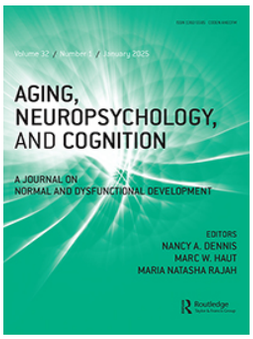

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Development of the Telephone-based Daily Instrumental Activities of Living (T-DIAL) to assess financial management remotely in older adults

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ABSTRACT

The current study evaluated the reliability and validity of a novel, performance-based banking task in 60 younger (18–34 years) and 60 older (50–85 years) adults. All participants completed the Telephone-based Daily Instrumental Activities of Living (T-DIAL) using interactive voice response technology to complete a series of mock actions with a financial institution via telephone. The T-DIAL showed strong inter-rater reliability and internal consistency. T-DIAL accuracy was significantly and independently related to better self-reported instrumental activities of daily living and executive functions at a large effect size. Findings from this study provided preliminary supportive evidence for the reliability and validity of the T-DIAL, which had robust associations with manifest everyday functioning and higher-order cognitive ability. Future work is needed on the psychometrics (e.g. test–retest reliability, normative standards), and construct validity (e.g. diagnostic accuracy) of the T-DIAL in neurocognitive disorders and under-served communities for whom remote evaluations might be particularly relevant.

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Introduction

Financial management is often listed amongst the instrumental activities of daily living (iADL), which are fundamental skills for functional independence. The ability to remember to pay bills on time, monitor account balances, navigate banking transactions, and detect potential scams can be essential for functional independence and well-being (Marson, 2013). Older adults may be especially vulnerable to declines in many aspects of financial management, partly due to age-related changes in brain structure and function. Even in the absence of pathological aging, older brains may show reductions in functional

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connectivity (e.g., anterior-posterior pathways in the default network) and white matter integrity, particularly in temporal and frontal systems (Andrews-Hanna et al., 2007; Kaup et al., 2011). Changes to these brain systems are commonly accompanied by cognitive declines in domains such as episodic memory, executive functions, and attention and information processing speed (Lindenberger, 2014). In turn, these cognitive declines can interfere with older adults' abilities to complete iADLs (e.g., Tucker-Drob, 2011), including financial management (e.g., Rahman et al., 2021). Thus, the accurate assessment of financial management capacity can play an important role in diagnosing and managing functional impairment in older adults.

Performance-based functional assessments (PBFAs) offer a skill-based approach to measure financial management capacity and other iADLs (e.g., medications, chores, transportation, and communication) in the laboratory and in naturalistic settings (Patterson et al., 2001; Robertson & Schmitter-Edgecombe, 2017; Schwartz et al., 2003). One's ability to manage finances can be measured via paper and pencil tasks (e.g., Loeb & Fe, 1996), self- or informant-report questionnaires (e.g., Lawton & Brody, 1969), and even online technologies (e.g., Moore et al., 2017; Rahman et al., 2021). To date, such assessments have shown promising evidence of construct and ecological validity, but they are often constrained to in-person laboratory methods that are limited in their usefulness for persons without adequate transportation or internet access. While modern society increasingly relies on technology for many iADLs (e.g., smart-phone applications for banking), a sizable minority of individuals are unable to reliably access or use modern technology for these purposes (Fox-Fuller et al., 2021; Yoon et al., 2020), including older adults, persons living in rural communities, and those with limited socioeconomic resources. In particular, older adults can face multiple barriers to access and use internet-based technologies, such as lower knowledge, self-efficacy, and financial means (Perrin & Atske, 2021; Vaportzis et al., 2017). Thus, there is a need to develop accessible, valid measures of financial management and other iADLs that can effectively reach these under-served populations in clinical and research settings.

One possibility is to assess financial management performance in older adults via telephone. Older adults are more likely than younger adults to use the telephone in daily life (Olson et al., 2011) and tend to prefer the telephone for some everyday activities (Subramanyam et al., 2018; Sullivan Baca et al., 2022). Thus, telephone-based assessment of financial management capacity could provide greater access to healthcare services for vulnerable older adults, which may facilitate early detection of neurocognitive disorders and inform clinical treatment planning (Kraal et al., 2021; Thompson et al., 2023). In support of the feasibility of this remote assessment approach for performance-based iADLs, performance-based neuropsychological assessments have been administered via telephone since the 1980s (e.g., Nesselroade et al., 1988). Although telephone-based neuropsychological assessment approaches are no replacement for comprehensive, in-person services, they nevertheless demonstrate feasibility (e.g., Sullivan Baca et al., 2022), adequate psychometric properties (e.g., Matchanova et al., 2021), and evidence of validity in clinical samples (e.g., Thompson et al., 2023).

Less consideration has been given to telephone-based assessment of iADLs. A recent review of telephone-based neuropsychological assessments did not include even a single PBFA (Carlew et al., 2020). This gap in the literature is surprising considering telephone use is commonly included in iADL subjective questionnaires (e.g., Custodero et al., 2021;

Heaton et al., 2004) and PBFA batteries administered in the laboratory (Higginson et al., 2010; Schillerstrom et al., 2013). Some studies have incorporated telephone use into laboratory-administered PBFAs in older adults (e.g., Czaja, Loewenstein, Lee, et al., 2017, 2017b) and persons with schizophrenia (Czaja, Loewenstein, Lee, et al., 2017), mild cognitive impairment (MCI; Czaja, Loewenstein, Sabbag, et al., 2017), and HIV (Scott et al., 2011; Woods et al., 2016). However, most studies on telephone-based PBFAs use report- and interview-based approaches (Zanin et al., 2022). The psychometric properties and reliability of self-report ADL assessments are similar between telephone compared to face-to-face administration (Dauphinot et al., 2020; Lin et al., 2010). For example, Thompson et al. (2023) demonstrated a self-report ADL measure administered remotely via telephone had strong internal consistency and expected relationships with demographics, neurocognition, and depression in persons with HIV disease. Nevertheless, questionnaire-based functional measures are subject to reporting biases, including the influence of depression and limited deficit awareness (Mitchell & Shiri-Feshki, 2009; Tucker-Drob, 2011).

