 (Letter Sequencing). Evaluation of standardized residuals and a normal probability plot revealed that assumptions of linearity and homogeneity of variance were met, however a single residual outlier was identified and removed from the analysis. The smallest variable tolerance value was 0.35, above the threshold indicating significant multicollinearity. The results of this regression are listed in Table 4 and were similar to those of the original regression; 71% of the variance in TIADL performance was accounted for, $F(3, 25) = 19.93$, $p = .0001$, and only D-KEFS TMT Condition 2 (Number Sequencing) predicting significant, independent variance in TIADL scores, $t = 3.08$, $p = .005$.

The final regression included D-KEFS TMT Condition 3 (Letter Sequencing) and age, GDS, and UPDRS Motor Examination as predictors of TIADL scores. Although age was not significantly correlated with TIADL scores, it was included in the regression because of the medium size of the effect. Evaluation of standardized residuals and a normal probability plot revealed that assumptions of linearity and homogeneity of variance were met, however a single residual outlier was identified and removed from the analysis. The smallest variable tolerance value was 0.63, above the threshold indicating significant multicollinearity. The results of this regression are listed in Table 5. The variables predicted 86% of the variance in TIADL scores, $F(4, 24) = 36.71, p = .0001$. Evaluation of the beta weights indicates that D-KEFS TMT Condition 3 (Letter Sequencing), $t = 7.29, p = .0001$, and GDS, $t = 4.02, p = .001$, predicted significant, independent variance in TIADL scores. The proportion of independent variance predicted by age approached significance, $t = 1.81, p = .083$.

Discussion

The purpose of the current study was to determine which component processes involved in the TMT contribute to the prediction of IADLs in a sample of non-demented individuals with PD. As found previously (Cahn et al., 1998; Muslimovic et al., 2008; Uc et al., 2005), the measure involving cognitive flexibility strongly correlated with IADL performance, independently predicting over 32% of the variance in IADLs. However, measures of visual scanning and sequencing that assess component processes involved in the cognitive flexibility task independently accounted for at least as much variability in IADL performance. The large correlations between these measures and IADL performance may be surprising given mean scaled scores that fell within the average range; however, the scaled score ranges indicate a great deal of variability in level of performance. Such heterogeneity in level of cognitive function is common in PD (Kehagia, Barker, & Robbins, 2010).

In a multiple regression, the independent contribution of Letter Sequencing (Condition 3) to the prediction of IADL performance was statistically significant and dramatically exceeded the independent contributions from Visual Scanning (Condition 1) and Number-Letter Switching (Condition 4) which were not statistically significant. A similar result was obtained when Letter Sequencing (Condition 3) was replaced with Number Sequencing (Condition 2) in the regression; Number Sequencing was the only TMT variable that made a significant independent contribution to the prediction of IADL performance. Therefore, it appears that sequencing in general, rather than the sequencing of letters specifically, is the key element of trail making in the prediction of IADLs. The importance of sequencing was supported by the ability of a sequencing task to predict significant independent variance in IADL performance beyond that accounted for by age, symptoms of depression, and motor symptom severity, ensuring that the relationship between sequencing and IADL performance was not explained by demographic, psychological, or disease-related variables.

It is important to note that these results are consistent with a mediation model where sequencing could mediate the relation between the cognitive flexibility measure and IADL performance. The initial variable (D-KEFS TMT Number-Letter Switching) is correlated with the outcome (TIADL; $r = .57, p < .01$) and the mediator (D-KEFS TMT Letter Sequencing; $r = .71, p < .01$), and the mediator affects the outcome when the initial variable is controlled (D-KEFS TMT Letter Sequencing $\beta = 0.82, p < .001$ in regression predicting TIADL; Baron & Kenny, 1986; Kenny, 2012). Of course, the veracity of this model is dependent upon the validity of the underlying conceptualization of trail making and its component processes (Kenny, 2012).