To our knowledge, only four studies in the neuropsychological literature examined the validity of telephone-based PBFAs, and all used interactive voice response (IVR) technology. IVR technology is commonly used to generate automated menus when consumers call a large business or institution to identify caller needs and direct them to the appropriate answer or destination, reducing the need for humans to man the phone lines. The automated menus are standardized with a computerized voice providing commands and requesting information from callers. Miller et al. (2013) found poorer performance on a laboratory-based IVR task (i.e., locating information about government statistics and airline tickets) was associated with older age, lower estimated IQ, and working memory difficulties in an older adult sample. Marshall et al. (2015) developed the Harvard Automated Phone Task (APT), which required participants to use an IVR system to refill a prescription, switch doctors, and transfer funds. The APT showed excellent test-retest reliability and discriminated between younger adult, healthy older adult, and MCI groups (Marshall et al., 2015, 2017). At two-year follow-up, poorer APT performance related to lower baseline performance in processing speed, executive functions, and memory (Marshall et al., 2017). Moreover, poorer APT performance was associated with worse daily functioning in healthy older adult and MCI groups, as measured by standard laboratory-based PBFAs and self-report (Marshall et al., 2019). Though encouraging, these emerging findings await replication and leave important gaps in the literature. Most notably, these telephone-based IVR tasks were administered in the laboratory and required use of physical objects (e.g., mock pill bottle), which limits their utility for remote telephone-based assessments.

The overarching aim of the current study was to evaluate the reliability and construct validity of a novel, telephone-based measure of older adults' functional capacity to manage and solve an everyday financial problem. This measure was developed by study authors from scratch using IVR technology, with the goal of administering the task remotely via telephone (i.e., the Telephone-based Daily Instrumental Activities of Living [T-DIAL] task). Specifically, the T-DIAL requires an individual to understand that a problem with a financial account exists and requires action, follow directions to contact the relevant financial entity, and navigate auditory prompts to provide the entity with the relevant information to resolve the financial problem via telephone keypad responses.

The reliability of the T-DIAL will be evaluated by way of its inter-rater reliability and internal consistency. The construct validity of the T-DIAL will be evaluated in several different ways. First, we will evaluate the association between T-DIAL accuracy and several demographic and descriptive variables that are related to banking and telephone use in daily life (e.g., frequency of using telephone for banking) and may therefore be important covariates for the primary analyses. In particular, we are interested in the association between T-DIAL accuracy and age. Based on the literature showing that older age is associated with poorer performance on measures of financial management (e.g., Rahman et al., 2021), we expected older adults would obtain lower T-DIAL accuracy scores than younger adults. Second, we will examine the association of the T-DIAL with other measures of iADLs, which assess a comparable super-ordinate construct that is being measured by the T-DIAL. In particular, we will examine the hypothesis that T-DIAL accuracy will be related to greater independence in self-reported iADLs (e.g., financial management, telephone use) and performance-based money management knowledge. Third, we will evaluate the associations between T-DIAL accuracy and well-validated clinical measures of neuropsychological functioning, which examine cognitive constructs that are theorized to support financial management and T-DIAL performance. Drawing from prior research on the cognitive correlates of financial management (e.g., Gerstenecker et al., 2017; Rahman et al., 2021) and other PBFAs in older adults (e.g., Tierney et al., 2022), we predict that the T-DIAL will place demands on attention (e.g., the ability to attend to the instructions and IVR prompts), learning and memory (e.g., encoding and retrieving instructions for a complex, novel task), and executive functions (e.g., cognitive flexibility to switch between and efficiently navigate the IVR prompts).

Methods

Participants

Participants were recruited via social media (e.g., Facebook, Twitter), community websites (e.g., Craigslist), University of Houston (UH) undergraduate research subject pool, word of mouth, and flyers in community centers. Inclusion criteria were stated age between 18–35 or greater than 50 years old, sufficient English language proficiency, location in the U.S., and capacity to provide informed consent. This discrepant age-group design was employed to increase the power to detect age effects in the context of a resource limited study. The cutoff of ≤35 years old in the younger adult group provided sufficient age differentiation from the older group, which aligns with common designs in the cognitive aging literature (e.g., Kordovski et al., 2021). The cutoff of ≥50 years for older adults was based upon evidence that age-related cognitive changes occur as early as the mid-40s (Elliott et al., 2021) and an increasing number of studies in the aging literature focusing on middle-aged samples (Ritchie et al., 2015). Exclusion criteria were the presence of severe psychiatric disorders (e.g., schizophrenia, bipolar disorder), neurological conditions (head injury with loss of consciousness >30 minutes, multiple sclerosis, brain cancer, seizure disorder, stroke, dementia), or failure on two embedded measures of performance validity (Greiffenstein et al., 1994; Sawyer et al., 2017; Soble et al., 2020). A total of 960 individuals initiated the online screening link, 369 individuals completed the screening questionnaire, and 139 individuals were assessed. Application of the study inclusion and exclusion

criteria yielded a final sample of 120 participants, comprised of 60 younger and 60 older adults. Among the younger group, 19 individuals were between 18 and 22 years old (i.e., potential college aged) and among the older group, 24 individuals were age 65 and older (i.e., age frequently considered "older adulthood").

Materials and procedures

Ethics approval was obtained through the UH Institutional Review Board (STUDY00003731) and all participants provided digital, informed consent. Participants were compensated with a $20 gift card or course credits for the 1.5-hour research study phone call. Evaluations were conducted remotely via telephone by research assistants through a designated GoogleVoice® number. All research assistants confirmed participants were in a quiet, safe, private location, and the call was not recorded at the onset of the study phone call. Participants were told to have paper and pencil ready and were instructed to only use these materials when explicitly prompted by the research assistant (e.g., to write down some scale response options).

Telephone-based Daily Instrumental Activities of Living (T-DIAL)

The T-DIAL was administered remotely via telephone. The task was developed by the first author with support from coauthors using IVR technology supported by Twilio Inc.© (2024). The T-DIAL required participants to call and accurately communicate information to resolve fraudulent charges on a mock credit card account. Participants were asked to imagine they noticed a large, unusual charge of $240 on their credit card for purchases at an establishment they had never visited. They were instructed to call the credit card company at the Twilio© phone number to report this fraudulent charge. Participants were provided five reference numbers and instructed to write them on a piece of paper; three numbers were directly relevant to the task (i.e., 5-digit number for the charge, 16-digit credit card number, 4-digit pin number) and two were not directly relevant (i.e., 5-digit zip code, current total credit card balance). Participants were instructed to hang up with the examiner and call the Twilio© phone number to complete the T-DIAL task within 10 minutes. As shown in Figure 1, the T-DIAL menu included five prompts that participants could navigate by pressing numbers on their telephone keypad. Each step was scored for accuracy, with a maximum of 2 points (2=correct on first trial, 1=correct on second trial, 0=failed all attempts or did not attempt). The range of possible scores was 0 to 10, with higher scores reflecting greater financial management accuracy. Completion time and individual responses were recorded and accessed through a password-protected Twilio© account.

Everyday functioning measures

Independent living scale. All participants completed the Money Management Subscale of the Independent Living Scale (ILS; Loeb & Fe, 1996). Although most ILS items were readily amenable to remote telephone assessment, some items were adapted (e.g., counting change via paper-and-pencil versus actual coins) and other items were omitted (e.g., writing a check). A total of 15 items from the Money Management subscale were included. Participants' responses for each item were scored using the standard ILS manual scoring, which includes 0, 1, and 2-point

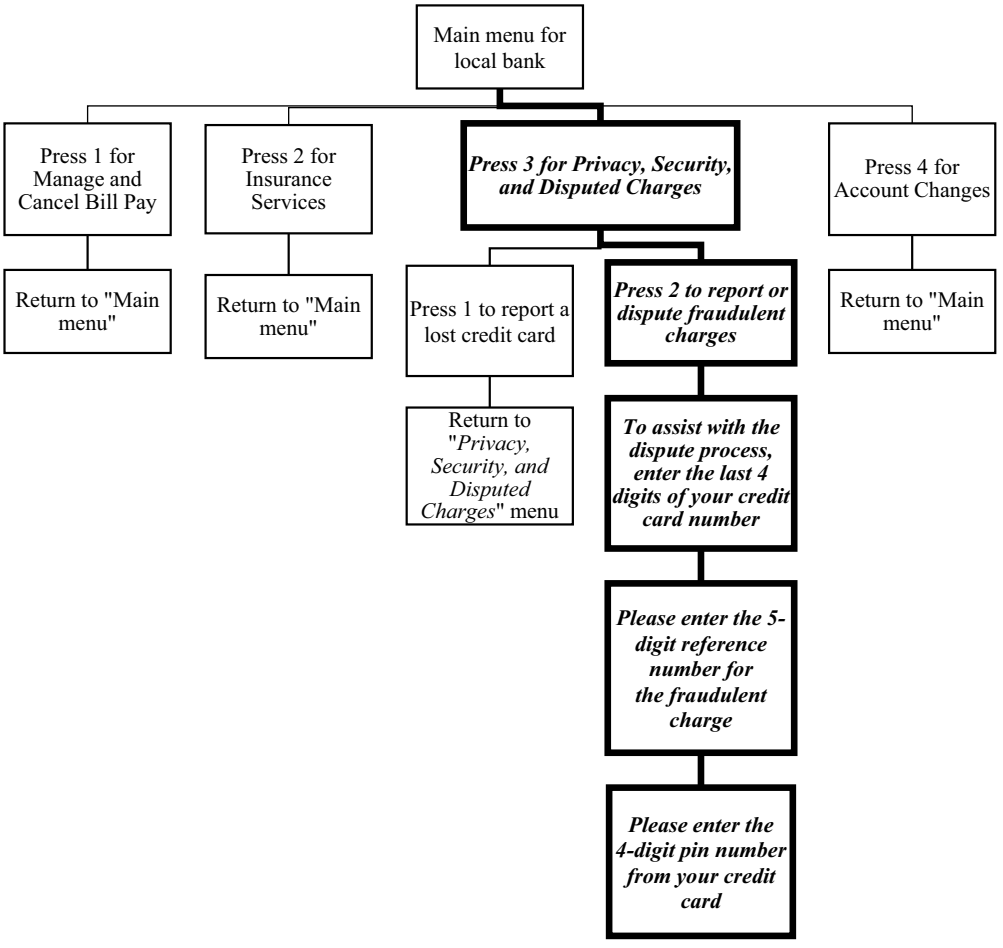

Figure 1. Phone tree options and correct steps to complete the Telephone-based Daily Instrumental Activities of Living (T-DIAL) financial task. *Bold italic text* and bolded borders indicate the correct menu option at each level.

responses whereby higher scores indicate better performance. These 15 items showed adequate internal consistency ($\alpha = 0.74$) and were summed to generate a total ILS score variable (sample range = 15–30).

Activities of daily living questionnaire. All participants completed the telephone version (Thompson et al., 2023) of the Activities of Daily Living Questionnaire (ADLQ; LaPlante, 2010), with seven basic (e.g., bathing) and seven instrumental (e.g., managing money) ADLs. Participants self-reported whether or not they needed help (1="Yes," 0="No") for each item. The seven items on the instrumental ADLQ (i.e., iADLQ) subscale were summed to generate a total iADLQ score used in the regression analyses, whereby higher scores indicated greater instrumental ADL problems ($\alpha = 0.63$, sample range = 0–4). Prior research supports the reliability and validity of this instrument administered via telephone (Thompson et al., 2023)

Neuropsychological measures

This study used a brief neuropsychological battery of commonly administered clinical tests that was previously adapted for telephone administration (Babicz et al., 2021; Matchanova et al., 2021; Thompson et al., 2023). Three domain-level composite scores were derived based on previously established factor structures of the test battery (Matchanova et al., 2021). Attention was assessed using the Weschler Adult Intelligence Scale-Fourth Edition (WAIS-IV) Digit Span Forward and Backward subtests (Wechsler, 2008) and Trial 1 from the Hopkins Verbal Learning Test – Revised (HVLT-R; Benedict et al., 1998; Brandt & Benedict, 2001). Learning and memory were assessed using the HVLT-R Long Delay Free Recall and Recognition trials, and a 4-trial event-based prospective memory task (adapted from Beaver & Schmitter-Edgecombe, 2017). Executive functions were assessed with action (verb) fluency (Piatt et al., 1999; Woods et al., 2005), category switching from the Delis-Kaplan Executive Functions Scale (DKEFS; Delis et al., 2001), and Oral Trail Making Test, part B (OTMT; Ricker & Axelrod, 1994). Raw scores for all clinical tests were converted to demographically-adjusted T-scores, which were averaged to create the domain-level composites as per the established factor structure (Matchanova et al., 2021).

Sample descriptors and potential covariates

Sociodemographic variables were collected via self-report at screening (see Table 1). Fund of verbal knowledge was assessed by the Information subtest of the WAIS-IV (Wechsler, 2008). Everyday telephone use was assessed by adapting questions from the Internet Use and Anxiety Questionnaire (Baggio et al., 2017), for which participants were allowed to write-down the scale anchors. Participants answered questions regarding approximate duration per day they used verbal telephone calls for daily activities (i.e., 0–30 minutes, 30–60 minutes, 1–2 hours, >2 hours). Participants also used a scale from 0–10 to subjectively rate the frequency with which they use the telephone to complete everyday banking tasks and anxiety when using the telephone to complete financial tasks (0=never to 10=all the time). Participants were asked whether they preferred the verbal telephone to the Internet for managing their personal finances. The Telephone Interview for Cognitive Status (TICS; Brandt et al., 1988) Tapping Item was used to assess psychomotor speed and required participants to tap onto the part of the phone they speak into five times. Finally, participants also reported on the type of personal telephone they were using, given that device and operating system may impact the reliability of phone-based assessments (Öhman et al., 2021).