The results reported here may shed light on previous studies finding a relation between the original TMT and ability to complete daily activities (Cahn et al., 1998; Muslimovic et al.,

2008; Uc et al., 2005), and suggest that the sequencing component rather than the cognitive flexibility component makes the greatest contribution to the prediction of daily functioning. Our results map nicely onto those of Cahn et al. (1998) who found that part B from the original TMT made a significant unique contribution to the prediction of IADLs. The results also agree with Muslimovic et al. (2008), who found that a composite including both parts A and B from the original TMT (as well as other measures) was correlated with daily functioning, and with Uc et al. (2005), who found a composite including TMT part B minus part A was correlated with daily functioning. Uc et al.'s finding that the TMT part B minus part A did not contribute to the prediction of daily activities in a regression analysis is consistent with our finding that Number-Letter Sequencing (Condition 4) did not predict significant independent variance in IADLs in the regression. Muslimovic et al.'s finding that the TMT tasks did not enter a regression predicting daily functioning is not entirely inconsistent with our results because they grouped the TMT tasks in a composite with other measures in the regression analysis.

The observed relation between the D-KEFS TMT cognitive flexibility task (i.e., Number-Letter Sequencing) and IADLs is consistent with the pathophysiology of PD which disrupts basal ganglia-thalamocortical circuits including dorsolateral prefrontal cortex (DLPFC; Braak & Braak, 2000) involved in trail making tasks (Moll, de Oliveira-Souza, Moll, Bramati, & Andreiuolo, 2002; Wager, Jonides, & Reading, 2004; Zakzanis, Mraz, & Graham, 2005). However, the fact that relatively simple sequencing tasks were more important in the prediction of IADLs than the cognitive flexibility task is somewhat surprising. Component processes that are involved in the sequencing tasks but not involved in the other TMT tasks and that could explain the relationship between the sequencing tasks and IADL performance could not be identified. Obviously, visual search, motor speed, and cognitive flexibility can be ruled out as processes unique to Letter Sequencing. In addition, an examination of the errors made by the participants on Letter Sequencing is not informative as very few made sequencing errors (i.e., connecting the letters in the wrong order; $n = 3$), set-loss errors (i.e., connecting a letter to a number; $n = 2$), or time-discontinue errors (i.e., failing to make a connection because the time limit was reached; $n = 1$). The observed relation between Letter Sequencing and IADL performance could be due to the significant language component present in the IADL tasks. Indeed, Delis et al. (2001) indicate that Letter Sequencing is sensitive to letter processing difficulties such as those experienced by individuals with verbal learning disabilities. However, individuals with learning disabilities were excluded from the study, and letter processing difficulties are not commonly associated with PD.

Perhaps the relation between sequencing and IADL performance observed here should not be shocking since others have reported a deficit in sequencing in PD that is associated with abnormal activation of the prefrontal cortex and caudate and that could be important in everyday tasks (Tinaz, Schendan, and Stern, 2008). The term "sequencing" is often used in reference to motor sequencing which is defined as "...a complex action involving the execution of different movements in a prescribed temporal sequence" (Fama & Sullivan, 2002, p. 754). Motor sequencing involves motor planning, is sensitive to frontal lobe damage, and is disrupted in PD (Disbrow et al., 2012). Evidence suggests that individuals with PD have difficulty initiating movement and switching between motor programs on motor sequencing tasks (Benecke et al., 1997; Cools et al., 1984; Evarts et al., 1981). Their deficits in sequencing movements are predicted by ability to complete cognitive sequencing tasks such as arranging pictures to tell a story, suggesting that the sequencing deficit is generic, impacting both cognitive and motor functions (Fama & Sullivan, 2002). Consistent with a link between cognitive and motor sequencing, deficient comprehension of complex sentences in PD is predicted by speech motor sequencing (Hochstadt, Nakano, Lieberman, & Friedman, 2006).

The sequencing involved in Letter Sequencing and Number Sequencing includes a motor component as examinees must initiate a new motor program at each target in order to draw a line in another direction to the next target. This motor sequencing component might contribute to the explanation of our results. The motor sequencing element is arguably more significant in the two sequencing tasks from the D-KEFS TMT compared to the Motor Speed and Visual Scanning tasks because Motor Speed provides a clear external cue (the dotted line) and Visual Scanning does not require switching between similar motor programs. The motor sequencing element is also present in Number-Letter Switching but might not play as large a role as the cognitive flexibility (i.e., switching between numbers and letters) element in determining completion time. That is, the variability in completion time in Number-Letter Switching would be largely due to variability in cognitive flexibility rather than motor sequencing. This interpretation is consistent with our results; Number-Letter Sequencing would be expected to correlate with IADL performance because of its motor sequencing component but it would not be expected to predict significant independent variance in IADL performance beyond that accounted for by the sequencing tasks on which performance is largely determined by motor sequencing.