Current mood was assessed using the 7-item version of the Geriatric Depression Scale (GDS-7; Adams et al., 2004) and the 5-item Geriatric Anxiety Inventory-Short Form (GAI-SF; Byrne & Pachana, 2011). For ease of administration via telephone, all items from the GDS-7 ($\alpha = 0.66$) and GAI-SF ($\alpha = 0.77$) were dichotomized (i.e., "yes" = 1, "no" = 0). Raw GDS-7 and GAI-SF total scores were moderately, positively correlated ($r_s = 0.37$, $p < .001$) and were thus converted to sample-based z-scores and averaged to create a single mood index to consider as a covariate. Presence, treatment, and severity of eight medical conditions (i.e., heart, lung, kidney, liver, and immune disease, diabetes, cancer, asthma) were assessed using the Health Comorbidity Questionnaire (Sangha et al., 2003), with higher scores indicating greater medical burden (possible score range 0 to 24). The measure showed strong internal consistency in the current sample ($\alpha = 0.81$).

Table 1. Descriptive information for sociodemographic, clinical, and telephone use variables for the study sample ($N = 120$) stratified by age groups.

	Older group ($n = 60$)		Younger group ($n = 60$)		
Variable	Mean (SD)/%	Range	Mean (SD)/%	Range	*p*-value
Sociodemographic Variables					
Age	63.0 (8.4)	50 – 85	26.0 (5.2)	18 – 34	—-
Gender Identity (% non-binary)	0.0		1.7		.446
Sex at Birth (% female)	76.7		70.0		.409
Education (years)	15.5 (2.0)	12–20	15.0 (2.0)	12–20	.156
Race/Ethnicity (%)					**.002**
Black/African American	10.0		28.3		
Other/Multi-racial	20.0		16.7		
White	63.3		35.0		
Hispanic/Latinx	6.7		20.0		
English Second Language (%)	11.7		16.7		.431
WAIS-IV Information (raw score)	16.7 (4.7)	5 – 24	13.0 (5.1)	4 – 23	**<.001**
Hollingshead Highest Occupation (of 7)	2.4 (1.2)	1 – 6	3.3 (1.7)	1 – 7	**.006**
Clinical Variables					
Medical Comorbidity Score (of 24)	1.4 (2.4)	0 – 14	0.5 (1.3)	0 – 6	**.005**
GDS Total (of 7)	1.0 (1.5)	0 – 6	1.6 (1.5)	0 – 6	—-
GAI-SF Total (of 5)	1.8 (1.7)	0 – 5	2.6 (1.8)	0 – 5	—-
Composite Mood Z-Score	−0.2 (0.8)	−1.1–2.0	0.2 (0.8)	−1.1–2.0	**.006**
Telephone Variables					
Own Smartphone (%)	100.0		100.0		–
Type of Phone (%)					**.044**
iPhone	51.7		71.7		
Android	36.7		25.0		
Other	11.6		3.3		
Telephone Time Daily Tasks (%)					**.022**
0–30 minutes	55.0		33.3		
30–60 minutes	16.7		13.3		
1–2 hours	16.7		21.7		
2+ hours	11.6		31.7		
Telephone Time Daily Socialize (%)					**.001**
0–30 minutes	53.3		28.3		
30–60 minutes	30.0		28.3		
1–2 hours	11.7		15.0		
2+ hours	5.0		28.3		
Prefer Phone to Manage Finances (%)	25.0		15.0		.169
Banking Telephone Frequency (of 10)	1.2 (2.1)	0 – 10	2.8 (3.0)	0 – 10	**<.001**
Anxiety with Telephone Use (of 10)	1.4 (2.3)	0 – 10	3.3 (3.1)	0 – 10	**<.001**

Variables are reported as mean (SD) and ranges or valid population % where applicable. Bold p-value indicates significant at $p < .05$. Other/Multi-racial included Asian/Pacific Islander, Native American, Middle Eastern, and multi-racial/ethnic identities; GDS = Geriatric Depression Scale; GAI-SF = Geriatric Anxiety Inventory-Short Form; Composite mood z-score was calculated by generating a sample-based z-score combining GDS and GAI-SF scores.

Data analysis

Data was inspected for quality assurance to correct any data entry or coding errors, outliers, or missing values. Outliers > 4 SDs from the sample mean were Winsorized. Little's Missing Completely at Random test was conducted using SPSS (version 26), which confirmed that any missing values were missing completely at random (all *ps* > .05). Thus, missing values were managed by imputing the sample mean for the variable. Primary statistical analyses were conducted using JMP Pro software (16.0.0). All primary study hypotheses were tested using correlations, chi-square, analysis of variance, multiple regressions, and logistic regression. The G*Power software (Faul et al., 2009) was used to conduct a power analysis which

determined that a sample size of $N = 120$ would afford adequate power (1-B=.81) to detect a small effect size with a critical alpha of .05 for multiple regression analyses with up to four covariates. Critical alpha was set at .05 for primary analyses, and Type I error adjustments were conducted as needed for *post hoc* analyses. Any variable included in Table 1 was initially considered as a covariate for each model using a data-driven approach, whereby variables that significantly ($p < .05$) related to *both* independent and dependent variables were included as covariates in that model (Field-Fote, 2019).

Results

Feasibility, reliability, and distribution of the T-DIAL

Every participant in the current study was able to complete the T-DIAL task. The most commonly self-reported challenges with the task were perceived errors entering numbers ($n = 13$), telephone connectivity issues ($n = 5$), audio clarity issues ($n = 2$), calling the wrong number ($n = 1$), and getting confused with the distractor information ($n = 1$).

Two raters independently scored all five T-DIAL responses from all 120 participants. Inter-rater reliability for scoring T-DIAL responses was excellent for item-level accuracy scores (intraclass correlation coefficient = 0.99). Moreover, the five individual scores derived from T-DIAL had strong internal consistency (Cronbach's $\alpha = 0.81$). Thus, a total summary accuracy score from the primary rater was used for all subsequent analyses.

The range of T-DIAL total accuracy scores achieved in the current sample varied from 0 to 10. The median score was 10 (IQR = 10, 10). Of note, T-DIAL accuracy was non-normally distributed (Shapiro-Wilk $p < .001$), with skewness of −2.9 and kurtosis of 8.4. We observed that 75.8% ($n = 91$) of the entire sample obtained perfect accuracy scores. Given this strong negatively skewed distribution, we generated a dichotomous "T-DIAL accuracy" variable in which participants were classified as either perfect (score = 10) or not-perfect (score <10).

T-DIAL associations with demographics, descriptive variables, and potential covariates

Next we examined the associations between T-DIAL accuracy group and the various demographic (excluding age), and descriptive variables listed in Table 1. The purpose of these exploratory analyses was to examine how T-DIAL performance relates to common demographic, clinical, and telephone use factors, as well as to establish possible covariates for the primary, hypothesis-driven analyses detailed below. The results showed that higher T-DIAL accuracy was associated with female sex at birth ($X^2 = 6.5$, p=.011), lower symptoms of depression and anxiety ($p < .001$), iPhone use ($X^2 = 8.13$, p=.017), frequency of using the telephone for banking activities ($X^2 = 4.75$, $p = .029$, Hedge's $g = 0.29$), and telephone motor dexterity ($X^2 = 5.56$, p=.018, Hedge's $g = 0.46$). T-DIAL was not significantly associated with any of the other variables in Table 1 (all ps>.05; see Table 2).

Table 2. Associations between Telephone-based Daily Instrumental Activities of Living (T-DIAL) accuracy groups with sociodemographic, clinical, and daily telephone-related variables in the entire sample ($N = 120$).

	T-DIAL perfect accuracy ($n = 91$)		T-DIAL not perfect accuracy ($n = 29$)		
Variable	Mean (SD)	Range	Mean (SD)	Range	*p*
Sociodemographic Variables					
Age	45.0 (19.8)	18 – 85	43.0 (20.2)	18 – 81	.679
Sex at birth (% female)	79.1		55.2		**.014**
Race/ethnicity (%)					.242
Black/African American	15.4		31.0		
Hispanic/Latinx	13.2		13.8		
Other/Multi-racial	20.9		10.4		
White	50.5		44.8		
English Second Language (%)	12.1		20.7		.264
Education (years)	15.4 (2.1)	12 – 20	14.8 (1.8)	12 – 18	.203
WAIS-IV Information (raw score)	15.1 (5.2)	5–24	14.0 (5.5)	4–23	.374
Hollingshead Highest Occupation (of 7)	2.7 (1.6)	1 – 7	3.2 (1.4)	1 – 6	.058
Clinical Variables					
Medical Comorbidity Score (of 24)	0.9 (2.0)	0 – 14	1.1 (1.8)	0 – 6	.338
Composite Mood Z-score	−0.2 (0.7)	−1.1 – 1.7	0.6 (0.9)	−1.1 – 2.0	**<.001**
Telephone Variables					
Owns a Smartphone (%)	100.0		100.0		–
Type of Phone (%)					**.017**
iPhone	68.1		41.4		
Android	27.5		41.4		
Other	4.4		17.2		
Telephone Time Daily Tasks (%)					.323
0–30 minutes	44.0		44.8		
30–60 minutes	17.5		6.9		
1–2 hours	19.8		17.3		
2+ hours	18.7		31.0		
Telephone Time Daily Socialize (%)					.135
0–30 minutes	46.2		24.1		
30–60 minutes	28.5		31.0		
1–2 hours	11.0		20.7		
2+ hours	14.3		24.1		
Prefer Phone to Manage Finances (%)	17.6		27.6		.254
Banking Telephone Frequency (of 10)	1.8 (2.8)	0 – 10	2.6 (2.5)	0 – 8	**.029**
Anxiety with Telephone Use (of 10)	2.2 (2.9)	0 – 10	2.8 (3.0)	0 – 10	.323

Variables are reported as mean (SD) and ranges or valid population % where applicable. Bold p-value indicates significant at $p < .05$. Other/Multi-racial included Asian/Pacific Islander, Native American, Middle Eastern, and multi-racial/ethnic identities; Medical comorbidities score was conducted using the Health Comorbidity Questionnaire with higher scores indicating greater comorbidities; Composite mood z-score was calculated by generating a sample-based z-score combining Geriatric Depression Scale (7-item) Geriatric Anxiety Scale-Short Form (5-item) scores, with higher scores indicating greater mood symptoms.

Age group differences on T-DIAL

Next we examined whether T-DIAL was associated with age. As shown in Table 1, the older adults were significantly more likely to be White, use Android smart phones, and use the phone for a variety of daily activities, including banking (*p*s<.05). Older adults also had greater funds of verbal knowledge, occupational attainment, medical comorbidities, and fewer mood symptoms (*p*s<.05). Among these age-related group differences, only phone type, mood z-score, and phone banking frequency were also related to T-DIAL accuracy (*p*s<.05; see Table 2). A logistic regression analysis covarying for these three factors was conducted to examine whether age group predicted T-DIAL accuracy (see Tables 3 and 4). The overall model was significant ($X^2(5, N = 120) = 26.52$, $p < .001$). Neither age group ($X^2 = 0.12$, p=.728,

Table 3. Descriptive table reporting Telephone-based Daily Instrumental Activities of Living (T-DIAL) outcome variables between the older and younger study groups.

	Older group ($n = 60$)		Younger group ($n = 60$)	
Variable	Mean (SD)	Range	Mean (SD)	Range
Completion Time (sec.)	97.4 (19.0)	33–164	100.6 (26.1)	22–163
Total Accuracy Score (of 10)	9.4 (1.6)	2–10	8.9 (2.4)	0–10
T-DIAL Accuracy (% perfect)	78.3		73.3	
Total Errors Score	0.6 (1.0)	0–5	0.5 (1.0)	0–5
T-DIAL Errors (% zero errors)	65.0		70.0	
Errors By Step (%)				
Step 1 – Choose Privacy Dept.	1.7		6.7	
Step 2 – Choose Dispute Charge	3.3		1.7	
Step 3 – Enter Credit Card Last 4	3.3		6.7	
Step 4 – Enter Reference Number	10.0		8.3	
Step 5 – Enter Pin Number	10.0		6.7	
Called > One Time (%)	23.3		18.3	
Perfect Accuracy After Re-Call (%)	5.0		6.7	

Variables are reported as mean (SD) and ranges or valid population % where applicable.

Table 4. Multiple logistic regression models demonstrating associations between study age group with Telephone-based Daily Instrumental Activities of Living (T-DIAL) accuracy, including relevant covariates.

Predictors	*B*	*B* SE	Wald X^2	*OR*	95% *CI OR*	*p*
T-DIAL Accuracy Model						**<.001**
Age Group	0.19	0.56	0.12			.728
Older				1.22	0.41, 3.64	.728
Younger				0.82	0.27, 2.47	.728
Mood Z-score	−1.17	0.33	12.77	0.31	0.16, 0.59	**<.001**
Phone Bank Frequency	−0.03	0.09	0.11	0.97	0.82, 1.15	.739
Type of Phone	2.35	0.88	7.71			**.021**
iPhone vs. Other				10.47	1.87, 58.72	**.008**
iPhone vs. Android				2.38	0.82, 6.93	.112

OR = Odds Ratio. T-DIAL Accuracy (i.e., perfect or not-perfect) was examined as a dichotomous variable. Mood Z-score was a composite measure of current self-reported depression and anxiety symptoms. Phone banking frequency was self-reported frequency of using the verbal telephone for banking activities. *Ps* significant at < .05 are bolded.

odds ratio (OR) = 1.22) nor telephone banking frequency ($X^2 = 0.11$, p=.739, OR = 0.97) were a significant predictor of T-DIAL accuracy. Mood z-score ($X^2 = 12.77$, $p < .001$, OR = 0.31) and type of phone ($X^2 = 7.71$, p=.021, iPhone vs. Other OR = 10.47) significantly predicted T-DIAL accuracy, whereby individuals with lower mood symptoms and iPhone users were more likely to obtain perfect T-DIAL scores. Note that null findings for age were also apparent when the above-detailed logistic regression was repeated using age as a continuous variable, rather than a dichotomous grouping variable (p = .806).