The symptoms of depression that the sample reported also made a significant, independent contribution to the prediction of IADLs. In fact, the correlation between symptoms of depression and IADLs was remarkably large ($r = .67$). In previous studies Uc et al. (2005) found that a depression measure had a correlation of $-.24$ with IADL ratings, and Hobson et al. (2001) noted a correlation between a depression measure and ADL ratings of $.43$. Muslimovic et al. (2008) found that a mixed measure of depression and anxiety correlated with disability ratings ($r = -.17$ to $-.22$). The relatively larger correlation between depression and IADLs reported here is surprising given the low level of depression reported and the exclusion of individuals with clinical levels of depression. A reasonable explanation is our use of a measure of IADLs with a speed component as opposed to a questionnaire measure of IADLs. Level of depression may have a greater influence on a timed task since psychomotor slowing is a symptom of depression. Regardless of the variability in the size of the correlations, these studies provide converging evidence that symptoms of depression are related to daily functioning in PD.

Other researchers have established a relationship between the motor symptoms of Parkinson's disease (PD) and the completion of daily tasks (e.g., Martínez-Martín et al., 2000; Tison et al., 1997). Consistent with this, in the current study motor symptom severity, as indicated by the Motor Examination of the UPDRS completed in the "on" state, was significantly correlated with IADL performance predicting 26% of the variance in IADLs. However, the Motor Speed (Condition 5) task from the D-KEFS TMT was not significantly correlated with IADL performance. This discrepancy may be a consequence of Motor Speed's selective focus on the dominant upper extremity. Despite the significant zero-order correlation between the UPDRS and IADL performance, this variable did not significantly contribute to the prediction of IADLs in the regression analysis. A similar result was reported by Cahn et al. (1998) providing converging evidence that cognitive dysfunction may be more important than motor symptoms in PD patients' ability to carry out more complicated daily activities.

The failure of level of education to correlate with IADL performance is not surprising given the relative simplicity of the tasks involved in the IADL measure. However, it is somewhat surprising that age did not significantly correlate with IADL performance given its relation to functional capacity in healthy elderly individuals (Zuccolo et al., 2012). This may be due to limited statistical power, given the size of the correlation ($r = .30$). Indeed, the beta weight for age in the regression predicting IADL performance approached significance. The discrepancy with results in the elderly may also be explained by differences between the

samples. Individuals with PD will experience far more severe difficulties with IADLs than healthy older adults and these difficulties are obviously related to the debilitating symptoms of PD rather than aging.

The results of the current study have implications for the everyday functioning of individuals with PD as well as their rehabilitation. Although it is acknowledged that the study is based on correlation and does not indicate any causal mechanisms between variables, it appears that sequencing ability is related to PD patients' ability to carry out IADLs. That is, difficulty with IADLs may be due to difficulty ordering the elements of these complex tasks and completing them in a timely fashion. Attempts to improve the daily functioning of individuals with PD should assess and treat basic deficits in sequencing. Aids that break down complex daily tasks into smaller, ordered steps may be helpful in this regard. Tasks with a large number of steps may be significantly more difficult for individuals with PD and therefore attempts to reduce the number of steps could be constructive. These suggestions obviously require a good deal of extrapolation from our data, but are at least worthy of empirical attention. It also appears that level of depression is related to the ability of individuals with PD to carry out IADLs. This is consistent with the well-known impact of depression on daily functioning; however, the current results suggest that even relatively mild "sub-clinical" symptoms of depression can impact the daily functioning of individuals with PD and should be explicitly assessed and treated.

In summary, this study provides evidence that the sequencing component of trail making tasks accounts for a large proportion of the relationship between these tasks and IADLs in non-demented individuals with PD. It also suggests that even amongst individuals that are experiencing sub-clinical symptoms of depression, such symptoms account for significant independent variance in IADL performance. As sequencing ability and level of depression appear more important in the prediction of IADLs than gross measures of motor symptomatology, they certainly appear worthy of clinical attention. It is important to note that our results may not generalize beyond the well-educated sample of participants. We did not consider the impact of medication on IADLs nor did we include questionnaire measures of IADLs and these limitations reveal areas for future research.

Acknowledgments

This work was supported by grants from the Department of Veterans Affairs Office of Research and Development, Rehabilitation Service (1101RX000181) and NINDS (R01NS064040) to ED. The authors wish to thank Elizabeth Dressler for her assistance with data management and analyses.