T-DIAL performance and everyday functioning measures

Instrumental activities of daily living questionnaire (iADLQ)

The relationship between T-DIAL accuracy and iADLQ score was examined using a multiple linear regression.[1] Mood z-score was the only variable to meet the above-described criteria for a covariate. As shown in Table 5, the overall model was significant ($F(2,119) = 7.70$, $p < .001$, adj. $R^2 = 0.10$). Mood z-score emerged as a significant predictor ($B = 0.24$, $t = 2.21$, p=.029), whereby higher mood symptoms predicted greater iADLQ scores (i.e., mild problems). There was also a main effect

of T-DIAL accuracy ($B = 0.44$, $t = 2.14$, p=.034), such that individuals who obtained perfect accuracy on the T-DIAL had significantly fewer self-reported problems on the iADLQ. A *post hoc* regression analysis using an adjusted $p < .01$ to reduce Type I error showed that T-DIAL accuracy did not interact with age to predict iADLQ score (B=-0.54, t=-1.43, p=.157), suggesting that pattern of T-DIAL performance in relation to self-reported functioning did not differ by age.

Independent living scale (ILS): money management subscale

A multiple linear regression was conducted to investigate whether T-DIAL accuracy predicted ILS Money Management subscale score. Covariates that met inclusion criteria for this model included mood z-score and phone banking frequency. Table 5 shows that the overall model was significant ($F(3,119) = 19.74$, $p < .001$, adj. $R^2 = 0.32$). Mood z-score significantly predicted ILS score (B = -1.06, t = -3.15, p = .002), whereby lower mood symptoms related to better ILS performance. Phone banking frequency also emerged as a significant predictor (B = -0.57, t = -6.02, $p < .001$), and greater frequency of using the telephone for everyday banking was associated with poorer ILS performance. T-DIAL accuracy did not significantly predict performance on the ILS (B = -0.31, t = -0.49, p = .627). A planned *post hoc* linear regression analysis with an adjusted $p < .01$ showed that T-DIAL accuracy did not interact with age to predict ILS performance ($B = 1.74$, $t = 1.67$, p=.097).

Post hoc analysis of incremental validity

An exploratory *post hoc* analysis was conducted to determine whether T-DIAL accuracy predicted iADLQ scores above and beyond the ILS. A *critical alpha* of .01 was used to limit Type I error. A multiple linear regression revealed the overall model was significant ($F(2,119) = 6.21$, p = .003, adj. $R^2 = 0.08$), which was driven by the main effect of T-DIAL accuracy predicting better iADLQ scores ($B = 0.55$, $t = 2.85$, p = .005), and ILS score did not significantly contribute to the model (B = -0.04, t = -1.47, p = .144).

Table 5. Multiple linear regression models demonstrating relationship between Telephone-based Daily Instrumental Activities of Living (T-DIAL) accuracy groups and functional outcomes, with relevant covariates.

Predictors	*B*	*B* SE	*B* 95% CI	R^2	Adj. R^2	p-value
ADLQ Model				0.12	0.10	**<.001**
T-DIAL Accuracy	0.44	0.20	0.03, 0.84			**.034**
Mood Z-Score	0.24	0.11	0.02, 0.45			**.029**
ILS Model				0.34	0.32	**<.001**
T-DIAL Accuracy	−0.31	0.64	−1.58, 0.96			.627
Mood Z-Score	−1.06	0.34	−1.73, −0.39			**.002**
Phone Banking Frequency	−0.57	0.09	−0.76, −0.38			**<.001**

ADLQ = Activities of Daily Living Questionnaire, instrumental ADLQ subscale scores were used. *ILS*=Independent Living Scale, Money Management subscale scores were used; T-DIAL Accuracy was examined as a dichotomous variable (i.e., perfect versus not-perfect). Mood Z-score was a composite measure of current self-reported depression and anxiety symptoms. Phone banking frequency was measured by self-reported frequency of using the verbal telephone for banking activities. P-values significant at $p < .05$ are bolded.

Table 6. Differences in everyday functioning and neuropsychological outcomes between the T-DIAL accuracy groups in the total sample ($N = 120$).

Variable	T-DIAL perfect ($n = 91$)	T-DIAL not-perfect ($n = 29$)
Instrumental ADLQ Subscale (of 7)	0.3 (0.7)	0.9 (1.3)
ILS Money Management Subscale (of 30)	26.9 (3.0)	25.4 (4.1)
Neuropsychological Domains (T-scores)		
Attention	51.8 (8.9)	51.5 (11.3)
Executive Functions	52.2 (8.2)	45.3 (10.2)
Memory	49.2 (7.4)	44.6 (7.7)

Values represent population mean (SD). *ADLQ* = Activities of Daily Living Questionnaire; *ILS* = Independent Living Scale.

T-DIAL performance and neurocognitive domains

A multiple logistic regression was conducted to determine whether domain-level neurocognitive scores (i.e., attention, memory, and executive functions) were associated with T-DIAL accuracy. Mood z-score and sex at birth met our inclusion criteria for covariates. Table 6 shows the simple associations between neurocognitive domain scores and T-DIAL performance group. The overall model was significant ($X^2(5,\ N = 120) = 26.60,\ p < .001$). A main effect was observed for executive functions predicting T-DIAL accuracy ($X^2 = 4.90,\ p = .027,\ \text{OR} = 1.1,\ \text{OR 95\% CI} = 1.01,\ 1.13$), such that individuals with perfect T-DIAL accuracy had better executive functions. Mood z-score was the only covariate that emerged as a significant predictor of T-DIAL accuracy ($X^2 = 10.27,\ p = .001,\ \text{OR} = 0.40,\ \text{OR 95\% CI} = 0.20,\ 0.71$), with perfect T-DIAL scorers endorsing fewer mood symptoms. A series of *post hoc* regressions showed that there were no significant interactions between age group and any neurocognitive domain in association with T-DIAL accuracy ($ps > .10$).

Discussion

Financial management is an important aspect of everyday functioning for older adults, but there are no performance-based functional assessments of this construct that can be delivered remotely and via telephone. The current study evaluated the reliability and construct validity of a novel performance-based task of financial management (i.e., T-DIAL) that was delivered remotely and via telephone to samples of older and younger adults. All participants were able to complete the task and overall performance accuracy was quite high. The task responses were easily coded and independent raters had very strong levels of agreement on scoring individual items. T-DIAL also showed acceptable levels of internal consistency, supporting the use of a total score. There was considerable negative skew and possible ceiling effects in the T-DIAL total score, with approximately three-quarters of the sample achieving perfect scores. Of note, such skewed distributions are not uncommon for performance-based, self-report, and observational measures of functional capacity (D. J. Moore et al., 2007). Although such floor and ceiling effects can be a psychometric challenge, they may also nevertheless reflect the conceptual focus of these tasks on the lower-order, fundamental skills necessary to complete daily activities (e.g., completing a telephone call

vs. managing a complex stock portfolio). Despite the skewed distribution of the T-DIAL, there was sufficient variance in performance across the sample to examine associations with demographic, functional, and cognitive outcomes.

Overall, this study provides mixed support for the construct validity of the T-DIAL. Of ecological relevance, T-DIAL accuracy was associated with manifest ADL independence, which is the superordinate construct assessed by the T-DIAL. Specifically, individuals who obtained perfect T-DIAL accuracy were significantly less likely to endorse mild problems on the iADLQ at a medium effect size, even after controlling for mood and scores on another PBFA. Thus, T-DIAL performance was able to identify individuals with subtle problems completing a telephone-based financial task who also tended to perceive mild problems with iADLs. These data therefore provide preliminary evidence for the incremental and criterion validity of the T-DIAL. Findings align with those of Marshall et al. (2019), who observed an association between a laboratory-administered, telephone-based banking task and self-reported ADLs among healthy older adults. The current study extends this work by demonstrating a relationship of similar strength between subjective iADLs and an in-home banking task, and by demonstrating the independence of the signal from mood and another measure of functional capacity. Of course, further investigation is needed to understand whether these associations are also present in relevant clinical populations, particularly among individuals with ADL dependence.

Moreover, future studies should examine relationships between T-DIAL performance and informant-rated and observational measures of everyday functioning to control for potential biases that limit the interpretation of self-report (Farias et al., 2005).

T-DIAL accuracy was not significantly associated with the laboratory-based ILS Money Management task and effect sizes were small-to-medium. This null finding was not predicted and does not support the construct validity of the T-DIAL. Possible explanations for the null finding include insufficient statistical power and use of a modified ILS that was delivered by telephone rather than in-person; indeed, the ILS did not relate strongly to self-reported IADLs in this sample either. Alternatively, there might truly be no meaningful relationship between T-DIAL and the modified ILS, which primarily involved numeracy and knowledge-based questions about financial concepts (e.g., counting change, knowledge regarding home insurance). Given the ILS was developed in 1996, it may also be susceptible to cohort effects such that questions are less personally relevant to younger adults (e.g., "What is social security income?") or may have low face validity for means of completing daily activities today (e.g., using checkbooks). In contrast, the T-DIAL required processing new information and engaging with IVR technology in real time via telephone to solve an everyday financial problem. The null findings align with prior studies in healthy older adults showing discordant relationships between less similar functional tasks (e.g., computer-based phone simulation task and laboratory structured PBFA; Czaja, Loewenstein, Lee, et al., 2017) vis-à-vis concordant associations between tasks that are logistically more similar (e.g., telephone call task and computer-based phone simulation task; Marshall et al., 2019). Indeed, the T-DIAL was related to important aspects of telephone use in everyday life, including device type and frequency of phone use for banking activities. Furthermore, the exploratory *post hoc* analysis suggested T-DIAL accuracy was more strongly associated with self-reported iADLs than this modified version of the ILS. Comparison of T-DIAL performance to logistically similar PBFAs should be explored in future studies.

Further evidence for the construct validity of the T-DIAL comes from analyses showing independent associations with several cognitive ability areas that were theorized to support performance on a telephone-based financial management task. In particular, T-DIAL accuracy showed the strongest univariable effect size relationships with memory and executive functions. The T-DIAL required individuals to engage in self-regulation while disconnected from the examiner to read their notes, shift between T-DIAL steps, and quickly discern relevant information among distractors to perform a delayed intention. These skills map onto memory and executive functions measures in this study, which involved prospective memory, verbal memory retrieval, set-shifting, and mental flexibility. Existing studies on IVR telephone-based financial tasks found poorer performance was related to worse memory and executive functions among cognitively healthy younger and older adults cross-sectionally (Marshall et al., 2015, 2017) and to declines in executive functions (Marshall et al., 2017). Although memory reveals mixed patterns in relation to accuracy on laboratory-based telephone tasks in healthy adults (Miller et al., 2013) and amnestic MCI samples (Czaja, Loewenstein, Sabbag, et al., 2017), there is a largely reliable association between memory and executive functions with everyday functioning in cognitively healthy older adults (e.g., Kelly et al., 2014). Future T-DIAL studies might examine relationships with other aspects of memory (e.g., time-based prospective memory) and executive functions (e.g., response inhibition, intraindividual variability). At the domain level, T-DIAL was not associated with measures of verbal attention and working memory, which were the strongest predictors of successful IVR task completion in a different older adult sample (Miller et al., 2013). This discrepancy may be explained by differences in task complexity, given that Miller et al. (2013) deployed four IVR tasks requiring both verbal and keypad responses, or given differences in the ways in which attention and working memory were assessed.

It is also worth noting that T-DIAL was associated with some technical and procedural aspects of everyday telephone use. For example, T-DIAL accuracy was associated with simple telephone motor task performance, frequency of using the telephone for banking activities, and device type. Interestingly, iPhone users were more likely to complete the T-DIAL task with perfect accuracy. This supported previous literature suggesting that device type influences performance on telephone-based assessments (Öhman et al., 2021). Based on engineering and technology studies, one possible explanation may be the operating system. Apple iOS on iPhones consists of one user-friendly, centralized user interface, whereas Androids have at least three different user interfaces and are compatible with several types of smartphones (e.g., Samsung, Motorola, Google), suggesting greater heterogeneity in set-up and accessibility for different comfort levels (Al-Obaidi et al., 2020). Another factor may be type of touch screen technology, with Apple iPhones using a more sensitive touch screen technology earlier on than Androids, so for older models there may be lower touch sensitivity requiring harder manual input to receive a response compared to the iPhone (Bhalla & Bhalla, 2010; Page, 2014; Sathyan & Manikandan, 2020). In line with current findings, the literature supports the notion that iPhone operating systems are perceived as more "user friendly" (Kortum & Sorber, 2015) and objectively more efficient for answering and making phone calls (Galletta & Dunn, 2014). In contrast, subjective usability of Android systems was comparable to iPhones among a sample of younger adults, whereas other studies suggest poorer usability in iPhones among persons of

lower SES (Rahmati et al., 2012) and preference for Android operating systems among older adults (Wong et al., 2017). In a sample of 80 older adults, about 1 in 5 had difficulty making and receiving calls on an Android smartphone due to difficulty finding correct icons to navigate to keypad, and 43% reported their large fingers increased number of errors for inputting information onto the touch screen (Wong et al., 2018). Studies that explicitly assess phone operating system, brand, and model to examine the influence of smartphone type, especially using personal devices, on performance-based functional tasks via telephone is needed in the aging and neuropsychology literature to identify problems and solutions to improve independence in daily activities completed via telephone.