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Table 1

Demographic and Neuropsychological Variables

	Raw		Scaled ^d			
	Mean	SD	Range	Mean	SD	Range
Ethnicity (Caucasian:African American:Hispanic:Asian)	26:2:1:1					
Gender (Male:Female)	14:16					
Age (years)	67.9	4.9	57-78			
Education (years)	16.2	2.6	12-24			
Disease Duration (years)	7.4	4.1	1-19			
TIADL, time + penalty (sec)	80.2	51.7	41-269			
UPDRS, Part III (/56)	18.0	8.9	5-35			
Geriatric Depression Scale (/30)	5.7	5.2	0-19			
TMT Condition 1: Visual Scanning (sec)	32.4	11.0	18-69	10.2	3.2	1-15
TMT Condition 2: Number Sequencing (sec)	49.1	29.0	24-173	11.5	3.0	1-16
TMT Condition 3: Letter Sequencing (sec)	48.2	28.9	23-174	11.8	2.6	1-15
TMT Condition 4: Number-Letter Switching (sec)	116.1	59.2	49-280	10.8	3.5	1-15
TMT Condition 5: Motor Speed (sec)	43.4	26.7	20-150	11.2	2.4	1-15

Note. TIADL = Timed Instrumental Activities of Daily Living; UPDRS = Unified Parkinson's Disease Rating Scale; TMT = Delis-Kaplan Executive Function System Trail Making Test.

^aMean (SD) = 10 (3).

Table 2

Intercorrelation Matrix

	1	2	3	4	5	6	7	8	9
1. TIADL									
2. Age (years)	.30								
3. Education (years)	.00	.15							
4. UPDRS, Part III	.51**	.35	-.01						
5. Geriatric Depression Scale	.67**	.12	-.12	.38*					
6. TMT Condition 1: Visual Scanning	.59**	.48**	-.10	.48**	.44*				
7. TMT Condition 2: Number Sequencing	.64**	.38*	.07	.37*	.39*	.76**			
8. TMT Condition 3: Letter Sequencing	.86**	.32	-.04	.54**	.49**	.72**	.80**		
9. TMT Condition 4: Number-Letter Switching	.57**	.35	-.30	.37*	.37*	.70**	.64**	.71**	
10. TMT Condition 5: Motor Speed	.14	.24	.11	.41*	.07	.42*	.37*	.18	.25

Note. TIADL = Timed Instrumental Activities of Daily Living; TMT = Delis-Kaplan Executive Function System Trail Making Test; UPDRS = Unified Parkinson's Disease Rating Scale.

* $p < .05$.

** $p < .01$.

Table 3
Regression for the Prediction of TIADL Performance with Trail Making Tasks: Letter Sequencing

	<i>B</i>	<i>SE B</i>	β
TMT Condition 1: Visual Scanning	−0.22	0.73	−0.05
TMT Condition 3: Letter Sequencing	1.68	0.28	0.94***
TMT Condition 4: Number-Letter Switching	−0.06	0.13	−0.07

Note. TIADL = Timed Instrumental Activities of Daily Living; TMT = Delis-Kaplan Executive Function System Trail Making Test.

 $p < .001$.

Table 4

Regression for the Prediction of TIADL Performance with Trail Making Tasks: Number Sequencing

	<i>B</i>	<i>SE B</i>	β
TMT Condition 1: Visual Scanning	0.80	0.72	0.21
TMT Condition 2: Number Sequencing	0.78	0.25	0.53**
TMT Condition 4: Number-Letter Switching	0.14	0.11	0.19

Note. TIADL = Timed Instrumental Activities of Daily Living; TMT = Delis-Kaplan Executive Function System Trail Making Test.

**
 $p < .01$.

Table 5

Regression for the Prediction of TIADL Performance with Demographic Variables and Letter Sequencing

	<i>B</i>	<i>SE B</i>	β
Age	1.35	0.75	0.16
Geriatric Depression Scale	2.97	0.74	0.35**
UPDRS Part III: Motor Examination (On)	-0.48	0.47	-0.10
TMT Condition 3: Letter Sequencing	1.09	0.15	0.70***

Note. TIADL = Timed Instrumental Activities of Daily Living; UPDRS = Unified Parkinson's Disease Rating Scale; TMT = Delis-Kaplan Executive Function System Trail Making Test.

**
 $p < .01$.

 $p < .001$.