The absence of age-related findings for the T-DIAL was surprising and does not support the construct validity of this task; indeed, this finding contrasts with literature showing younger adults tend to outperform their older counterparts on PBFAs (Becattini-Oliveira et al., 2019), including telephone-based tasks (Marshall et al., 2015, 2017; Miller et al., 2013). Moreover, age did not moderate any of the associations between T-DIAL and everyday functioning or neurocognition in this study (i.e., the strength of the relationship between the T-DIAL and other factors did not differ across older and younger adults). Prior studies showing age effects on telephone-based tasks included slightly older samples and tasks that were administered in the laboratory with more complex instructions and longer menu options. Therefore, it is possible that the T-DIAL is not sufficiently complex to elicit age effects, which might be more subtle in relatively younger, highly educated, and mostly White older adults. This interpretation is also supported by the ceiling effects observed for the T-DIAL in these samples. It is also possible that, as compared to laboratory-based tests of capacity, the more naturalistic, in-home administration format of the T-DIAL lent itself to better performance among the older adults (Schnitzspahn et al., 2011). On the other hand, the relative simplicity of the T-DIAL and the absence of age-related deficits may provide some advantages for its use in under-served groups and persons with neurocognitive disorders for whom floor effects are sometimes common (Saxton & Boller, 2006).

One consistent theme that emerged in the current study was the importance of mood symptoms in relation to T-DIAL performance. By definition, clinically significant depression and anxiety impact daily functioning and may include cognitive symptoms (American Psychiatric Association APA, 2013). Although mood is a well-established predictor of manifest everyday functioning (e.g., household management, self-care), the association between mood and PBFAs, including financial management, is inconsistent (e.g., Christensen et al., 2019). One reason is that most PBFAs are conducted in highly controlled laboratory settings, which are often quiet, structured, and guided directly by an examiner. However, participants in the current study completed the T-DIAL in their own home environments while disconnected from the examiner and interfacing independently with IVR prompts. In this way, the T-DIAL was more similar to naturalistic assessments of iADLs (Byerly et al., 2005; Rootes-Murdy et al., 2018), which show associations with mood more reliably. Individuals with mood dysregulation may have greater difficulty harnessing the cognitive resources necessary to initiate, navigate, and complete financial management tasks in naturalistic settings. Indeed, this interpretation is supported by the independent effects of both mood symptoms and higher-order cognitive functions on T-DIAL performance. Further work may compare performance on the T-DIAL between

laboratory and in-home settings using a within-subjects design to understand the role of mood based upon context.

Limitations to this study include the relatively young age range of older adults, which potentially reduced ability to detect functional difficulties given lower incidence of functional problems (Vieira et al., 2013). In addition, use of an age-discrepant group design may have limited detection of age-related differences in T-DIAL performance, rather than recruiting all ages 18+ and exploring age as a continuous variable, which may be preferable in future validation studies of the T-DIAL. Several characteristics of the older group may impact the generalizability of results, including over-representation of White individuals and persons with higher educational attainment. Deployment of the T-DIAL task in an older adult sample with a range of educational attainment, racial-ethnic backgrounds, older age (i.e., 70 and older), and greater levels of functional dependence is certainly needed to understand the utility of this measure in older adult populations. Collateral reported everyday functioning was not collected due to feasibility, which could supplement self-reported functioning to reduce bias in future validation studies. Given the sample was cognitively healthy, it was difficult to determine "normal" T-DIAL performance and future goals include exploration of T-DIAL performance in cognitively impaired samples to define impaired vs. normal performance. In addition, future examination of the T-DIAL must include more representative samples in both younger and older groups to increase validity of assessing potential age effects that may exist in the general population. The screening survey asked participants for self-reported medical and psychological history, which introduces risk of poor historians, biases, or underreporting potentially confounding variables. The screener also did not explicitly assess history of substance use or prior psychiatric hospitalization, and there is a selection bias given adults without adequate hearing were excluded. Telephone-based administration carries limitations including difficulty measuring exact reaction time, inability to visually observe participant behaviors, and limitation to auditory-verbal neuropsychological assessments. Recruitment through Internet and virtual means introduced bias toward individuals familiar with technology. Type of phone was collected as iPhone, Android, or "other" to encompass flip phones or non-smart phones; however, the study did not explicitly query what type of phone participants had if they selected "other;" thus it is unknown how technologically outdated they may have been. Lastly, the study was not preregistered.

Despite these limitations, this study provides preliminary evidence for the feasibility and reliability of the T-DIAL in healthy older adults, as well as some mixed evidence for its construct validity. The current findings support the conclusion that most well-educated older adults who frequently use smart phones can complete the T-DIAL task with great accuracy. However, it remains to be determined whether the T-DIAL will work when deployed in clinical populations or cognitively healthy adults with lower education. Future studies might use the T-DIAL, a seemingly simple functional task in healthy populations, to understand whether this measure could detect subtle functional difficulties between cognitively healthy adults and persons with neurocognitive disorders (e.g., Puente et al., 2014). Developing more complex iterations of the T-DIAL may increase reliability, validity, and diagnostic sensitivity. Such modifications could include adding financial tasks (e.g., calling to renew car insurance plan), and assessing other functional domains such as transportation (e.g.,

calling to manage air travel plans) and health management (e.g., refilling a prescription via telephone). Repeated measures or longitudinal designs could determine whether the T-DIAL is sensitive to detect intraindividual functional changes over time. An experimental design may help understand if T-DIAL performance improves with alleviation of executive demands (e.g., eliminating distractor information, using concrete transitions to support set-shifting). Such studies may inform interventions to help adults with neurocognitive disorders improve success in everyday financial activities via telephone.

Note

1. The iADLQ subscale included two items that assessed self-reported problems with using the telephone and managing finances, for which among the entire sample zero individuals endorsed requiring help to use the telephone, and five individuals endorsed requiring assistance with financial management.

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No potential conflict of interest was reported by the author(s).

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Data availability statement

The data that support the findings of this study are available from the corresponding author, SPW, upon reasonable request.

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